Ohio Department of Transportation

Roadside Safety Field Guide

Guidelines for the Installation and Maintenance of Roadside Safety Hardware.

2013

U.S. Department of Transportation
Federal Highway Administration

STATE OF OHIO
DEPARTMENT OF TRANSPORTATION

THE OHIO ITAP CENTER
This guide was sponsored by the Federal Highway Administration (FHWA), under FHWA Contract DTFH61-10-D-00021, Roadside Safety Systems Installers and Designers Mentor Program.

The following individuals prepared or reviewed this document:

**Project Team**
William P. Longstreet - FHWA Safety Office COTM
Karen L. Boodlal - KLS Engineering, LLC
Richard D. Powers - KLS Engineering, LLC
John C. Durkos - KLS Engineering, LLC

**ODOT Representative**
Maria Ruppe - Contract Lead

The guide has been printed by the Ohio Local Technical Assistance Program (LTAP) Center. Additional copies available electronically on the Ohio LTAP website at [www.dot.state.oh.us/ltap](http://www.dot.state.oh.us/ltap)

October 23, 2013
# Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contents</td>
<td>ii</td>
</tr>
<tr>
<td>Acronyms</td>
<td>iv</td>
</tr>
<tr>
<td>Glossary</td>
<td>v</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Guardrail Basics</td>
<td>3</td>
</tr>
<tr>
<td>Barrier Guidelines</td>
<td>3</td>
</tr>
<tr>
<td>Establishing Barrier Guidelines</td>
<td>3</td>
</tr>
<tr>
<td>Considerations</td>
<td>4</td>
</tr>
<tr>
<td>Clear Zone</td>
<td>4</td>
</tr>
<tr>
<td>Design Options (In order of preference)</td>
<td>5</td>
</tr>
<tr>
<td>Roadside Obstacles</td>
<td>6</td>
</tr>
<tr>
<td>Roadside Slopes (Embankments)</td>
<td>7</td>
</tr>
<tr>
<td>Barriers</td>
<td>8</td>
</tr>
<tr>
<td>Additional Design Considerations</td>
<td>18</td>
</tr>
<tr>
<td>Design Deflection Distance</td>
<td>18</td>
</tr>
<tr>
<td>Height Measurement</td>
<td>19</td>
</tr>
<tr>
<td>Barrier Placement on Slopes</td>
<td>19</td>
</tr>
<tr>
<td>Guardrail and Curb</td>
<td>21</td>
</tr>
<tr>
<td>Guardrail and Trees</td>
<td>23</td>
</tr>
<tr>
<td>Connections to Bridge Barriers</td>
<td>23</td>
</tr>
<tr>
<td>Guardrail at Intersections and Driveways</td>
<td>26</td>
</tr>
<tr>
<td>Terminals and Crash Cushions</td>
<td>28</td>
</tr>
<tr>
<td>Terminals</td>
<td>28</td>
</tr>
<tr>
<td>Types of Terminals</td>
<td>29</td>
</tr>
</tbody>
</table>
Acronyms

AASHTO  American Association of State Highway and Transportation Officials
ADT  Average Daily Traffic
DOT  Department of Transportation
EMS  Emergency Medical Services
FHWA  Federal Highway Administration
\( L_R \)  Runout Length
LON  Length of Need
MUTCD  Manual on Uniform Traffic Control Devices
MASH  Manual for Assessing Safety Hardware
NCHRP  National Cooperative Highway Research Program
RDG  Roadside Design Guide
ROR  Run off Road
TCP  Traffic Control Plan
TL  Test Level
TTC  Temporary Traffic Control
TTCZ  Temporary Traffic Control Zone
WZ  Work Zone
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 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.

**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
Guardrail 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 ODOT Location and Design Manual, Standard Construction Drawings and Approved Proprietary Products 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 the guardrail system more hazardous than the condition being shielding?
2. Is an existing guardrail installation still warranted?
3. If the guardrail is installed as originally planned, is there a possibility of a motorist still reaching the hazard?
4. Can the guardrail be extended to shield a secondary obstruction?
5. Are there any vertical obstructions within the guardrail system’s design deflection?
6. Is the guardrail ending within 200 feet of the start of another guardrail run that could be connected?
7. Is the guardrail terminating within 200 feet of a cut slope?
8. Does the slope need any regrading?
9. Has the guardrail height been reset after an overlay?
10. Is the best end treatment for the site being used?
11. Is guardrail considered in sensitive areas such as school playgrounds and reservoirs?
12. Is there adequate soil support behind strong post guardrail 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 guardrail systems.
Part 1

Guardrail 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 4 and 5 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 guardrail since these sections are often less effective than no barrier at all.
- Avoid short gaps between guardrail installations by making guardrail 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 guardrail is not required due to the height of the slope.
- Consider guardrail 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>Design Speed (mph)</th>
<th>Design ADT</th>
<th>Foreslopes</th>
<th>Backslopes</th>
<th>Steeper than 1V:4H</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1V:6H or flatter</td>
<td>1V:6H to 1V:4H</td>
<td>1V:6H or flatter</td>
</tr>
<tr>
<td>≤40</td>
<td>&lt; 750</td>
<td>8 ft</td>
<td>8 ft</td>
<td>8 ft</td>
</tr>
<tr>
<td></td>
<td>750-1500</td>
<td>11</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>1500-6000</td>
<td>13</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>OVER 6000</td>
<td>15</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>45-50</td>
<td>&lt; 750</td>
<td>11</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>750-1500</td>
<td>13</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>1500-6000</td>
<td>17</td>
<td>23</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>OVER 6000</td>
<td>19</td>
<td>26</td>
<td>21</td>
</tr>
<tr>
<td>55</td>
<td>&lt; 750</td>
<td>13</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>750-1500</td>
<td>17</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>1500-6000</td>
<td>21</td>
<td>27</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>OVER 6000</td>
<td>23</td>
<td>29</td>
<td>23</td>
</tr>
<tr>
<td>60</td>
<td>&lt; 750</td>
<td>17</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>750-1500</td>
<td>22</td>
<td>29</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>1500-6000</td>
<td>28</td>
<td>36*</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>OVER 6000</td>
<td>31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>27</td>
</tr>
<tr>
<td>65-70&lt;sup&gt;d&lt;/sup&gt;</td>
<td>&lt; 750</td>
<td>19</td>
<td>23</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>750-1500</td>
<td>25</td>
<td>32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>1500-6000</td>
<td>30</td>
<td>38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>OVER 6000</td>
<td>32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>42&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28</td>
</tr>
</tbody>
</table>

See ODOT Location and Design Manual, Figure 600-1E, April 2013.

**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: Guardrail 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:

<table>
<thead>
<tr>
<th>Obstacle</th>
<th>Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>At Bridge ends, piers and abutments</td>
<td>Shielding should be generally considered.</td>
</tr>
<tr>
<td>Culverts, pipes and headwalls</td>
<td>Judgment decision based in size, shape and location of obstacle.</td>
</tr>
<tr>
<td>Sign/Luminaire supports</td>
<td>Shielding generally required for non-breakaway supports.</td>
</tr>
<tr>
<td>Rough slopes in cut sections</td>
<td>Shielding should be generally considered.</td>
</tr>
<tr>
<td>Utility poles</td>
<td>Shielding may be considered if utility pole cannot be justifiably relocated.</td>
</tr>
<tr>
<td>Bodies of water</td>
<td>Judgment decision based on location and depth of water (greater than 1 foot) and likelihood of encroachment.</td>
</tr>
<tr>
<td>Ditches (transverse)</td>
<td>Shielding generally required if likelihood of head-on impact is high.</td>
</tr>
<tr>
<td>Retaining Walls</td>
<td>Judgment decision based on relative smoothness of wall and anticipated maximum angle of impact is greater than 15 degrees.</td>
</tr>
</tbody>
</table>
Mechanically Stabilized Wall (MSE)  Shielding should be generally considered.

Noise Walls  Shielding should be generally considered

Ref: ODOT Location and Design Manual, Section 601.1, Roadside Barrier Warrants.

**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**

AASHTO Roadside Design Guide, 4th Edition, 2011, Figure 5-1(b), Pg 5-6.
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 New Jersey Safety-Shape Barrier was the most widely used safety shape concrete barrier prior to the introduction of the F-shape. As shown, the "break-point" between the 55 deg and 84 deg slope is 13 inches above the pavement, including the 3 inch vertical reveal. The flatter lower slope is intended to redirect vehicles impacting at shallow angles with little sheet metal damage, but can cause significant instability to vehicles impacting at high speeds and angles. TL-4: 32” Tall and TL-5: 42” Tall.

- The Single Sloped Barrier, developed in Texas, has a constant 10.8 degree slope and performs comparably to the New Jersey barrier.
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”

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

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”

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) are 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. Although some systems have been successfully tested with three cables, ODOT requires four-cable designs on all new median barrier installations.

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 3 are weaved around post. Cables are interweaved around 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.

Safence by Gregory Highway Products
http://www.gregorycorp.com/highway_safence.cfm

**Post:** C-Shaped post, can be driven or socketed

**Cable:** 3 or 4 cable combination. All cables are inserted in a slot at the center of the post and separated by plastic spacers.

**Typical Post Spacing:** 6.5 to 32.2 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 post.

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 the appropriate variables and using the formula on page 10 to calculate the LON (the “X” value) shown in the diagram below.

**Approach Barrier Layout**
\( X \) = Distance from the obstruction to end of barrier need.

\( Y \) = Distance from edge of through traveled way to end of barrier need.

\( L_A \) = Distance from edge of through traveled way to lateral extent of obstruction.

\( L_1 \) = Tangent length of barrier upstream from obstruction.

\( L_2 \) = Distance from edge of through traveled way to barrier.

\( L_3 \) = Distance from edge of through traveled way to obstruction.

\( L_C \) = Distance from edge of through traveled way to outside edge of the clear zone.

\( L_R \) = The theoretical Runout Length needed for a vehicle leaving the roadway to stop.

\( a : b \) = Flare Rate.

2011 AASHTO Roadside Design Guide, Figure 5-39, pg 5-49.
Length of Need Procedure:

1. Choose an appropriate $L_A$ as it is a 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 ($L_R$) from the table below.

3. The designer selects the tangent length, $(L_1)$, if the barrier is flared. If the installation is parallel to the roadway, $L_1 = 0$. If a semi rigid barrier is connected to a rigid barrier, the tangent length should be at least as long as the transition section.

4. If the barrier is flared away from the roadway, the maximum recommended flare rate shown on page 14 should not be exceeded.

5. Calculate the Length of Need ($X$) from the following equation and round the calculated value up to the nearest 12.5-foot or 25-foot rail segment:

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

6. For parallel installations i.e. no flare rate, the previous equation becomes:

$$X = \frac{L_A - L_2}{L_A / L_R}$$
### Runout Lengths

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Runout Length ($L_o$) Given Traffic Volume (ADT) (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Over 10,000</td>
</tr>
<tr>
<td>70</td>
<td>360</td>
</tr>
<tr>
<td>65</td>
<td>330</td>
</tr>
<tr>
<td>60</td>
<td>300</td>
</tr>
<tr>
<td>55</td>
<td>265</td>
</tr>
<tr>
<td>50</td>
<td>230</td>
</tr>
<tr>
<td>45</td>
<td>195</td>
</tr>
<tr>
<td>40</td>
<td>160</td>
</tr>
<tr>
<td>35</td>
<td>135</td>
</tr>
<tr>
<td>30</td>
<td>110</td>
</tr>
</tbody>
</table>

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

### Length of Need for Opposing Traffic

- $X$ is determined using the same equation.
- All lateral dimensions are measured from the centerline for a two-lane roadway. See the layout at the bottom of this page.
- There are three ranges of clear zone width, $L_C$, 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.

**Approach Barrier Layout for Opposing Traffic**

*2011 AASHTO Roadside Design Guide, Figure 5-42, pg 5-54.*
**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 from the Table on page 10. 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 impossible for a vehicle to reach the hazard from that point, 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, guardrail flare rates, 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 W-Beam Guardrail is 27 1/8”, 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.

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 W-beam guardrail on slopes steeper than 1V:6H.
- W-beam 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 systems 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.

- Cable barrier can be placed anywhere on a 1V:6H or flatter roadside slope, but that are 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.
Guardrail 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:

- Guardrail should not be used with curb installation on high speed (Design Speed of 50 mph and higher), rural roads.
- When guardrail/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 guardrail terminal should be limited to a 2 inch height.

If the curb exceeds 4 inches, follow these guidelines:

1. Strong post W-beam or Thrie-beam guardrail should be used.
2. Stiffen the guardrail
   - 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 guardrail.
4. The guardrail height is measured from the edge of travel lane to the top of rail when the guardrail is placed in front of or at the face of the curb.
5. When guardrail is placed behind the face of curb follow the recommendations shown in the table below (See 602.1.5 Guardrail with Curbs).
<table>
<thead>
<tr>
<th>Speed</th>
<th>Guardrail at Curb</th>
<th>Guardrail Behind Curb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 45 mph</td>
<td>Maximum of 6 in. sloping faced curb: MGS guardrail up to 6 in. behind curb.</td>
<td>No closer than 8 ft.</td>
</tr>
<tr>
<td>45 and 50 mph</td>
<td>Maximum of 6 in. sloping faced curb: MGS guardrail up to 6 in. behind curb.</td>
<td>No closer than 13 ft.</td>
</tr>
<tr>
<td>Over 50 mph</td>
<td>Maximum of 4 in. sloping faced curb: MGS guardrail up to 6 in. behind curb. Above 55 mph, the sloping face of the curb should be 3:1 or flatter and 4 in. or smaller.</td>
<td>Guardrail should not be located behind curb.</td>
</tr>
</tbody>
</table>

Ref: ODOT, Standard Construction Drawing, BP-5.1, 2013
Guardrail and Trees

- Generally guardrail 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 guardrail 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 Ohio 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 guardrail 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 guardrail 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 guardrail 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 then 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 guardrail and snag on the bottom edge of the bridge parapet.
Guardrail 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 W-beam guardrail 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 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 W-beam, modifications can be made to the posts, the W-beam-to-post connections, and the end treatment along the intersecting road or driveway. ODOT’s typical treatment at such locations is shown here.
See Figure 603-3 for treatment beyond approach.

PREFERRED MINIMUM APPROACH TREATMENT

Bridge Limits

25' 12.5'

Drive or Side Road Approach

Approach Limit

Edge of Traveled Way

Type T Anchor Assembly

Bridge Terminal Assembly
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. Ohio 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).

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

Flared Terminals (Type B): have up to 4-foot offset at the approach end, but require a larger platform for installation.

Tangent Terminals (Type E): are installed parallel to the roadway but may have a 2-foot offset over the first 50 feet of length.

NOTE:

- At the trailing end of guardrail, a distance of 50 feet beyond the end treatment is to be kept clear of all roadside obstructions (hazards) or the rail may be 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 end treatments on both the approach and trailing ends of the guardrail.

• 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 include those often used in Ohio.

For additional terminals go to the FHWA website at [http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/index.cfm](http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/index.cfm)

• TL-2 Terminals (acceptable on roadways with ≤ 45 mph Design Speed)

• Energy Absorbing Terminals

• Non-Energy Absorbing Terminals

**TL-2 Terminals**

**Modified Eccentric Loader Terminal (MELT) – Type B**

![Modified Eccentric Loader Terminal (MELT) – Type B](image)

**Test Level:** NCHRP 350: TL-2
Characteristics:
- Flared terminal – installed on a parabolic curve with a 4’ offset.
- No impact head.
- Uses standard w-beam rail elements.
- Strut between the steel tube foundation for the two end posts act together to resist cable loads.
- Comprised of wooden posts only.

NOTE: The non-crashworthy BCT has no ground strut and only two weakened posts.

Energy Absorbing Terminals
- Used for single runs of strong post guardrail
- Redirection begins beyond the third post

Extruder Terminal ET-2000 Plus – Type E


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”.

30
Sequential Kinking Terminal (SKT-350) – Type E

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 guardrail 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 W-beam rail with offset of 0’ to 2’-0”.

31
Flared Energy Absorbing Terminal (FLEAT) – Type B

http://roadsystems.com/fleat.htm

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

Characteristics:

- Flared terminal.
- Rectangular impact front face, with steel tube on top.
- Rail has 5 slots (1/2” x 4” long) on both the top and bottom corrugations of the w-beam section.
- There may be 3 additional (1/2”x4” long) slots in the valley of the rail which makes it interchangeable with the SKT system.
- Breakaway steel end posts #1 and #2, standard steel guardrail posts #3 and beyond.
- 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 W-beam rail with offset of 2’-6” to 4’-0”.

32
Non-Energy Absorbing Terminals

- Used for single runs of strong post w-beam guardrail.
- Redirection begins beyond the third post.

Slotted Rail Terminal (SRT-350) – Type B


Test Level: NCHRP 350: TL-3

Characteristics:

- Flared terminal.
- No impact head.
- Longitudinal slots on w-beam rail element.
- Strut and cable anchor bracket between posts #1 and #2 act together to resist the cable loads.
- Slot Guards on downstream end of slots.
- Steel and wood post options available.
- Parabolic flare on wood post option.
- Straight line flare on all SYTP steel post and HBA steel/wood post option.
- Should be installed at locations where sufficient runout area exists behind and downstream of the terminal.
- End of w-beam rail with offset of 4’-0”
- Wood post option has 3’-0” to 4’-0” offsets.
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 the Ohio Standard Construction Drawing MGS 5.2. shows minimum grading requirements for a flared terminal. Note that the areas approaching and immediately adjacent to the terminal should be no steeper than 1V:8H. Steeper adjoining slopes should be gently transitioned to a flatter slope to minimize rollover potential. Embankment 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.

**ODOT Crash Cushions Types**

**Type 1** – Redirective and gating

**Type 2** – Partially reusable, redirective and non-gating

**Type 3** – Low maintenance, self-restoring impact attenuators used at high frequency impacting areas.

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](http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/index.cfm)

**Permanent Impact Attenuators – ODOT Type 1**

**Brakemaster 350**

[Image of Brakemaster 350]


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

**How it works:** During head-on impacts, the system telescopes rearward, using friction technology to decelerate the vehicle.

**Locations:** Median protection.
Crash Cushion Attenuating Terminal (CAT-350)

[Image]


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

**How it works:** During head-on impacts, the system telescopes rearward, shearing out tabs between the slots to decelerate the vehicle.

**Locations:** Median protection.

FLEAT Median Terminal (FLEAT-MT)

[Image]

http://www.roadsystems.com/fleat-mt.html

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

**How it works:** During head-on impacts, the impact head translates down the rail kinking the rail to decelerate the vehicle.

**Locations:** Median protection.
Permanent or Work Zone Impact Attenuators – ODOT Type 2
QuadGuard Family

http://www.energyabsorption.com/products/products_quadguard2_crash.asp

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.

**Permanent or Work Zone Impact Attenuators – ODOT Type 3**

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)

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

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.
**Work Zone Impact Attenuators ONLY**

**Absorb 350**

![Absorb 350 Image](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**

![SLED Image](trafficdevices.com/cgi-local/SoftCart.exe/newproducts.htm?L+scstore+tsjv8007fff838f8+1364)

**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.
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)

[Image of Energite III Module (sand)]

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

Fitch Universal Module (sand)

[Image of Fitch Universal Module (sand)]

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

Big Sandy (sand)

[Image of Big Sandy (sand)]

Part 3

Maintenance

Guardrail 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 guardrail 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 guardrail 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.

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 with deflection measurement](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>
<tbody>
<tr>
<td>Medium</td>
<td>6-9 inches of lateral deflection between any two adjacent posts. Note: For deflection over 9 inches, use post/rail deflection guidelines.</td>
</tr>
<tr>
<td>Low</td>
<td>Less than 6 inches of lateral deflection between any two adjacent posts.</td>
</tr>
</tbody>
</table>

### 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

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>
</table>
| **Medium**        | One or more of the following thresholds:  
|                   | • 2 or more posts with blockout attached  
|                   |   with post-rail separation less than 3 inches.  
|                   | • 1 or more post with post-rail separation  
|                   |   which exceeds 3 inches. |
| **Low**           | 1 post with blockout attached with post-rail  
|                   |   separation less than 3 inches. |
**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><strong>High</strong></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><strong>Medium</strong></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>
### W-beam Barrier Repair Threshold

**Damage Mode:** Twisted Blockout

<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.</td>
</tr>
<tr>
<td></td>
<td>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)
### Relative Priority

<table>
<thead>
<tr>
<th>Repair 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.</td>
</tr>
<tr>
<td></td>
<td>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 a guardrail or terminal is damaged to the point where repairs are needed, several questions should be asked before the damaged hardware is simply replaced in-kind:

- Is the barrier warranted or could it be removed?
- Does the barrier meet current design standards or should it be upgraded?
- Is the terminal an acceptable crash-tested design? (NOTE: the Breakaway Cable Terminal (BCT) must be replaced; the Modified Eccentric Loader Terminal (MELT) is considered crashworthy only at speeds up to 45 mph).
- If crashworthy, is the terminal the most appropriate type for the location? (NOTE: Non-energy absorbing terminals require a significant traversable runout area behind and parallel to the rail; energy absorbing terminals require less runout distance for low-angle impacts).
- Turned-down terminals are not considered crashworthy.
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
ware/

FHWA Longitudinal Barriers
http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hard
ware/barriers/

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.roadsafelhc.com/

NCHRP Report 350:

Ohio Strategic Highway Safety Plan

ODOT Design Standards

ODOT Location and Design Manual
Ohio Local Technical Assistance Program (LTAP) Center

Ohio Department of Transportation
1980 W. Broad Street, MS 1240
Columbus, OH 43223

614-387-7359  ∞  1-877-800-0031

[Website Link]

email: ltap@dot.state.oh.us

Printed Fall 2013