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## Acronyms

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<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transportation Officials</td>
</tr>
<tr>
<td>ADT</td>
<td>Average Daily Traffic</td>
</tr>
<tr>
<td>DOT</td>
<td>Department of Transportation</td>
</tr>
<tr>
<td>EMS</td>
<td>Emergency Medical Services</td>
</tr>
<tr>
<td>FHWA</td>
<td>Federal Highway Administration</td>
</tr>
<tr>
<td>$L_R$</td>
<td>Length of Roadside Travel</td>
</tr>
<tr>
<td>LON</td>
<td>Length of Need</td>
</tr>
<tr>
<td>MUTCD</td>
<td>Manual on Uniform Traffic Control Devices</td>
</tr>
<tr>
<td>MASH</td>
<td>Manual for Assessing Safety Hardware</td>
</tr>
<tr>
<td>NCHRP</td>
<td>National Cooperative Highway Research Program</td>
</tr>
<tr>
<td>RDG</td>
<td>Roadside Design Guide</td>
</tr>
<tr>
<td>ROR</td>
<td>Run off Road</td>
</tr>
<tr>
<td>TCP</td>
<td>Traffic Control Plan</td>
</tr>
<tr>
<td>TL</td>
<td>Test Level</td>
</tr>
<tr>
<td>TTC</td>
<td>Temporary Traffic Control</td>
</tr>
<tr>
<td>TTCZ</td>
<td>Temporary Traffic Control Zone</td>
</tr>
<tr>
<td>WZ</td>
<td>Work Zone</td>
</tr>
</tbody>
</table>
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 appearances may be determined. Three evaluation criteria are considered, namely (1) structural adequacy, (2) 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.

**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 vehicle’s path of impact.

**Impact Attenuator**—See Crash Cushion.

**Length of Need**—Total length of a longitudinal barrier needed to shield an area of concern.
**Level of Performance**—The degree to which a longitudinal barrier, including bridge railing, is designed for containment and redirection of different types of vehicles.

**Longitudinal barriers**—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-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 are assumed to be non-recoverable, but may still be considered traversable 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.

**Performance Level**—See Level of 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 no-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 50ft$^2$ in area. Small roadside signs may be defined as those less than 50ft$^2$ 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 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).
**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, there are four classes of traffic barriers, namely; roadside barriers, median barriers, bridge railings, 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
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 hazardous fixed object or terrain feature. The purpose of this document is to summarize important information contained in the TxDOT Roadway Design Manual and Standard Construction Drawings that can be used in the field to ensure that all barrier installations are built and maintained to current standards and can be expected to perform acceptably when hit.

Questions We Must Ask Ourselves
When reviewing proposed and existing barrier installations in the field, we need to ask ourselves the following questions:

1. Is an existing barrier installation still warranted?
2. Is the barrier system more hazardous than the condition being shielding?
3. If the barrier is installed as originally planned, is there a possibility of a motorist still reaching the hazard?
4. Can the barrier be extended to shield a secondary obstruction?
5. Are there any vertical obstructions within the barrier system’s design deflection?
6. Is the metal beam guard fence terminal within 200 feet of the start of another guard fence run and, if so, could the two runs be connected?
7. Does the slope need regrading?
8. Has the barrier height been reset after an overlay?
9. Is the best end treatment for the site being used?

10. Is barrier considered in sensitive areas such as school playgrounds and reservoirs?

11. Is there adequate soil support behind strong post metal beam guard fence shielding a slope or are longer posts required?

This document provides the information needed to answer these and other questions pertaining to optimal design, installation, and maintenance of barrier systems.
Part 1

Barrier Basics

Barrier Guidelines:

- Are pre-determined situations or conditions where the use of a traffic barrier is normally considered. Refer to the Tables on pages 6 through 8 for fixed object and embankment guidelines.
- Should be considered when determining the need for a barrier, but they should not be construed as warrants.
- Are not a substitute for engineering judgment.

Establishing Barrier Guidelines

- Barrier guidelines are based on the premise that a traffic barrier should be installed only if it reduces the severity of potential crashes.
- There are instances where it is not immediately obvious whether the barrier or the unshielded condition presents the greater danger to a motorist.
- In such instances, guidelines may be established by using a benefit/cost analysis whereby factors such as design speed, roadway alignment, and traffic volumes can be evaluated in relation to the barrier need. Costs associated with the barrier (installation, maintenance, and crash-related costs) are compared to crash costs associated with the unshielded condition.
- This procedure is typically used to evaluate three options:
  1. Remove or reduce the condition so that it no longer requires shielding,
  2. Install an appropriate barrier,
  3. Leave the condition unshielded.
Considerations

- Consider eliminating short lengths of guard fence since these sections are often less effective than no barrier at all.
- Avoid short gaps between guard fence installations by making guard fence continuous where the points of need are determined to be about 200 feet apart or less.
- Consider keeping the slope clear of fixed objects when guard fence is not required due to the height of the slope.
- Consider guard fence in sensitive areas such as school playgrounds or reservoirs.

Clear Zone

The term “clear zone” is used to designate an area bordering the roadway, starting at the edge of the traveled way, which is available for safe use by errant vehicles. Safe use generally means the slope is flat enough and free of fixed object hazards so a motorist leaving the road is able to stop and return to the roadway safely.

The clear zone distances shown below represent minimum recommended distances and are based on limited data.
The best answer to the question “How wide should the clear zone be?” is “As wide as practical in each situation – but at least as wide as the distances, shown in the Table below”.

### Design Clear Zone

<table>
<thead>
<tr>
<th>Location</th>
<th>Functional Class</th>
<th>Design Speed (MPH)</th>
<th>Avg. Daily Traffic</th>
<th>Clear Zone Width (ft)</th>
<th>Min.</th>
<th>Desirable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>Freeway</td>
<td>All</td>
<td>All</td>
<td>30 (16 for ramps)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arterial</td>
<td>All</td>
<td>0 – 750</td>
<td>10</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>750 – 1,500</td>
<td>16</td>
<td>16</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt;1,500</td>
<td>30</td>
<td>30</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Collector</td>
<td>≥ 50</td>
<td>All</td>
<td>10</td>
<td>10</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 45</td>
<td>All</td>
<td>10</td>
<td>10</td>
<td>--</td>
</tr>
<tr>
<td>Suburban</td>
<td>All</td>
<td>All</td>
<td>&lt; 8,000</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8,000 – 12,000</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12,000 – 16,000</td>
<td>10</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt;16,000</td>
<td>20</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Urban</td>
<td>Freeway</td>
<td>All</td>
<td>All</td>
<td>30 (16 for ramps)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>All (Curbed)</td>
<td>≥ 50</td>
<td>All</td>
<td>Use above suburban criteria in so far as available border width permits</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 45</td>
<td>All</td>
<td>4 from curb face</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All (Uncurbed)</td>
<td>≥ 50</td>
<td>All</td>
<td>Use above suburban criteria</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 45</td>
<td>All</td>
<td>10</td>
<td>10</td>
<td>--</td>
</tr>
</tbody>
</table>

See TxDOT Roadway Design Manual
Design Options (In order of preference)

- Remove the hazard.
- Redesign the obstruction so it can be traversed safely.
- Relocate the obstruction to a point where it is less likely to be struck.
- Reduce impact severity by using an appropriate breakaway device or crash cushion.
- Shield the obstruction with a longitudinal traffic barrier if it cannot be eliminated, relocated or redesigned.
- Delineate the obstruction if the above alternatives are not practical or cost effective.

REMEMBER: Barrier can also be a hazard and should only be used where the results of leaving the roadway and overturning or striking a fixed object would be more severe than the consequences of striking the barrier.

Roadside Obstacles

Roadside features that are normally considered for shielding are shown in the table below. Note that many man-made hazards can be redesigned or relocated to make shielding unnecessary. Traffic volumes and speeds, roadway geometrics, and the offset distances to the hazard are factors that should be considered when deciding on barrier installation. The following conditions within the clear zone are normally considered more hazardous than a roadside barrier:

---

6
<table>
<thead>
<tr>
<th>Obstacle</th>
<th>Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steep Embankment Slope</td>
<td>Need based on embankment height and slope (see graph on page 8)</td>
</tr>
<tr>
<td>Rough Rock Cut</td>
<td>Within horizontal clearance for highway class and traffic volume</td>
</tr>
<tr>
<td>Boulders</td>
<td>Within horizontal clearance for highway class and traffic volume and diameter exceeds 6”</td>
</tr>
<tr>
<td>Water Body</td>
<td>Within horizontal clearance for highway class and traffic volume and permanent depth exceeds 2 ft.</td>
</tr>
<tr>
<td>Lateral Drop-off</td>
<td>Within horizontal clearance for highway class and traffic volume and steeper than 1V:1H and depth exceeds 2 ft.</td>
</tr>
<tr>
<td>Side Ditches</td>
<td>Within horizontal clearance for highway class and traffic volume and unsafe cross section.</td>
</tr>
<tr>
<td>Parapet Wall/Wingwall/Bridge Rail End</td>
<td>Within horizontal clearance for highway class and traffic volume and approaching traffic</td>
</tr>
<tr>
<td>Area Alongside Bridges</td>
<td>Within horizontal clearance for highway class and traffic volume and approaching traffic</td>
</tr>
<tr>
<td>Trees</td>
<td>Within horizontal clearance for highway class and traffic volume and dia. exceeds 6”.</td>
</tr>
<tr>
<td>Culvert Headwall</td>
<td>Within horizontal clearance for highway class and traffic volume and size of opening exceeds 3 ft.</td>
</tr>
<tr>
<td>Wood Poles, Post</td>
<td>Within clear zone for highway class and traffic volume and cross section/area exceed 50 in².</td>
</tr>
</tbody>
</table>
Obstacle | Guidelines
--- | ---
Bridge Piers, Abutments at Underpasses | Within horizontal clearance for highway class and traffic volume
Retaining Walls | Within horizontal clearance for highway class and traffic volume and not parallel to travel way.

Ref: TxDOT Roadway Design Manual.

Roadside Slopes (Embankments)
Although the AASHTO RDG graph for barrier requirements at embankments suggests that slopes steeper than 1V:3H are candidates for shielding, it does not take traffic speeds or volumes or roadway geometrics into consideration. Some transportation agencies have developed modified guidelines based on these additional factors.

Barrier Requirements for Embankment Heights

TdDOT Roadway Design Manual, 2013, Figure A-1, page A-5
Barriers
A roadside barrier is a longitudinal barrier used to shield motorists from natural and man-made obstacles located along either side of a traveled way. They are usually categorized as rigid, semi-rigid or flexible depending on their deflection characteristics when impacted.

Rigid Systems:

- The F-Shape Barrier has the same basic geometry as the New Jersey barrier, but the "break-point" between the lower and upper slopes is 10 inches above the pavement. This modification results in less vehicle climb in severe impacts and improved post-crash trajectories. The 7.5 inch horizontal distance from the toe of the F-shape to its top corner also reduces the roll angle of impacting trucks and other vehicles with high centers-of-gravity. TL-4: 32” Tall and TL-5: 42” Tall.

- The Single Sloped Barrier has a constant 10.8 degree slope and its crash performance is similar to the F-shape barrier.

- Low Profile Barrier is a TL-2 system and can be used in work zone applications on roads posted for 45 mph or less.
Semi-Rigid Systems: Midwest Guardrail System (MGS)

**Test Level:** NCHRP 350/MASH TL-3

**Post:** W6 x 9 or W6 x 8.5 x 6 ft.
Steel or 6” x 8” or 8” diameter wood posts.

**Post Spacing:** 6’-3”

**Height:** 31”

**Block-outs:** 8” or 12” timber or plastic block-outs.

**Rail Splices:** mid-span, between posts

Strong-Steel or Wood Post W-Beam with wood or plastic block-outs

**Test Level:** NCHRP 350/MASH TL-3

**Post:** W6 x 9 or W6 x 8.5 x 6 ft. Steel or 6” x 8” or 8” diameter wood posts.

**Post Spacing:** 6’-3”

**Height:** 28”

**Block-outs:** 6” wide x 8” x 14” routed (w/steel post) timber or plastic block-outs.
Double block-outs can be used.
Flexible Systems:
High tension cable barriers (Propriety Systems) is installed with a significantly greater tension in the cables than generic, low-tension, three-cable systems. The deflection of these systems depends on the type of system, the post spacing and the distance between anchors. The high-tension systems also result in less damage to the barrier and usually the cables remain at the proper height after an impact which damages several posts. Note that the cable heights above ground may vary by manufacturer and by test level.

All of these systems have been tested successfully on slopes as steep as 1V:4H, but lateral placement must follow manufacturer’s recommendations.

Brifen Wire Rope Safety Fence (WRSF) by Brifen USA
http://www.brifenusa.com/

**Post:** Z-shaped post, can be driven or socketed

**Cable:** 3 or 4 cable combination. Top cable is placed in a center slot at top of the post and cables 2 and the lower cables are interwove around the posts.

**Typical Post Spacing:** 10.5 to 21 ft.
Gibraltar
http://www.gibraltartx.com/

Post: C-channel post, can be driven or socketed
Cable: 3 or 4 cable combination. Cables are attached using a single hair pin and are placed on alternate sides of adjacent posts.
Typical Post Spacing: 10 to 30 ft.

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

Post: C-Shaped and I-beam Post, can be driven or socketed
Cable: 3 or 4 cable combination. Cables are placed in a wave-shaped slot at the center of the post and separated by plastic spacers. Some versions also have cables that are supported on the flanges of the posts.
Typical Post Spacing: 6.5 to 32.5 ft.
Nu-Cable by Nucor Marion Steel
http://nucorhighway.com/nu-cable.html

Post: U-Channel Post, can be driven or socketed

Cable: 3 or 4 cable combination. Cables are attached using locking hook bolts or hook bolts and a strap. 2 of 4 cables are placed on one side of post and the other two are placed on the opposite side.

Typical Post Spacing: 6.5 to 32.5 ft.
Length of Need (LON) is defined as the length of barrier needed in advance (upstream) of a fixed object hazard or a non-traversable terrain feature to prevent a vehicle that has left the roadway from reaching the shielded feature. It is determined by selecting appropriate variables and using the formula on page 16 to calculate the LON (the “L” value) shown in the diagram below.

Approach Barrier Layout
CZ  Clear Zone width
CZ_{SB}  Clear Zone width for southbound traffic
CZ_{NB}  Clear Zone width for northbound traffic
L_{RT}  Length of roadside travel
D_{SB}  Distance from edge of southbound travel lane to far side of area of concern or to outside edge of clear zone whichever is least.
D_{NB}  Distance from edge of northbound travel lane to far side of area of concern or to outside edge of clear zone whichever is least.
L_u  Guard fence length upstream of area of concern.
L_p  Guard fence length parallel to area of concern.
L_D  Guard fence length downstream of area of concern.
L_{TOTAL}  Length of guard fence needed. (L_u + L_p + L_D).

**TxDOT Length of Need Procedure:**

To determine needed length of guard fence for a given obstacle, design equations have been formulated for low volume (ADT 750 or less) and higher volume (ADT more than 750) conditions. A clear zone width of 16 ft and length of roadside travel of 200 ft are incorporated in the low volume design equation (for use on roadways when the present ADT volume is 750 or less). If the clear zone required is less than 16 ft and the present ADT is 750 or less the shorter distance can be used in lieu of 16 ft. to calculate the LON.

1. Choose an appropriate D distance as it is the most critical part of the design process. This distance should include all features or hazards that need to be shielded, up to the design clear zone at each site.
2. Select a Runout Length (200’ or 250’, based on ADT) from the table below.
3. Determine the location of the barrier face relative to the edge of the travel lane (G).
4. Calculate the Length of Need (L) from the following equation and round the calculated value up to the nearest 12.5-foot or 25-foot rail segment:

   - **Low Volume (ADT < 750)**
   
   \[ L = 200 - \frac{200}{D} \times G \]
Where:
D = Distance from edge of travel lane to far side of hazard, or 16 ft, whichever is less.
G = Guard fence offset from edge of travel lane, ft.

- **High Volume (ADT > 750)**

\[ L = 250 - \frac{250}{D} \times G \]

Where:
D = Distance from edge of travel lane to far side of hazard, or 30 ft, whichever is less.
G = Guard fence offset from edge of travel lane, ft.

### TxDOT Runout Lengths

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Runout Length ((L_R)) Given Traffic Volume (ADT) (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Under 750</td>
</tr>
<tr>
<td>80</td>
<td>200</td>
</tr>
<tr>
<td>70</td>
<td>200</td>
</tr>
<tr>
<td>60</td>
<td>200</td>
</tr>
<tr>
<td>50</td>
<td>200</td>
</tr>
<tr>
<td>40</td>
<td>200</td>
</tr>
<tr>
<td>30</td>
<td>200</td>
</tr>
</tbody>
</table>

Ref: TxDOT Location and Design Manual, Figure 602-1E, April 2013

### Length of Need for Opposing Traffic

- X (or L) is determined using the same equation.
- All lateral dimensions are measured from the centerline for a two-lane roadway. See the layout on page 14.
- There are three ranges of clear zone width, \(L_C\) (or D), which deserve special attention:
1. If the barrier is beyond the appropriate clear zone for opposite direction traffic, no additional barrier and no crashworthy end treatment is required. (NOTE: an appropriate barrier anchor remains necessary to ensure proper containment and redirection for near-side impacts).

2. If the barrier is within the appropriate clear zone but the area of concern is beyond it, no additional barrier is required; however a crashworthy end treatment should be used.

3. If the area of concern is within the clear zone for opposing traffic, the barrier must be extended to prevent opposite-direction hits.

**Length of Need (LON) Field Check:** A straightforward method to verify correct LON in the field is to stand on the roadway edge directly opposite the shielded feature, and then pace off the appropriate runout length based on ADT (i.e., 200 or 250 feet) upstream along the edge line. At that point, turn and look at the shielded area. If the proposed (or actual) guardrail installation crosses that line of sight, then the area is adequately covered. (NOTE: if the terrain makes it unlikely for a vehicle to reach the hazard from that point (as might be the case if there is a traversable, non-recoverable slope beyond the rail), the installation may be longer than needed. On the other hand, if the intervening terrain is also hazardous or if there are other significant obstacles in the immediate vicinity, it may be desirable to extend the barrier to shield all of the dangerous conditions.)

**Additional Design Considerations**

Although it is critical that the correct length of need be installed, there are several other placement considerations essential to good barrier performance. These include adequate deflection distances behind each type of barrier,
barrier height, and the location of barrier on slopes and behind curbs. These factors are discussed in the next sections.

**Design Deflection Distance** is based on the results of 62-mph impacts into the barrier at a 25-degree impact angle by the NCHRP Report 350 or MASH pickup truck. In the field, actual deflections can be much greater (or less) depending on actual impact conditions. Note that the AASHTO RDG measures the distance from the back of the posts.

**Height Measurement** The minimum height of Strong-Steel Post metal beam guard fence is 28” and MGS is 31”, measured as shown below or from the gutter line when set above a curb. If set behind a sidewalk barrier height should be set from the sidewalk elevation. For high tension cable barriers, the height of the top and bottom cables is critical and must meet manufacturers’ specifications.
Barrier Placement on Slopes
Barrier, regardless of type, performs best when an impacting vehicle is stable when contact is first made. Since vehicles running off the road at high speeds tend to become airborne and are likely to override barrier placed on a slope, the following guidelines apply:

- Do not place metal beam guard fence on slopes steeper than 1V:6H. Note: TxDOT requires 1V:10H
- Metal beam guard fence systems can be placed anywhere on 1V:10H or flatter slopes.
- MGS barrier can be installed on 1V:8H slopes but 1V:10H is preferred.
- When the slopes are between 1V:10H and 1V:6H, the face of the barrier must not be between 2 to 12 feet beyond the grade hinge point.
- Strong post metal beam guard fence need 2 feet of soil support behind the rail for support. When 2 feet is not obtainable, strong posts that are a minimum of 1 foot longer shall be provided.
- High tension cable barriers can be placed anywhere on a 1V:6H or flatter roadside slope, but there some placement restrictions when used in a median application. Most proprietary systems can be placed on 1V:4H slopes, but manufacturers’ recommendations must be followed.

See AASHTO Roadside Design Guide, 4th Edition, Figure 5-38, pg 5-47.
Guard fence and Curb
Curbs do not have a significant redirection capability and can have the same type effect on vehicle trajectory as slopes, i.e., wheel impact with a curb can cause a vehicle to vault over a barrier placed above or beyond it. The following guidelines apply:

- Guard fence should not be used with curb installation on high speed (Design Speed of 50 mph and higher), rural roads.

- When guard fence/curb combinations are unavoidable, the curb type and barrier placement should follow the recommendations shown in the details below. Any curb in front of a guard fence terminal should be limited to a 2 inch height.

If the curb exceeds 4 inches, follow these guidelines:
1. Strong post metal beam guard fence should be used.
2. Stiffen the guard fence
   - Add a rubrail or
   - Double nest the rail or
   - Bolt a W-beam to back of the posts
3. Curb must be flush with, or slightly behind, the face of the guard fence.
4. The guard fence height is measured from the edge of travel lane to the top of rail when the guard fence is placed in front of or at the face of the curb.
5. When standard metal beam guard fence is placed behind curb, the face of the barrier should be aligned with the face of the curb.
6. For 31” height metal beam guard fence, the face of the rail may be 6” beyond the face of the curb or 8ft beyond face of curb.
Guard fence and Trees
- Generally guard fence is not used to shield utility poles or trees. However, individual trees and poles that are in vulnerable locations and cannot be removed or relocated are sometimes shielded.
- Where guard fence is used in front of poles or trees due to other obstructions barrier deflection must be considered.
- Consider removing trees where they are an obstruction and in locations where they are likely to be hit.
- Use crash history at similar sites, scars indicating previous crashes or field reviews to determine removable trees.
- Tree removal is usually a preferred option but an assessment regarding its expense and effectiveness should be considered.
- Roadways through wooded areas with heavy nighttime traffic volumes, frequent fog, and narrow lanes should be well delineated.
- Pavement markings and post mounted delineators are among the most effective and least costly improvements that can be made to a roadway.

Connections to Bridge Barriers
Since there are numerous bridge barrier designs currently in place on Texas highways, the attachment details shown in the latest Design Standards for new construction will not always be directly applicable for every project. However, crashworthy designs can be developed if three concerns are met: an adequate transition between the bridge end and the approach guardrail, an adequate attachment to the bridge barrier itself, and the elimination of any potential snag points at the bridge end.
• A transition is simply a gradual stiffening of the approach guard fence at the bridge end so the rail cannot deflect enough to result in a vehicle “pocketing” when it reaches the rigid bridge barrier.

• A structurally adequate attachment of the guard fence to the bridge barrier is shown on the transition details as well. This detail is needed to prevent the approach railing from pulling free from the bridge barrier. Some existing bridge railings may not be structurally adequate to support such a connection. In such situations extending the guard fence across the structure eliminates the need for a structural connection at the bridge end and may increase the capacity of the bridge barrier itself.

• Finally, if the bridge barrier is significantly higher than the approach railing, a truck or SUV impacting the approach railing could lean over the railing far enough to snag on the end of the bridge barrier, or if no rubrail or concrete curb is used, a vehicle’s tire could fold under the guard fence and snag on the bottom edge of the bridge parapet.
Guard fence at Intersections and Driveways
When secondary roads or driveways intersect a main road so close to a bridge or other hazard that a full run of barrier cannot be installed, a strong post metal beam guard fence can be curved around the radius where the two roads meet. While the site conditions can vary greatly, there are two major concerns that should be addressed.

1. If the hazard is a bridge end or pier, a crashworthy transition design is required. A crash cushion can be used if the space is too limited to use a standard transition. The section of barrier along the primary road must be long enough and designed to react in tension to redirect impacting vehicles away from the shielded rigid object.

2. Oftentimes the feature traversed by a structure or another hazardous feature between the intersecting road and the structure can be shielded using a curved rail design. By using a curved rail design, high angle impacts into the curved section are likely. To reduce the risk of a vehicle going through or over the metal beam, modifications can be made to the posts, the metal beam-to-post connections, and the end treatment along the intersecting road or driveway. TxDOTs typical treatment at such locations is shown here.
TxDOT Short Radius
Part 2

Terminals and Crash Cushions

Terminals
Crashworthy terminals anchor a barrier installation and are designed to eliminate spearing or vaulting when hit head-on, or redirect a vehicle away from the shielded object or terrain feature when the barrier is struck on the traffic face near the terminal. Texas requires’ TL-3 end terminals on the NHS.

Definitions:

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

NOTE:

- At the trailing end of guard fence, a distance of 50 feet beyond the end treatment is to be kept clear of all roadside obstructions (hazards) or the rail maybe extended to shield such secondary hazards.
- This "downstream clear zone" is intended to minimize the likelihood that a vehicle may be forced into an obstruction by the barrier.
- On two lane highways with two-way traffic, provide crashworthy end treatments on both the approach and trailing ends of the guard fence when the trailing ends are within the clear zone of opposing traffic.
- On four-lane divided highways, use crashworthy end treatments on the approach ends. If the departure rail is within the clear zone for opposing traffic, provide end treatments on both the approach and trailing ends. Note that oftentimes no rail is needed on the departure ends of bridges on divided roadways unless site specific circumstances require additional barrier.
Types of Terminals
The following terminals are those primarily used in Texas.

For additional terminals go to the FHWA website at

Energy Absorbing Terminals
● Used for single runs of strong post metal beam guard fence
● Redirection begins beyond the third post

Extruder Terminal ET-2000 Plus


Test Level: NCHRP 350: TL-2 and TL-3

Characteristics:
● Tangent terminal.
● Rectangular impact front face (Extruder head).
● Rectangular holes in 1st rail support the tabs of the cable anchor bracket.
● Steel HBA and SYTP and wood post options are available.
● SYTP Retrofit in tube sleeve option available.
● End of W-beam rail with offset of 0’ to 2’-0”.

** Effective October 28, 2014, the ET-Plus system is suspended as an alternative in contracts and is discontinued for use in new installations.
Sequential Kinking Terminal (SKT-350)

http://roadsystems.com/skt.html

**Test Level:** NCHRP 350: TL-2 and TL-3

**Characteristics:**

- Tangent terminal.
- Square impact front face.
- Has a feeder chute (channel section that surrounds the rail) which gets wider at the downstream end.
- Breakaway steel end posts #1 and #2 and standard steel metal beam guard fence posts #3 and beyond.
- Rail has 3 (1/2” x 4” long) slots in the valley of the rail.
- There may be 5 additional slots (1/2” x 4” long) on both the top and bottom corrugations of the w-beam section, which makes it interchangeable with the FLEAT system.
- Cable anchor bracket is fully seated on the shoulder portion of the cable anchor bolts.
- All hinge steel post, plug weld steel posts, or wood posts available.
- End of metal beam rail with offset of 0’ to 2’-0”.
X-Lite

http://www.barriersystemsinc.com/xlite-end-terminal

Test Level: NCHRP 350: TL-3

Characteristics:
- Rectangular Impact Face.
- All steel driven posts.
- Uses a slider mechanism between post 1 and 2 that gathers and retains the rail when hit.
- The anchor consists of posts #1 and #2 connected by tension struts and a soil plate below grade on post #2.
- Both Tangent and Flared Layout.

Softstop


Test Level: MASH TL-3

Characteristics:
- Rectangular Impact Face.
- All steel driven posts.
- Breakaway steel posts at #1 and #2, standard steel guardrail posts #3 and beyond.
- Impact head flattens and extrudes w-beam guardrail upon end-on impact.
Non-Crashworthy Terminals

Downstream Anchor Terminal (DAT)

● These terminals may be used on the downstream end of metal beam guard fence installations when they are outside the clear zone for opposing traffic.

● Both designs provide tensile continuity in the metal beam rail when it is stuck near the trailing end.

** The TAS system is not acceptable on the upstream end of any roadway.

Terminal Anchor Section (TAS)
Terminal Grading Details

A barrier terminal is most likely to perform best when a vehicle is stable at the moment of impact and there is a traversable runout area immediately behind the terminal. Whenever practical, a barrier should be extended until these conditions can be met.

When a grading platform must be built it is critical that it be designed and constructed to blend with the original embankment and not cause instability in a vehicle before, during, or after a crash into the terminal. A grading drawing from Texas’ Standard Construction Drawing SGT (8) 31-11 shows approach grading requirements for a terminal. Note that this area should be no steeper than 1V:10H. Steeper adjoining slopes should be gently transitioned to a flatter slope to minimize rollover potential. The grading around and immediately beyond a terminal should not cause instability in a vehicle before, during, or after a crash into the terminal.
Crash Cushions
Crash cushions are generally used to shield hazards in freeway gore areas or the ends of permanent or temporary traffic barriers.

For additional commonly used attenuators throughout the U.S., go to the FHWA website at http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/index.cfm

QuadGuard Family

Test Level: NCHRP 350/MASH TL-2 and TL-3
How it works: Hex-foam cartridges crush upon impact. Specially fabricated side panels having four corrugations slide back on a single track when struck head-on. Energy absorbing cartridges in each bay may need to be replaced after each crash. Requires a paved pad.
Locations: Median or shoulder protection. Gore two-side protection.
TAU-II

http://www.barriersystemsinc.com/#/tau-ii

Test Level: NCHRP 350/MASH TL-2 and TL-3
How it works: Energy absorbing cartridges crush upon impact. Thrie beam panels slide back when struck head-on. Anchored at the front and rear of system. Energy absorbing cartridges in each bay may need to be replaced after each crash. Requires a paved pad.
Locations: Median or shoulder protection. Gore two-side protection.

Trinity Attenuating Crash Cushion (TRACC)

Test Level: NCHRP 350 TL-2 and TL-3
How it works: Consists of a series of w-beam fender panels and an impact face which absorbs energy by cutting metal plates on the top sides of the guidance tracks when forced backward in an end on impact. Requires Paved Pad.
Locations: Median or shoulder protection. Gore two-side protection.
REACT 350


**Test Level:** NCHRP 350 TL-2 and TL-3

**How it works:** Hollow high molecular weight, high density polyethylene cylinders crush upon impact. Cables on the side are for side impacts. Requires a paved pad.

**Locations:** Median or shoulder protection. Gore two-side protection.

QuadGuard Elite Family


**Test Level:** NCHRP 350 TL-2 and TL-3

**How it works:** High Density Polyethylene cylinders and flex-belt nose collapse upon impact. Specially fabricated
side panels having four corrugations slide back on a single track when struck head-on. Requires a paved pad. **Locations:** Median or shoulder protection. Gore two-side protection.

**Smart Cushion Innovation (SCI)**

http://www.workareaprotection.com/attenuator.htm

**Test Level:** NCHRP 350 TL-2 and TL-3

**How it works:** Hydraulic cylinders in the attenuator provides resistance to stop a vehicle before it reaches the end of the cushion’s usable length. Requires a paved pad. **Locations:** Median or shoulder protection. Gore two-side protection.
Hybrid Energy Absorption Reusable Terminal

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

Test Level: NCHRP 350 TL-3

How it works: High Molecular Weight / High Density Polyethylene side panels connected to steel diaphragms mounted on tubular steel tracks which compress upon impact. Requires a paved pad.

Locations: Median or shoulder protection. Gore two-side protection.

QUEST

Test Level: NCHRP 350 TL-2 and TL-3

How it works: Designed to attach to a concrete median barrier. Consists of a series of W-beam fender panels supported by diaphragms with a trigger mechanism at the nose that releases the front assembly for end on hits.
BEAT-SSCC (Single Sided Crash Cushion)

http://www.roadsystems.com/beat-sscc.html

Test Level: NCHRP 350 TL-3

How it works: Mandrel section of the impact head bursts the tubing to absorb the impact energy. Attaches directly to rigid barriers, bridge rails and abutments.

Locations: Shoulder protection. Ground mounted or surface mounted post on a concrete pad.

Work Zone Impact Attenuators ONLY

Absorb 350

http://www.barriersystemsinc.com/#/absorb-350

Test Level: NCHRP 350 TL-2 and TL-3

How it works: Plastic waterfilled elements allow vehicles to be decelerated.

Locations: Any locations where it is safe for the post impact trajectories to be on the back side of the system.
SLED

http://traffixdevices.com/cgi-local/SoftCart.exe/newproducts.htm?L+scstore+tsjv8007fff838f8+1364541558

Test Level: NCHRP 350 TL-2 and TL-3

How it works: Plastic waterfilled elements allow vehicles to be decelerated.

Locations: Any locations where it is safe for the post impact trajectories to be on the back side of the system.

ACZ-350

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

Test Level: NCHRP 350 TL-3

How it works: Plastic waterfilled elements allow vehicles to be decelerated.

Locations: Any locations where it is safe for the post impact trajectories to be on the back side of the system.
Sand Barriers

Test Level: NCHRP 350 TL-2 and TL-3
How it works: Sand-filled plastic barrels dissipate the kinetic energy of an impacting vehicle by transferring the vehicle’s momentum to the variable masses of sand in the barrels that are hit.
Locations: Temporary Construction Worksites i.e. Ends of Concrete Barriers; Gore Two-sided Protection; Wide Medians; Bridge Piers.

Energite III Module (sand)

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

Fitch Universal Module (sand)

http://www.energyabsorption.com/products/products_universal_barr els.asp

Big Sandy (sand)

http://www.traffixdevices.com/products/attenuators/big-sandy/
Crashguard

Part 3

Maintenance

Metal beam guard fence systems must be kept in good working condition (near “as-built condition”) if they are to contain and redirect impacting vehicles. Some deterioration occurs as a result of crash damage and environmental degradation. Much of this damage can be considered “cosmetic” and may not measurably affect barrier performance. However, some kinds of damage may seriously degrade performance such as those listed below in the Longitudinal Barrier Damage and Terminal Damage sections. Repairs to these types of damage should be given priority.

While it is not practical to quantitatively define “in a timely manner”, each identified damaged barrier site must be assessed, prioritized and scheduled for repairs based upon risk exposure (highway type, extent of barrier/terminal damage, potential for being restruck within the repair time window).

Longitudinal Barrier Damage

The types of guard fence damage listed below may result in inadequate structural and substandard redirective performance.

- Vertical tears in the W-beam rail that begin at the top or bottom edge. These are likely to result in rail separation in a subsequent crash.
- Similarly, holes in the rail resulting from damage or deterioration that reaches the top or bottom of a rail or one hole with a section greater than 1 inch or several holes with a dimension less than 1 inch within a 12.5-foot length of rail.
- More than 2 missing or ineffective splice bolts.
• More than 9 inches of lateral deflection over a 25-foot length of rail.
• Top rail height more than 2 inches lower than the original rail height.
• Rail flattening that increases the W-beam section width from its original 12 inches.

Terminal Damage

These types of guard fence terminal damage can result in inadequate performance if hit:

• Broken or damaged end posts.
• Missing or very slack rail-to-end post cables.
• Missing cable bearing plate at end posts.
• Impact head not properly aligned with W-beam rail elements.
• W-beam rail element not properly seated in the impact head.

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. These rankings, along with the perceived likelihood of a second impact in the same location can be used to set repair priorities. There are constant advancements in roadside safety hardware. Some of the examples may not pertain to every model of proprietary equipment. Please use the information below when pertinent per the corresponding standards and installation manuals.

Repair priority scheme

<table>
<thead>
<tr>
<th>Priority Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>A second impact results in unacceptable safety performance including barrier penetration and/or vehicle rollover.</td>
</tr>
<tr>
<td>Medium</td>
<td>A second impact results in degraded but not unacceptable safety performance.</td>
</tr>
<tr>
<td>Low</td>
<td>A second impact results in no discernible difference in performance from an undamaged barrier.</td>
</tr>
</tbody>
</table>
### W-beam Barrier Repair Threshold

**Damage Mode:** Post and Rail Deflection

![Diagram of W-beam barrier showing deflection and damage length](image)

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

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High</strong></td>
<td>One or more of the following thresholds:</td>
</tr>
<tr>
<td></td>
<td>• More than 9 inches of lateral deflection anywhere over a 25 ft length of rail.</td>
</tr>
<tr>
<td></td>
<td>• Top of rail height 2 or more inches lower than original top of rail height.</td>
</tr>
<tr>
<td><strong>Medium</strong></td>
<td>6-9 inches lateral deflection anywhere over a 25 ft length of rail.</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>Less than 6 inches of lateral deflection over 25 ft length of rail.</td>
</tr>
</tbody>
</table>
### W-beam Barrier Repair Threshold

**Damage Mode:** Rail Deflection Only

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
</table>
| **Medium**        | 6-9 inches of lateral deflection between any two adjacent posts.  
                   | Note: For deflection over 9 inches, use post/rail deflection guidelines. |
| **Low**           | Less than 6 inches of lateral deflection between any two adjacent posts. |

### W-beam Barrier Repair Threshold

**Damage Mode:** Rail Flattening

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
</table>
| **Medium**        | One of more of the following thresholds:  
                   - Rail cross-section height, h, more than 17” (such as may occur if rail is flattened).  
                   - Rail cross-section height, h, less than 9” (such as a dent to top edge). |
| **Low**           | Rail cross-section height, h, between 9 and 17 inches. |
**W-beam Barrier Repair Threshold**

**Damage Mode:** Posts Separated from Rail

![Detached Posts](image)

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.

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medium</strong></td>
<td>One or more of the following thresholds:</td>
</tr>
<tr>
<td></td>
<td>• 2 or more posts with blockout attached with post-rail separation less than 3 inches.</td>
</tr>
<tr>
<td></td>
<td>• 1 or more post with post-rail separation which exceeds 3 inches.</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>1 post with blockout attached with post-rail separation less than 3 inches.</td>
</tr>
</tbody>
</table>
W-beam Barrier Repair Threshold

**Damage Mode:** Missing/Broken Posts

![Missing Post Image]

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>One or more posts:</td>
</tr>
<tr>
<td></td>
<td>• Missing</td>
</tr>
<tr>
<td></td>
<td>• Cracked across the grain</td>
</tr>
<tr>
<td></td>
<td>• Broken</td>
</tr>
<tr>
<td></td>
<td>• Rotten</td>
</tr>
<tr>
<td></td>
<td>• With metal tears</td>
</tr>
</tbody>
</table>

W-beam Barrier Repair Threshold

**Damage Mode:** Missing Blockout

![Missing Blockout Image]

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>Any blockouts</td>
</tr>
<tr>
<td></td>
<td>• Missing</td>
</tr>
<tr>
<td></td>
<td>• Cracked across the grain</td>
</tr>
<tr>
<td></td>
<td>• Cracked from top or bottom blockout through post bolt hole</td>
</tr>
<tr>
<td></td>
<td>• Rotted</td>
</tr>
</tbody>
</table>

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**W-beam Barrier Repair Threshold**

**Damage Mode:** Twisted Blockout

Any misaligned blockouts, top edge of block 6 inches or more from bottom edge.

Note: Repairs of twisted blockout are relatively quick and inexpensive.

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Any misaligned blockouts, top edge of block 6 inches or more from bottom edge. Note: Repairs of twisted blockout are relatively quick and inexpensive</td>
</tr>
</tbody>
</table>

**W-beam Barrier Repair Threshold**

**Damage Mode:** Non-Manufactured holes

(such as crash induced holes, lug-nut damage, or holes rusted-through the rail)

Height of non-manufactured hole
<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
</table>
| High              | One or more of the following thresholds:  
|                   | • More than 2 holes less than 1” in height in a 12.5’ length of rail.  
|                   | • Any holes greater than 1” height.  
|                   | • Any hole which intersects either the top or bottom edge of the rail.  |
| Medium            | 1-2 holes less than 1” in height in a 12.5’ length of rail.  |

**W-beam Barrier Repair Threshold**

**Damage Mode:** *Damage at Rail Splice*

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
</table>
| High              | More than 1 splice bolt:  
|                   | • Missing  
|                   | • Damaged  
|                   | • Visibly missing any underlying rail  
|                   | • Torn through rail  |
| Medium            | 1 splice bolt:”  
|                   | • Missing  
|                   | • Damaged  
|                   | • Visibly missing any underlying rail  
|                   | • Torn through rail  |
W-beam Barrier Repair Threshold

**Damage Mode:** *Vertical Tear*

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Any length vertical (transverse) tear</td>
</tr>
</tbody>
</table>

W-beam Barrier Repair Threshold

**Damage Mode:** *Horizontal Tear*

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>Horizontal (longitudinal) tears greater than 12 inches long or greater than 0.5 inches wide. Note: for horizontal tears less than 12 inches in length or less than 0.5 inches in height, use the non-manufactured holes guidelines.</td>
</tr>
</tbody>
</table>
### End Terminal Repair Threshold

**Damage Mode:** *Damage End Post*

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Not functional (sheared, rotted, cracked across the grain)</td>
</tr>
</tbody>
</table>

### End Terminal Repair Threshold

**Damage Mode:** *Anchor Cable*

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Missing</td>
</tr>
</tbody>
</table>
End Terminal Repair Threshold
Damage Mode: Anchor Cable

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>More than 1” of movement when pushed down by hand</td>
</tr>
</tbody>
</table>

End Terminal Repair Threshold
Damage Mode: Cable Anchor Bracket

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>Loose or not firmly seated in rail</td>
</tr>
</tbody>
</table>
End Terminal Repair Threshold
Damage Mode: *Stub Height*

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>Height which exceeds 4”</td>
</tr>
</tbody>
</table>

End Terminal Repair Threshold
Damage Mode: *Lag Screws (Energy Absorbing Terminals Only)*

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Missing or failed lag Screws</td>
</tr>
</tbody>
</table>
End Terminal Repair Threshold
Damage Mode: Bearing Plate

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>Loose or Misaligned</td>
</tr>
</tbody>
</table>

End Terminal Repair Threshold
Damage Mode: Bearing Plate

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Repair Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Missing Bearing Plate</td>
</tr>
</tbody>
</table>
Repair/Upgrade/Remove
When safety hardware has been damaged to the extent that it will not function properly if struck again, it should be repaired or replaced as soon as practical. The damaged area should be delineated with reflective cones, tubes, or barrels and a “Guardrail Damage Ahead” sign should be installed in the case of extreme damage.

Several questions should be answered before the hardware is restored to its pre-crash condition:

- Is the section of guardrail still required under current design standards?
- Can guardrail installation be avoided with the elimination of the hazard or the flattening of the slope?
- If it is determined that the guardrail is still necessary and more than approximately 25 percent or more of the installation requires replacement, the installation should be upgraded to current design standard.
- Was the terminal or crash cushion a currently acceptable design? If not, upgrade to current standard.

NOTE: repair priority should be given to hardware along curves or ramps or similar locations where subsequent hits are likely to occur.
Resources


Manual on Uniform Traffic Control Devices for Streets and Highways, 2009

AASHTO, Manual for Assessing Safety Hardware, 2009

FHWA Hardware Policy and Guidance
http://safety fhwa dot gov/roadway_dept/policy guide/road hard

FHWA Longitudinal Barriers
http://safety fhwa dot gov/roadway_dept/policy guide/road hard

AASHTO Task Force 13 website https://www.aashtotf13.org/

AASHTO Guide to Standardized Highway Barrier Hardware;

https://www.aashtotf13.org/Barrier-Hardware.php

NHTSA FARS web site: http://www-
fars.nhtsa.dot.gov/Main/index.aspx

Roadside Safety Pooled Fund sites:

MwRSF: http://mwrsf-qa.unl.edu/

TTI: http://www.roadsidepooledfund.org/

NCHRP Research Projects
http://www.trb.org/NCHRP/Public/NCHRPProjects.aspx

Bridge Rail Guide: http://guides.roadsafellc.com/

NCHRP Report 350: