NCHRP Report 350, released in 1993, was formally adopted by FHWA for the NHS.

This was the first time that FHWA adopted these Procedures.
# Test Level For Roadside Barriers

<table>
<thead>
<tr>
<th>NCHRP 350 Test Level For Barriers</th>
<th>Largest Vehicle Mass</th>
<th>Large Vehicle Impact Speed</th>
<th>Impact Angle for Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL-1</td>
<td>4400 lb.</td>
<td>31 mph</td>
<td>25 deg.</td>
</tr>
<tr>
<td>TL-2</td>
<td>4400 lb.</td>
<td>43 mph</td>
<td>25 deg.</td>
</tr>
<tr>
<td><strong>TL-3</strong></td>
<td><strong>4400 lb.</strong></td>
<td><strong>62 mph</strong></td>
<td><strong>25 deg.</strong></td>
</tr>
<tr>
<td>TL-4</td>
<td>17,650 lb</td>
<td>50 mph</td>
<td>15 deg.</td>
</tr>
<tr>
<td>TL-5 &amp; TL-6</td>
<td>79,400 lb</td>
<td>50 mph</td>
<td>15 deg.</td>
</tr>
</tbody>
</table>
NCHRP 350, TL 3 Small Car
Note deflection and rail separation from posts.
GUARDRAIL
Galvanized Steel Plate Beam Guardrail
Previous Standard – No Gutter

- Top of Rail: 27.50"
- Splice at Post
- Post Length: 6’-9”
- 6” Wood or Steel Blockout
- Aggregate Shoulders Special, Type C
Guardrail Height

An installation too low may allow a larger vehicle to climb or override the barrier.
Standard C1: Galvanized Steel Plate Beam Guardrail
Midwest Guardrail System with Gutter

- Top of Rail: 31”
- 6” Wood Blockout
- 3’ Aggregate Shoulders Special, Type C
- Splice Mid Span
- Post Length 6’-0”

Tollway Detail
Connecting to Existing Guardrail
Increasing Guardrail Height

This work shall consist of the complete removal and re-erection of existing steel plate beam guardrail and traffic barrier terminals.
# Guardrail – 3 Types

<table>
<thead>
<tr>
<th>Guardrail System</th>
<th>Post Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGS- 31” Type A</td>
<td>6’- 3”</td>
</tr>
<tr>
<td>MGS- 31” Type B</td>
<td>3’- 1 ½”</td>
</tr>
<tr>
<td>½-Post Spacing</td>
<td></td>
</tr>
<tr>
<td>MGS- 31” Type C</td>
<td>1’-6 ¾”</td>
</tr>
<tr>
<td>¼-Post Spacing</td>
<td></td>
</tr>
</tbody>
</table>
MGS W-Beam Rail (2 types)

Post Spacing Type A (6’-3”) and Type B (3’-1½”)

Post Spacing Type C (1’-6¾”)

12’-6” W-Beam Section, 12 gauge,
Since there is a considerable contribution to the redirection capability of the system from the strength of the strong posts, it is necessary to develop adequate soil support for the post to prevent it from pushing backwards too easily.
Galvanized Steel Plate Beam Guardrail

SECTION WITH GUTTER
Galvanized Steel Plate Beam Guardrail

SECTION WITHOUT GUTTER

SHOULDER POINT
AGGREGATE SHOULDERS SPECIAL, TYPE C
(SEE NOTE 4)

GROUND LINE

APPROVED FILL MATERIAL
AS REQUIRED

PAVED SHOULDER

24 1/8"

(SEE NOTE 3)

TOP OF RAIL

1:10 MAX.

1' 0"

3 1/4"

1' 0"

5 5/8"

SEE NOTE 10

1' 0"

4' 0"

EDGE OF SHOULDER

3' 1/4"

STREET POST
6' 0"

LONG

(SEE NOTE 10)

17
Galvanized Steel Plate Beam Guardrail

POST BOLT WITH STD. HEX NUT

W6×9 OR W6×8.5 STEEL POST

STEEL POST CONSTRUCTION

9’ POST IDENTIFICATION (STAMP BOTH SIDES)
Aggregate Shoulder Material

Aggregate Shoulders
Special, Type C

Aggregate Shoulders
Type B
Aggregate Shoulder Material

DO NOT MOUND AGGREGATE – Restricts Roadway Drainage
Galvanized Steel Plate Beam Guardrail

Shall Not Be Bolted Down
Galvanized Steel Plate Beam Guardrail

Shall Not Be Encased in Concrete
Galvanized Steel Plate Beam Guardrail

Shall Not Be Encased in Asphalt
Guardrail Post Leave-Outs
Guardrail Post Leave-Outs

- 18” x 24” Leave–Out
- Fill Leave-out with: CA6
- Cap Leave-out with: 4” CMA or CLSM

L=18”  W=24”  15”
Guardrail Post Leave-outs Video
Wood Block-Out

NOTE:
ALL HOLES 3/4" DIA.

WOOD BLOCK-OUT AND
STEEL POST DETAILS
Wood Block-Out

Two Piece Wood Block-Out Option
Wood Block Grading Rules

- Southern Pine Inspection Bureau
- West Coast Lumber Inspection Bureau
Wood Block Defect-Splits

A split is a separation of the wood through the piece to the opposite surface or to an adjoining surface due to the tearing apart of wood cells.

Splits are limited to 1/6 the block length (14”) = 2 1/4”.
Wood Block Defect - Split

Limited to 1/6 the block length(14”) = 2 1/4”
This split runs entire length of wood block-out.
Wood Block Defect-Shakes

Shakes are a lengthwise separation of the wood which occurs between or through the annual rings of growth.

Shakes are limited to 1/3 the thickness (6”) on end = 2”.
Wood Block Defect - Shakes

Ring Shake

Heart Shake
Wood Block Defect-Checks

Checks are a separation of the wood normally occurring across or through the rings of annual growth and usually as a result of seasoning. Checks are limited to the sum of $\frac{1}{2}$ the thickness (6") = 3".

Always measure perpendicular to the face of the block if check is on the 6-inch face, not the actual length of the crack.
Wood Block Defect - Check
Wood Block Defect-Knots

Knots are a portion of branch or limb that has become incorporated in a piece of lumber. Knots shall be measured as shown in Figure.

F- Measure least dimension.

G- Measure along corner or measure size most nearly representing diameter of branch causing the knot.

The sum of the sizes of all knots in any 6” length of piece must not exceed twice the size of the largest knot permitted.

<table>
<thead>
<tr>
<th>Nominal Width</th>
<th>Approximate Knot Size</th>
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<tbody>
<tr>
<td>6”</td>
<td>1-7/8”</td>
</tr>
<tr>
<td>12”</td>
<td>3-3/4”</td>
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</table>
Wood Block Defect - Knots

Knot

3¾” Max.
Wood Block Defect - Routed Edge
Standard D4: Delineators

Reflector Marker Type B
### Revised Permanent Delineation Spacing

<table>
<thead>
<tr>
<th></th>
<th>MAINLINE</th>
<th>RAMP</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>TANGENT</td>
<td>CURVE</td>
</tr>
<tr>
<td>* GUARDRAIL</td>
<td>100’</td>
<td>100’</td>
</tr>
<tr>
<td>* CONCRETE BARRIER (DOUBLE FACE)</td>
<td>100’</td>
<td>100’</td>
</tr>
<tr>
<td>* CONCRETE BARRIER (SINGLE FACE)</td>
<td>100’</td>
<td>100’</td>
</tr>
<tr>
<td>SHOULDER NARROWING</td>
<td>3 @ 15’</td>
<td>3 @ 15’</td>
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<tr>
<td>BRIDGE APPROACHES</td>
<td>3 @ 15’</td>
<td>3 @ 15’</td>
</tr>
<tr>
<td>* BRIDGE PARAPET</td>
<td>50’</td>
<td>50’</td>
</tr>
<tr>
<td>* NOISE ABATEMENT WALL (CRASH WORTHY)</td>
<td>100’</td>
<td>100’</td>
</tr>
<tr>
<td>POST MOUNTED DELINEATOR</td>
<td>200’</td>
<td>200’</td>
</tr>
<tr>
<td>POST MOUNTED DELINEATOR (RAMP TAPERS AND TANGENTS)</td>
<td>100’</td>
<td>100’</td>
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# New Temporary Delineation Spacing

<table>
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<tr>
<th>TEMPORARY DELINEATION SPACING</th>
<th>TANGENT</th>
<th>REVERSE CURVE</th>
<th>SHIFT</th>
<th>TAPER</th>
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<tbody>
<tr>
<td>TEMPORARY CONCRETE BARRIER</td>
<td>50’</td>
<td>25’</td>
<td>25’</td>
<td>25’</td>
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</tbody>
</table>

* When adjacent shoulder is used as a traveled lane, use spacing requirements as shown for temporary delineation.
Q: IDOT reflector Type A details the use of butterfly delineators (metal) that slip under the bolt on guardrail. Why are they not used on the Tollway?

A: This type delineator when connected at posts may imitate the behavior of the old steel washers and allow the rail to remain attached to the post and possibly become pulled down during impact events.
Barrier clearance distance is measured from back of post to face of obstacle.
Midwest Guardrail System Video
## Barrier Clearance Distance

<table>
<thead>
<tr>
<th>Guardrail System</th>
<th>Post Spacing</th>
<th>Desirable Barrier Clearance Distance</th>
<th>Minimum Barrier Clearance Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGS- 31” Type A</td>
<td>6’- 3”</td>
<td>42”</td>
<td>28”</td>
</tr>
<tr>
<td>MGS- 31” Type B</td>
<td>3’- 1 ½”</td>
<td>30”</td>
<td>23”</td>
</tr>
<tr>
<td>½ Post Spacing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MGS- 31” Type C</td>
<td>1-6 ¾”</td>
<td>24”</td>
<td>14”</td>
</tr>
<tr>
<td>¼ Post Spacing</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Minimum Barrier Clearance distances are only to be used for Existing Obstacles.
Galvanized Steel Plate Beam Guardrail
Galvanized Steel Plate Beam Guardrail

Transition to 1/4-post spacing
Storage Areas In Work Zones

- Materials or equipment when placed behind guardrail, shall be placed a minimum of 4 feet behind the guardrail posts.
Q: Guardrail crosses a drainage structure and post cannot be placed where required. Can additional block-outs be used to offset the post?

A: No; the Tollway does not allow additional block-outs.
Maximum Post Spacing
Q: Guardrail crosses a drainage structure and post cannot be driven. Should post be omitted or moved?

A: Post should not be omitted. All posts should be used.

MGS (31-inch rail height) single rail section has been successfully tested to span up to 9’- 4½”. 
Long-Span Test (Too Long)
Galvanized Steel Plate Beam Guardrail Drainage Structure Conflict

(0.5) x Normal Post Spacing

(1.5) x Normal Post Spacing

TYPE A GUARDRAIL–DRAINAGE STRUCTURE CONFLICT
ONE POST
Galvanized Steel Plate Beam Guardrail

Drainage Structure Conflict

(1.5) x Normal Post Spacing

(0.5) x Normal Post Spacing
Q: Would drilling a new hole in the Midwest Guardrail System (MGS) guardrail weaken the system?

A: FHWA does not recommend altering a conventional w-beam rail by drilling new holes to accommodate the MGS.

However, drilling may be permitted to accommodate the repositioning of posts at drainage structures when pre-punched spacing rail cannot be configured. The use of torching is not allowed.
Temporary Access To Work Area
Remove and Reinstall Existing Guardrail

- MOT Manual identifies conditions in which this operation is allowed.
Questions?

MGS
NON-PROPRIETARY TERMINALS
Non-Proprietary Traffic Barrier Terminals

- Each run of guardrail needs to be anchored on **each end** with a terminal.

- Tollway Standards – Traffic Barrier Terminals
  - Type T2
  - Type T5
  - Type T10
  - Type T6
  - Type T6B
Standard C7:
Traffic Barrier Terminal Type T2

Wood Posts in Steel Tubes (6’)
Bearing Plate K
Yoke and Channel Strut
Anchor Plate T with ¾” cable assembly

Typically utilized on the departing end of a steel plate beam guardrail system.

None of length counts toward length of need
Traffic Barrier Terminal Type T2 with Gutter
Traffic Barrier Terminal Type T2
Without Gutter
Traffic Barrier Terminal Type T2
Traffic Barrier Terminal Type T2

- Cable is tightened to a **taut condition; cannot lift up on the cable more** than 1 inch.
Traffic Barrier Terminal Type T2

Bearing Plate K
Proper Orientation
Traffic Barrier Terminal Type T2

Terminal location is dependent on offset distance to the obstacle.

- **Condition 1**  \((\geq 28\”, \leq 6’)\)
- **Condition 2**  \((>6’, <12’)\)
- **Condition 3**  \((\geq 12’)\)
Traffic Barrier Terminal Type T2
Condition 1
Traffic Barrier Terminal Type T2
Condition 2
Traffic Barrier Terminal Type T2 Condition 3
Traffic Barrier Terminal Type T2

Deficiencies?

Steel Foundation
Tubes Too High-
Potential Snag Point

Bearing Plate K Not
Correctly Orientated

No Aggregate Shoulder
Material
Standard C8: Traffic Barrier Terminal Type T5

Terminal is typically utilized to connect to the departing end of a NEW bridge.

14.67’ counts toward length of need
Traffic Barrier Terminal Type T5

42” Length (embedded 38”)

PLATE C PLACED BETWEEN PLATE E AND RAIL ELEMENT.

1” DIA. ANCHOR BOLT SEE NOTE 6

WHEN END OF PARAPET IS TAPERED USE TIMBER WEDGE IN BETWEEN PLATE C AND THE CONCRETE.

* POST BOLT WITH PLATE WASHER F PLACED UNDER HEAD AND NUT.

TYPE T5 - CONCRETE BRIDGE PARAPET
Traffic Barrier Terminal Type T5

Plate G is placed between Plate E and the Rail Element.
Traffic Barrier Terminal Type T5

Plate G was placed over the rail element.
Traffic Barrier Terminal Type T5

- Plate G was placed behind Plate E.
- Bolts were epoxied into concrete.
- Plate Washer D was not installed.
No Plate Washer D was installed. Standard Washer was used with nut set into Plate G end plate instead of rod.
Standard C11: Traffic Barrier Terminal Type T10

**Flared Wing**

**Tangent Wing**

Typically utilized to connect to the departing end of an existing concrete structure.

Zero counts toward length of need
Traffic Barrier Terminal Type T10

Mounting height and use of base plate is different than IDOT
Standard C9: Traffic Barrier Terminal Type T6

Typically utilized to attach to the upstream end of retaining walls and the bridge concrete parapet where gutter is installed.

43.15’ counts toward length of need
*Standard C9: Traffic Barrier Terminal Type T6*

Post spacing becomes closer as it nears the bridge parapet and the rail is stiffened by transitioning to a single then double section of thrie beam.
Traffic Barrier Terminal Type T6

Note that this is different than IDOT
Traffic Barrier Terminal Type T6

Alternate Detail

Individual Plates

PARAPET STEEL BEARING PLATE DETAIL

1" DIA. HOLES (TYP.)
Standard B3: Type G-3 Gutter Transition
Standard B3:
Type G-2 Gutter Transition
Gutter Transition at Terminal Type T6

Gutter profile transitions to match barrier wall face profile.

Gutter does not conflict with terminal posts.
Improper Gutter Transitions
Guardrail Block-outs

Use of multiple block-outs is not allowed.
Standard C10:
Traffic Terminal Barrier Type T6B

Typically utilized to attach at the upstream end of retaining walls and bridge concrete parapets where gutter does not exist

43.15’ counts toward length of need
Traffic Barrier Terminal Type T6B

*WITH STANDARD WASHERS, AFTER TIGHTENING, CUT THE ANCHOR BOLTS FLUSH WITH THE NUTS AND DAMAGE THE NUTS TO PREVENT THEM FROM LOOSENING. BOLTS SHALL BE ANCHORED INTO DRILLED HOLES USING A CHEMICAL ADHESIVE. MINIMUM EMBEDMENT 10".*
Type T6 installed instead of Type T6B
Vehicle Impact (Wheel Snag)
Questions?

Terminals:
T2, T5, T10, T6, T6B
PROPRIETARY TERMINALS
Standard C6: Traffic Barrier Terminal
Type T1 (Special)
Traffic Barrier Terminal Type T1 (Special)
GATING PORTION OF TERMINAL
Runoff Path

Area of Concern

NID
Runoff Path

FIGURE 5.24 Approach barrier layout variables
Traffic Barrier Terminal
Type T1 (Special)

Recovery Area 20' x 90'

37.5' counts toward length of need
NCHRP 350 Terminal Tests

Test 30

Test 31

Test 32

Test 33

Test 34

Test 35

Test 39

Illinois Tollway
Traffic Barrier Terminal
Type T1(Special)
Traffic Barrier Terminal
Type T1(Special)
Traffic Barrier Terminal Type T1(Special)-Anchor
Traffic Barrier Terminal
Type T1 (Special) without Gutter
Traffic Barrier Terminal
Type T1 (Special), w/ Gutter, Type G-3

Recovery Area 20’ x 90’
Trinity Highway Products

ET-31

Test Level 3
ET 31, Post 1 (Hinged Breakaway™)

BOTTOM POST

TOP POST

TOWARDS POST 2
ET 31, HBA Post 1

TOWARDS POST 2

3/4” DIA. X 2 ½” HEX HD BOLT W/WASHER AND LOCK WASHER UNDER HEX NUT

3/8” DIA. X 2” HEX HD BOLT W/WASHER AND LOCK WASHER UNDER HEX NUT

HIGH STRENGTH BOLTS
THE EARS ON THE HBA BOTTOM POSTS SHOULD NOT BE MORE THAN 4” ABOVE THE FINISHED GRADE.
ET 31, Post 2 (Steel Yielding Post)

4 Holes
ET 31, Posts 3-8 (Standard Line Posts)

SECTION "A-A"
(TYP @ POSTS #3 THRU #8)
ET 31, Installation of the Strut

PN 19258A BEARING PLATE  
PL 5/8 x 8” x 8”  

VIEW "K-K"
E.T. 31, Post 1

Do not bolt the rail to Post 1.
ET 31, Attaching the Extruders head
Extruder Head should be Parallel to the Guardrail – Not dipping down.
ET 31, Installation of Anchor Bracket
ET 31, Installation of Cable and Bearing Plate
SKT-SP-MGS

Assembly Instructions for
SKT-SP Tangent Terminal &
FLEAT-SP Flared Terminal

SP – Standard Post System Guardrail Terminals

ROAD SYSTEMS, INC.
P.O. Box 2163
Big Spring, Texas 79721
Phone: (432) 263-2435  FAX: (432) 267-4039

Technical Support & Marketing Phone: (330) 346-0721
Technical Support & Marketing Fax: (330) 346-0722

All RSI Installation Manuals can be downloaded from RSI web site
www.roadsystems.com

RSI
Road Systems, Inc.
Big Spring, TX 79721
Phone: (432) 263-2435  Fax: (432) 267-4039

SKT-SP-MGS Terminal
Midwest Guardrail System
31" Top of Rail

Illinois Tollway

120
SKT-SP-MGS

Standard steel guardrail posts at locations #3 and beyond.

- Hinged Post #1 & #2
- Special Slots in End Panel
- No Rail to Post Attachment at Post #1
- Impact Head
Be sure the 5/8" x 9" hex bolt at Hinged Post #1 is on the upstream side of the post.

The lower section post #1 should not be driven with the upper post attached.
SKT-SP-MGS Post 1

Post Cap

Soil Plate 1'-2" x 1'-8"

Lower Post #1 W6" x 15# Post
SKT-SP-MGS Post 1

Upper Post #1 6” x 6” x ⅛ Tube

Rectangular Openings Both Sides

Upper Post #1
SKT-SP-MGS Posts 1-2 (Hinged Post)

3/4" bolt at hinged post #2 on downstream side of the post

5/8" bolt at hinged post #1 on upstream side of the post
SKT-SP-MGS Post 2 (Hinged Post)

- 3/4" bolt at hinged post #2 on downstream side of the post (facing post #3)

- Open-ended slot on upstream side of the post (facing post #1)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
| E | Upper Post #2 W6"
| d | 5/8" x 1 1/4" Guardrail Splice Bolt
| f | 5/8" Washer
| g | 5/8" Nut
| h | 3/4" x 8 1/2" Hex Bolt
| j | 3/4" Nut

Illinois Tollway
SKT-SP-MGS Posts 3-8 (Standard Line Posts)
SKT-SP-MGS Cable Anchor Bracket

Bolted to Rail w/ Special Shoulder Bolts (8 places)
SKT-SP-MGS Anchor Bracket Shoulder Bolts

1/2” x 1-1/4” A325 STRUCTURAL BOLTS

W-BEAM RAIL

1/2” STRUCTURAL NUTS

1-1/16” O.D. x 9/16” I.D. STRUCTURAL WASHERS ON BOTH SIDES OF RAIL
PROPRIETARY TERMINALS (cont.)
Standard C12: Traffic Barrier Terminal Type T1-A

For Ramp Installation with Design Speed \( \leq 40 \text{ MPH} \)

20’ x 65’ Recovery Area
Traffic Barrier Terminal Type T1-A (Special) without Gutter

12.5’ counts toward length of need

20’ x 65’ Recovery Area
Traffic Barrier Terminal Type T1-A (Special) with Gutter, Type G-2

Type G-2 Modified Gutter

20’ x 65’ Recovery Area
Installation on Curve: Traffic Barrier Terminal Type T1 (Special)
Traffic Barrier Terminal Type T1-A (Special)

No curved W-beam sections are permitted within terminal limits
Trinity Highway Products

ET-31
Test Level 2
Road Systems, Inc.

SKT SP-MGS

Test Level 2
Questions?

Terminals:
T1 (Special), T1-A (Special)
ENERGY ATTENUATOR
QuadGuard HS-Energy Attenuator

The only crash cushion to be completely tested using NCHRP 350 criteria at 70 mph (113 km/h).

TABLE "A"

<table>
<thead>
<tr>
<th>SYSTEM WIDTH</th>
<th>&quot;A&quot; I.D. OF BARRELS</th>
<th>&quot;B&quot; BARRIER WALL</th>
<th>&quot;C&quot; PANE</th>
<th>TYPICAL BARRIER APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>60&quot;&lt;br&gt;1520&lt;br&gt;1520</td>
<td>505&lt;br&gt;550&lt;br&gt;1200</td>
<td>860&lt;br&gt;1000&lt;br&gt;3000</td>
<td>100</td>
<td>90%</td>
</tr>
<tr>
<td>72&quot;&lt;br&gt;1830&lt;br&gt;1830</td>
<td>790&lt;br&gt;860&lt;br&gt;3300</td>
<td>1060&lt;br&gt;1200&lt;br&gt;3600</td>
<td>100</td>
<td>90%</td>
</tr>
</tbody>
</table>

KEY

1. QuadGuard Cartridge
2. Normal
3. HS Diaphragm
4. Diaphragm
5. Noise Assembly
6. Tension Panel
7. Backup

TABLE

<table>
<thead>
<tr>
<th>MODEL</th>
<th>SYSTEM WIDTH</th>
<th>SYSTEM LENGTH</th>
<th>DIAPHRAGM&lt;br&gt;810 (24.2)&lt;br&gt;950 m (31.5)&lt;br&gt;950 m (31.5)</th>
<th>DIAPHRAGM&lt;br&gt;782 (20.0)&lt;br&gt;880 m (28.9)&lt;br&gt;880 m (28.9)</th>
<th>R diaphragm&lt;br&gt;810&lt;br&gt;950 m (31.5)&lt;br&gt;950 m (31.5)</th>
<th>R diaphragm&lt;br&gt;782&lt;br&gt;880 m (28.9)&lt;br&gt;880 m (28.9)</th>
<th>H diaphragm&lt;br&gt;810&lt;br&gt;950 m (31.5)&lt;br&gt;950 m (31.5)</th>
<th>H diaphragm&lt;br&gt;782&lt;br&gt;880 m (28.9)&lt;br&gt;880 m (28.9)</th>
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<tbody>
<tr>
<td>AGG</td>
<td>60&quot;&lt;br&gt;1520</td>
<td>60&quot;&lt;br&gt;1520</td>
<td>810 (24.2)&lt;br&gt;950 m (31.5)</td>
<td>782 (20.0)&lt;br&gt;880 m (28.9)</td>
<td>810&lt;br&gt;950 m (31.5)</td>
<td>782&lt;br&gt;880 m (28.9)</td>
<td>810&lt;br&gt;950 m (31.5)</td>
<td>782&lt;br&gt;880 m (28.9)</td>
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<tr>
<td>S</td>
<td>72&quot;&lt;br&gt;1830</td>
<td>72&quot;&lt;br&gt;1830</td>
<td>810 (24.2)&lt;br&gt;950 m (31.5)</td>
<td>782 (20.0)&lt;br&gt;880 m (28.9)</td>
<td>810&lt;br&gt;950 m (31.5)</td>
<td>782&lt;br&gt;880 m (28.9)</td>
<td>810&lt;br&gt;950 m (31.5)</td>
<td>782&lt;br&gt;880 m (28.9)</td>
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Revisions

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<tr>
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<tr>
<td>3/20/90</td>
<td>E</td>
<td>Added Item 6</td>
</tr>
<tr>
<td>6/6/90</td>
<td>F</td>
<td>Removed Item 6</td>
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Eagle Industries, Inc. Engineering and Research Department

QuadGuard® HS

Design Model RH0-1-14 photographic view.

Tension strut backup, 4" transition on left side.
QuadGuard HS-Energy Attenuator

9 Bay Unit
TL-3
70 MPH
QuadGuard HS-Energy Attenuator
QuadGuard – Concrete Pad

Pad shall be installed per manufacturer’s requirements

Site Considerations

• Cross Slope $\leq 8\%$

• Slope $\Delta$ front to back $\leq 2\%$

• Maximum curb height $\leq 2''$

• Cross slopes in front of unit
QuadGuard – Monorail

Every hole and slot in backup and monorail must have an MP-3 bolt anchoring it.
QuadGuard – Backup Assembly

**Concrete Backup**

**Tension Strut Backup**

![Diagram of Concrete Backup](image1)

![Diagram of Tension Strut Backup](image2)

**Figure 14**
Anchoring Backup Face Plate to Concrete Backup

**Figure 15**
Anchoring Tension Strut Backup to Foundation
QuadGuard – Quad-Beam Diaphragms

Figure 23
Diaphragm spacing

Figure 19
Monorail Guide Attachment
(Diaphragms 4 through 9)
QuadGuard – HS Diaphragms

Figure 23
Diaphragm spacing
QuadGuard – Fender Panel Assembly

Figure 25
Fender Panel Assembly
QuadGuard – Fender Panel Assembly

Figure 26a
Mushroom Washer Attachment

Figure 26b
Mushroom Washer Detail

Figure 27
Mushroom Washer Orientation
QuadGuard – Transition Panels

**Figure 5**
Quad-Beam to Safety Barrier Transition Panel

**Figure 6**
Quad-Beam to Thrie Transition Panel

**Figure 7**
Quad-Beam to W Transition Panel

**Figure 8**
Quad-Beam End Shoe Transition Panel
QuadGuard – Transition Panels

Transition Panel to Guardrail

Asymmetrical – connects to MGS
Symmetrical – connects to previous standard

Figure 7
Quad-Beam to W Transition Panel
Placing a cartridge in the first or second bays, or placing a cartridge in the wrong bay may result in unacceptable crash performance as described in NCHRP 350.
Questions?

Energy Attenuators: QuadGuard
MEDIAN PIER PROTECTION
Standard C2: Median Pier Protection

NOTES:
1. "MEDIAN PIER PROTECTION" MAY BE USED WHERE REQUIRED TO PROVIDE CORNER PROTECTION OF EXISTING PIER BEAMS.
2. "MEDIAN PIER PROTECTION" MAY BE USED WHERE REQUIRED TO PROVIDE CORNER PROTECTION OF EXISTING PIER BEAMS.
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PROFILE:

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ILinois Tollway

Sheet 2 of 3

155
Questions ?

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