CLEAR-ZONE / OBSTRUCTION-FREE-ZONE CONCEPT

The adequate roadside width for 80% of errant motorists to be able to regain control of their vehicles - applicable to new or reconstruction work area

1999 - Top 5 Fixed Objects Causes of Fatalities

- 1. Trees and shrubs 3350
- 2. Culverts / ditches 1480
- 3. Embankments 1270
- 4. Guardrail 1185
- 5. Utility poles 1070

CLEAR ZONE (CZ)

Clear-Zone widths for various Design Speeds, AADTs, Cut Slopes and Fill Slopes are shown in IDM Figure 49-2A.

- Figure values applicable to shoulder widths up to 12 feet
- Measured from edge of adjacent travel lane
- Where inadequate R/W width - R/W is CZ

CLEAR ZONE
CLEAR-ZONE ADJUSTMENTS

- Horizontal Curve Correction Factors – See IDM Figure 49-2B for curve radii up to 2860 feet
- Horizontal curve / CZ adjustment transition – See IDM Figure 49-2C
- Applies to each new construction / reconstruction, 3R / partial 4R project
- If unable to practically apply - requires Level Two Design Exception
- See IDM Figure 49-2D for CZ tangent to curve transition

CLEAR-ZONE WIDTHS (FEET)

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Design Year ADT &gt; 3,000</th>
<th>6:1 or Flatter</th>
<th>5:1 or Flatter</th>
<th>4:1 or Flatter</th>
<th>3:1 or Flatter</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 750</td>
<td>10 - 12</td>
<td>7 - 10</td>
<td>6 - 10</td>
<td>5 - 10</td>
<td>4 - 10</td>
</tr>
<tr>
<td>750 ≤ T &lt; 1500</td>
<td>10 - 12</td>
<td>7 - 10</td>
<td>6 - 10</td>
<td>5 - 10</td>
<td>4 - 10</td>
</tr>
<tr>
<td>1500 ≤ T &lt; 6000</td>
<td>10 - 12</td>
<td>7 - 10</td>
<td>6 - 10</td>
<td>5 - 10</td>
<td>4 - 10</td>
</tr>
<tr>
<td>T &gt; 6000</td>
<td>10 - 12</td>
<td>7 - 10</td>
<td>6 - 10</td>
<td>5 - 10</td>
<td>4 - 10</td>
</tr>
</tbody>
</table>

CLEAR-ZONE

- **Design Year ADT** - Total ADT on two-way roadway or Directional ADT on one-way roadway (ramp, or each roadway of divided highway)
- **CZ** - Constant as much as practical on a project or on adjacent project if parallel design time period
**CLEAR-ZONE ADJUSTMENTS**

- **Slope Averaging** - Flat to 4:1 slopes within CZ - See IDM Figure 49-2E
- Averaging starts at edge of shoulder
- Only applies to slopes in same direction - cannot average cut and fill slopes together
- Fill slope steeper than 4:1 non-recoverable - Provide clear runout area at bottom of slope - See IDM Figure 49-2F for example
**CLEAR-ZONE APPLICATIONS**

- New facility - Provide 6:1 fill slope adjacent to roadway in CZ - See IDM Figure 49-2G
- Reconstructed cut slope (traversable ditch) - check both cut and fill CZ widths - Use greatest
- Toe of backslope within 10 feet of shoulder edge (break) - Use backslope CZ
- Ditch not traversable - Reconstruct
- 2:1 backslope retained or provided - See IDM Figure 49-2H
CLEAR-ZONE APPLICATIONS

- Cut slope (new facility) - See IDM Figure 49-2G, and do not use 2:1 backslopes
- Auxiliary lane - Determine CZ for both ML and auxiliary lane, using ML design speed and respective ADTs - Use most extreme CZ - See IDM Figure 49-2I
- Ramp CZ - Determined as on ML - Design speed varies along a ramp

CLEAR-ZONE APPLICATIONS

- Rural or urban collector with design speed 30 MPH or less, or local road or street - CZ is 10 feet - Adjust for curves
- Urban road or street with vertical curbs - CZ is 10 feet or to R/W line, whichever is less

Desirable transverse slopes within the Clear Zone are shown in IDM Fig. 49-3A
APPURTENANCE-FREE AREA

- Area measured from face of curb or edge of travel lane, or if no curb, free of anything protruding above paved or earth surface
- Area is 20 inches wide except at signal support where it is 30 inches
- See IDM Figure 49-2K

PARKING LANES ON STREET

- Continuous (24 hr.) parking - No CZ required but provide appurtenance-free area
- Sometimes used as travel lane - CZ required as measured from right edge of parking lane
CLEAR-ZONE OBSTRUCTIONS

TREATMENT OF OBSTRUCTIONS
- Remove and Dispose
- Relocate Outside CZ
- Relocate within CZ for Safe Traversal
- Modify in Place for Safe Traversal
- Leave in Place and Make Breakaway
- Leave in Place and Shield with Barrier
- Leave in Place and Delineate

TYPES OF OBSTRUCTIONS
- Body of Water 2 ft or deeper
- Boulder
- Bridge-Cone Slope, 2:1 or steeper
- Bridge Pier
- Bridge-Railing End
- Culvert End without acceptable end treatment (point where culvert top protrudes from sideslope is within CZ)

- Concrete Headwall on culvert
- Ditch or Sideslope Steeper than 4:1
- Mailbox Support (wood post greater than 4 x 4 square or 4.5 in. dia., or steel pipe 1.5 to 2 in. dia.)
- Non-Breakaway Sign or Lighting Support
- Retaining Wall End
- Rough Rock Cut
TYPES OF OBSTRUCTIONS

- Rutted or Eroded sideslope
- Steel Pipe or Sign Post with inside diameter greater than 2 in.
- Tree
- Utility Pole
- Wood Post, cross-sectional area greater than 23 in.$^2$

SIDE-DITCH TREATMENT

- Use IDM Fig. 49-3B, 49-3C, or 49-3D, depending on ditch-bottom width, to determine if Foreslope-Backslope combination is CZ-Desirable, Acceptable, or Undesirable.

TYPES OF OBSTRUCTIONS

- Sideslope at edge of shoulder steeper than 1:1 and higher than 2 feet
- Driveway or Public Road Approach, ditch check, or median crossover transverse slopes steeper than shown in IDM Figure 49-3A
**PREFERRED DITCH CROSS SECTIONS**

- **Slant-lined area** - Cross section which can be traversed by vehicle with unrestrained occupants
- **Crosshatched area** - Cross section which can be traversed by vehicle with restrained occupants
- **Light unlined area** - Cross section undesirable for traversing by vehicles in general (minor encroachment into area permissible)

**Embankment slopes steeper than 4:1, especially 3:1 or steeper** - Severely limit range of backslopes available for safe traversing of ditch (may result in vehicle rollover if soft or rutted embankment)
**SIDE-DITCH TREATMENT**

- If Foreslope-Backslope combination is in the Undesirable Area of the appropriate Figure, treat the ditch as follows:

**Undesirable Side-Ditch Slopes in CZ**

**ADDITIONAL R/W IS AVAILABLE**

- Flatten one or both ditch side slopes to bring into Desirable or Acceptable Area
- Move ditch bottom outside of CZ

**OBSTRUCTION-FREE ZONE**

Definition - Roadside area next to travelway free from hazards and obstructions.

*Not the same as CZ.*
Obstruction-Free Zone

- Obstruction-Free Zone widths for various Functional Classifications, Design Speeds, and AADTs are shown in proposed new IDM Figure 55-5A(1).

APPURTENANCE-FREE AREA IN OBSTRUCTION-FREE ZONE

- Same as for CZ - See IDM Figure 55-5A

<table>
<thead>
<tr>
<th>FUNCTIONAL CLASSIFICATION</th>
<th>SHOULDER OR CURBS</th>
<th>DESIGN SPEED (MPH)</th>
<th>DESIGN YEAR AADT</th>
<th>OBSTRUCTION-FREE ZONE EXTENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTERSIAL SHOULDER</td>
<td>2-55</td>
<td>2-1500</td>
<td>&lt; 50</td>
<td>10 FT from edge of travel lane, or R/W width, whichever is less</td>
</tr>
<tr>
<td>COLLECTOR SHOULDER</td>
<td>2-55</td>
<td>1500</td>
<td>&lt; 50</td>
<td>10 FT from edge of usable shoulder, or R/W width, whichever is less</td>
</tr>
<tr>
<td>LOCAL ROAD OR STREET</td>
<td>ANY</td>
<td>ANY</td>
<td>ANY</td>
<td>6 FT from edge of usable shoulder, or R/W width, whichever is less</td>
</tr>
<tr>
<td>ANY</td>
<td>CURB, 2 IN. HEIGHT</td>
<td>&lt; 50</td>
<td>ANY</td>
<td>2 FT back of front face of curb</td>
</tr>
<tr>
<td>ANY</td>
<td>CURB, &lt; 5 IN. HEIGHT</td>
<td>ANY</td>
<td>ANY</td>
<td>SAME AS FOR SHOULDERS</td>
</tr>
<tr>
<td>ANY</td>
<td>CURB, ANY HEIGHT</td>
<td>ANY</td>
<td>ANY</td>
<td>SAME AS FOR SHOULDERS</td>
</tr>
<tr>
<td>ANY</td>
<td>CURB, ANY HEIGHT, NEAR TRAFFIC</td>
<td>ANY</td>
<td>ANY</td>
<td>2.5 FT back of front face of curb</td>
</tr>
</tbody>
</table>

APPURTENANCE-FREE ZONE

Proposed New IDM Figure 55-5A(1)
**OBSTRUCTION-FREE ZONE**

- **ON-STREET PARKING AREAS** - Similar treatment as with CZ
- **OBSTRUCTIONS** - None rising more than 4 inches above ground or surrounding surface unless made breakaway or shielded

**SHIELING OBSTRUCTION**

- Similar treatment as with CZ obstacle treatment
- Remove or redesign
- Relocate outside OFZ
- Make breakaway
- Shield
- Delineate

**CONSIDERATIONS**
- Lateral Placement
- Longitudinal Extent, or Length of Need
- Extent of Barrier Deflection
- Type of Barrier
ROADSIDE BARRIER
LATERAL PLACEMENT

Desirable Lateral Placement

- **New Construction or AADT > 100,000:**
  - Front Face of barrier is 2 ft outside paved-shoulder width

- **Reconstruction:**
  - Front Face of barrier is 1 ft outside paved-shoulder width

Lateral Placement

- **CONSIDERATIONS**
  - Clearance between obstruction and barrier
  - Desirable shoulder width
  - Probability of vehicle impact on barrier
  - Terrain effects on errant vehicle’s impact
  - Barrier flare rate

BARRIER DEFLECTION
**Barrier Length of Need**

- **In Advance of Obstruction for Adjacent Traffic**
- **Graphical Determination, Tangent Section or Inside Horizontal Curve**
- **Graphical Determination, Outside Horizontal Curve**
- **Mathematical Determination, Tangent Section Only**

**Barrier Length of Need (LoN)**

\[ \text{LoN} = L_{\text{ADV}} + L_{\text{OBS}} + L_{\text{OPP}} \]

Where:

- \(L_{\text{ADV}}\) is LoN in advance of obstruction
- \(L_{\text{OBS}}\) is the obstruction length
- \(L_{\text{OPP}}\) is the trailing-end length or the length needed to protect opposite-direction traffic

<table>
<thead>
<tr>
<th>TEST LEVEL</th>
<th>TYPE OF RAIL</th>
<th>CRASH TEST</th>
<th>MAXIMUM DYNAMIC DEFLECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL-2</td>
<td>GUARDRAIL, 10' BEAM, 0-0' POST SPACING</td>
<td>2</td>
<td>2'-3&quot;</td>
</tr>
<tr>
<td>TL-2</td>
<td>GUARDRAIL, 10' BEAM, 3-11' POST SPACING</td>
<td>2</td>
<td>2'-0&quot;</td>
</tr>
<tr>
<td>TL-2</td>
<td>GUARDRAIL, 10' BEAM, 1-6&quot; POST SPACING</td>
<td>2</td>
<td>1'-4&quot;</td>
</tr>
<tr>
<td>TL-2</td>
<td>GUARDRAIL, NESTED OVER LONFILL CULVERT</td>
<td>1</td>
<td>2'-6&quot;</td>
</tr>
<tr>
<td>TL-2</td>
<td>WIRE-ROPE BARRIER, 10'-4&quot; POST SPACING</td>
<td>2</td>
<td>10'-0&quot;</td>
</tr>
<tr>
<td>TL-2</td>
<td>GUARDRAIL, TYPE B, 12'-6&quot; POST SPACING</td>
<td>1</td>
<td>8'-0&quot;</td>
</tr>
<tr>
<td>TL-2</td>
<td>GUARDRAIL, TYPE B, 3'-1&quot; POST SPACING</td>
<td>1</td>
<td>6'-0&quot;</td>
</tr>
<tr>
<td>TL-1</td>
<td>GUARDRAIL, TYPE B, 1'-11&quot; POST SPACING</td>
<td>1</td>
<td>3'-11&quot;</td>
</tr>
<tr>
<td>TL-3</td>
<td>GUARDRAIL, TYPE B, 1'-6&quot; POST SPACING</td>
<td>1</td>
<td>2'-6&quot;</td>
</tr>
<tr>
<td>TL-3</td>
<td>GUARDRAIL, TYPE B, 3'-6&quot; POST SPACING</td>
<td>2</td>
<td>2'-6&quot;</td>
</tr>
<tr>
<td>TL-4</td>
<td>WIRE-ROPE BARRIER, 10'-4&quot; POST SPACING</td>
<td>3</td>
<td>10'-0&quot;</td>
</tr>
<tr>
<td>TL-4</td>
<td>CONCRETE BARRIER, SHAPE 1, 2'-6&quot; HEIGHT</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>TL-4</td>
<td>CONCRETE BARRIER, SHAPE 1, 2'-6&quot; HEIGHT</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

**BARRIER TYPES AND DEFLECTIONS**

Proposed Revision of IWH Figure 48-5A
**Barrier Length Of Need EXAMPLE**

**LoN EXAMPLE**

- **Lateral Placement**
  
  *Since this is new construction, the front face of the barrier is 2 ft outside the edge of the paved shoulder.*

  \[
  \text{10-ft Paved Shld. + 2-ft Offset} = FF \text{ at 12 ft outside of travel lane edge}
  \]

**Length-of-Need Example**

- **New Construction**
- **Two-Lane, Two-Way Route**
- **Design Speed: 60 mph**
- **AADT = 7000**
- **Right-Side Shoulder Width: 10 ft**
- **High-Fill-Area Sideslope of 2.5:1**
- **Tangent Alignment in Level Terrain**

**LoN Determination**

- **Determine CZ width from IDM Figure 49-2A, Clear-Zone Distances (ft), New Construction / Reconstruction**
LoN Determination

- From IDM Fig. 49-2A, Clear-Zone Width, Line CP = 30 ft from edge of travel lane, based on relatively flat (6:1) slope beyond foreslope.

LoN Determination

- Determine Runout Length, L_{BR}, from IDM Figure 49-5F, Design Elements for Barrier Length of Need.
<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Runout Length $L_R$ (ft)</th>
<th>Slip Line Offset $L_s$ (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>120</td>
<td>366, 146</td>
</tr>
<tr>
<td>40</td>
<td>240</td>
<td>180, 155</td>
</tr>
<tr>
<td>50</td>
<td>360</td>
<td>120, 200</td>
</tr>
<tr>
<td>60</td>
<td>480</td>
<td>60, 250</td>
</tr>
</tbody>
</table>

**From IDM Fig. 49-5F, Runout Length $L_R$, Line PR = 340 ft.**

**Determine Starting Point of Barrier, F, from IDM Fig. 49-4F, Barrier Warrant for Embankments (60 mph)**
Interpolation between the 6000 and 12,000 AADT lines yields Fill Height of 8.3 ft.

The longitudinal point where this occurs corresponds to where the transverse distance from the shoulder break line to the toe of slope is 

\[(2.5)(8.3) = 20.8 \text{ FT.}\]

At Point F, where fill is 8.3 ft high, scale the \( L_R \) distance of 340 ft along Line PR.
Draw a line, along the face of the barrier from Point F to where it crosses Hypotenuse CR, at Point N.

This line, FN, is the Length of Need required to shield traffic from the fill height.
LoN, the length of Line $FN$, can be calculated by proportioning as follows:

$$\frac{CF \ [18 \text{ ft}]}{CP \ [30 \text{ ft}]} = \frac{FN}{PR \ [340 \text{ ft}]}$$

$FN$, or LoN, therefore is 264 ft.
TYPES OF ROADSIDE BARRIERS

Roadside barrier types are based on National Cooperative Highway Research Program Report 350 (NCHRP 350) Test Levels

### Passage of an NCHRP 350 Crash Test

- **This consists of a given device’s ability to contain and redirect the test vehicle.**
- **The vehicle has remained upright throughout the test.**
- **After impact and stopping, the vehicle is pointing in its original direction in its original traffic lane.**

<table>
<thead>
<tr>
<th>Test Level</th>
<th>Test Vehicle</th>
<th>Impact Speed (mph)</th>
<th>Test Angle (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL-2</td>
<td>4000-lb Pickup Truck</td>
<td>44</td>
<td>25</td>
</tr>
<tr>
<td>TL-3</td>
<td>4000-lb Pickup Truck</td>
<td>62</td>
<td>25</td>
</tr>
<tr>
<td>TL-4</td>
<td>17,000-lb Single-Axle Truck</td>
<td>50</td>
<td>15</td>
</tr>
<tr>
<td>TL-5</td>
<td>80,000-lb Tandem and Tri-Axle Truck</td>
<td>60</td>
<td>15</td>
</tr>
</tbody>
</table>

NCHRP 350 TEST LEVEL CRASH TEST CRITERIA

Proposed New ISHR Figure 49-4A
**TL-3 BARRIERS**

- **W-Beam Guardrail, 6’-3” Posts Spacing**
  Used where clearance between front guardrail face and obstruction is 3 ft or greater.

- **W-Beam Guardrail, 1’-6¾” Posts Spacing**
  Used where clearance between front guardrail face and obstruction is at least 1.25 ft but less than 2 ft.

- **W-Beam Guardrail, 3’-1½” Posts Spacing**
  Used where clearance between front guardrail face and obstruction is at least 2 ft but less than 3 ft.

- **Nested W-Beam Guardrail, any of the non-nested post spacings just indicated**
  Used at a large drainage structure where too little cover atop such structure precludes driving guardrail posts.
**TL-3 BARRIERS**

- **Double-Faced W-Beam Guardrail, 6’-3” Posts Spacing**
  Used on a divided roadway as a median-side bridge-approach guardrail to one of the bridge structures in a set of twins.

- **Wire-Rope Safety Barrier**
  Used where the clearance between the barrier and the obstruction is at least 10 ft.
  
  THIS IS NOT YET AN INDOT-APPROVED SYSTEM. IT IS BEING USED ONLY IN SELECTED EXPERIMENTAL LOCATIONS.

**TL-4 BARRIERS**

- **Thrie-Beam Guardrail, 6’-3” Posts Spacing**
  New Facility: available deflection distance of at least 3 ft, on tangent or on horizontal curve of radius of 1435 ft or greater, such that:
  - Barrier is warranted; and
  - Design-year AADT ≥ 100,000.

- **Thrie-Beam Guardrail, 6’-3” Posts Spacing**
  New Facility: available deflection distance of at least 3 ft, on horizontal curve of radius of less than 1435 ft, such that:
  - Barrier is warranted;
  - Design speed 50 mph or higher; and
  - Design-year AADT ≥ 10,000.
TL-4 BARRIERS

- **Thrie-Beam Guardrail, 6’-3”**
  - **Posts Spacing**
    - 4R or 3R Work: available
      - deflection distance of at least 3 ft, on tangent or on horizontal curve of radius of 1435 ft or greater

- **Thrie-Beam Guardrail, 6’-3”**
  - **Posts Spacing**
    - 4R or 3R Work: available
      - deflection distance of at least 3 ft, on horizontal curve of radius of less than 1435 ft.

- **Thrie-Beam Guardrail, 6’-3”**
  - **Posts Spacing**
    - 4R or 3R Work: available
      - Barrier is in place, but must be moved transversely to accommodate lanes or shoulders widened, or horizontal curves improved, to 3R standards, and barrier is still warranted; and Design-year AADT ≥ 100,000.

- **Thrie-Beam Guardrail, 6’-3”**
  - **Posts Spacing**
    - 4R or 3R Work: available
      - Barrier is in place, but must be moved transversely to accommodate lanes or shoulders widened, or horizontal curves improved, to 3R standards, and barrier is still warranted; and Design speed 50 mph or higher; and Design-year AADT ≥ 10,000.
**TL-4 BARRIERS**
- **Thrie-Beam Guardrail, 6’-3” Posts Spacing**
  - Partial 3R Work:
    - Guardrail currently in place;
    - Guardrail still warranted; and
    - A guardrail run has been damaged, or gets impacted, on average, 2 or more times per year.

**TL-5 BARRIER**
- **Concrete Shape F, 3’-9” Truck Height**

**The only TL-5 Barrier is**
- **Concrete, Shape F, 3’-9” Truck Height**

**TL-4 BARRIERS**
- **Concrete Shape F, 2’-9” Common Height**
  - Zero deflection distance available.
  - Most typical use is on an urban freeway where a barrier is warranted.

**TL-5 BARRIER**
- Radius of less than 1435 ft
- Undercrossing route, or parallel route below within 120 ft of overhead travel lane, has design-year AADT ≥ 7500
- An errant truck would violate a TL-3 or TL-4 device, and reach the undercrossing or lower parallel route
GUARDRAIL END TREATMENTS (GRETs)

TL-3 GRETs
- **Type OS – Outside Shoulder**
- Dissipates energy when hit head-on.
- Can redirect errant vehicle on one side only.
- Used with single-faced guardrail.
- Proprietary device.

Guardrail End Treatments

**TL-3 TREATMENTS**
- Design speed for Test Level 3 is 60 mph. Test Level 3 is acceptable for a wide range of high-speed highways.
GUARDRAIL END TREATMENT TYPE OS SKT-350

1. IMPACT HEAD
2. GROUND STRUT
3. CABLE ANCHOR
4. CABLE ANCHOR BRACKET
5. FOUNDATION TUBE SLEEVE
6. TIMBER POST & BLOCK
7. W-BEAM RAIL

GRET Type OS

- A 37’-6” portion of the downstream end can function as guardrail. It may be applied to the guardrail’s length-of-need requirement.

TL-3 GRETs

- **Type MS – Median Shoulder**
- Dissipates energy when hit head-on.
- Can redirect errant vehicle on two sides.
- Used with double-faced guardrail.
- Proprietary device.
**GUARDRAIL END TREATMENT TYPE MS**
CAT-350

---

**TL-3 GRETs**

- Type OS or MS proprietary devices are chosen by the contractor from the Department's Approved List of Guardrail End Treatments

---

**GUARDRAIL END TREATMENT TYPE MS**
FLEAT-MT 350

---

**APPROVED MATERIALS LIST**
GUARDRAIL END TREATMENTS

<table>
<thead>
<tr>
<th>TYPE OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROAD SYSTEMS, INC.</td>
</tr>
<tr>
<td>SKT-350, Wood Posts with All Foundation Tubes</td>
</tr>
<tr>
<td>SKT-350, Plug Weld Steel Posts with All Foundation Tubes</td>
</tr>
<tr>
<td>SKT-350, Hinged Steel Posts</td>
</tr>
<tr>
<td>TRINITY INDUSTRIES, INC.</td>
</tr>
<tr>
<td>ET-PLUS, Wood Posts with All Foundation Tubes</td>
</tr>
<tr>
<td>ET-PLUS, Steel Yielding Terminal Posts with All Foundation Tubes</td>
</tr>
<tr>
<td>ET-PLUS, Hinged Steel Posts</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TYPE MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROAD SYSTEMS, INC.</td>
</tr>
<tr>
<td>FLEAT-MT, with All Foundation Tubes</td>
</tr>
<tr>
<td>TRINITY INDUSTRIES, INC.</td>
</tr>
<tr>
<td>CAT-350, with All Foundation Tubes</td>
</tr>
</tbody>
</table>
GRET Type MS
- A 12’-6” portion of the downstream end can function as guardrail. It may be applied to the guardrail’s length-of-need requirement.

Non-NCHRP-350 GRET
- Type I
  - Used only on a local-agency route, or a local agency’s approach to an INDOT route.
  - Local-agency-route AADT ≤ 400.
  - No federal participation in funding.
  - Not proprietary.

TL-3 GRETs
- Type II
  - Functions like GRET Type OS
  - Used where cut slopes or backslopes above the roadway grade are encountered.
  - Can redirect errant vehicle on one side only.
  - Approach foreslope must be 4:1 or flatter.
  - Not proprietary.

IMPACT ATTENUATORS
Impact Attenuators

- All Impact Attenuators are NCHRP 350 Test Level 1, Test Level 2, or Test Level 3 devices, and are all proprietary.
- Design speed for Test Level 1 is 30 mph or lower.
- Design speed for Test Level 2 is 45 mph or lower.
- Design speed for Test Level 3 is 60 mph. Test Level 3 is acceptable for a wide range of high-speed highways.

IMPACT ATTENUATORS

Impact attenuators are used to shield barriers under the following conditions:
- For the terminal end of a concrete median barrier, an impact attenuator R1 or R2 is typically used.
- If truck-height barrier does not connect to the common-height concrete barrier, the ends must be tapered down to the common-height concrete barrier and terminated with an appropriate impact attenuator.
- At the end of truck-height concrete bridge railing.
- Pier located on median side on multi-lane divided roadway with single or twin overhead structures.
- Space limitations for barrier transition length plus guardrail end treatment length, where the barrier end must be shielded.

TYPES OF IMPACT ATTENUATORS

Type ED

- ED stands for Energy Dissipation. This is a non-redirective energy dissipation device. It consists of a number of gravel-filled modules that are installed in a specific geometric array in front of a hazard. As the impacting vehicle passes through the array, its speed is slowed by transfer of its momentum to the gravel, allowing for controlled safe, steady deceleration.
Type R1

- R1 stands for Redirective on 1 side. This is an energy dissipator with redirective capability on only one side.

Type R2

- R2 stands for Redirective on 2 sides. This is an energy dissipator with redirective capability on two sides.
Type CR

- CR stands for Clearance Restriction. It is an energy dissipator with directive capability on two sides. It is used where lateral clearance restrictions make installation and maintenance difficult.
**Type CR**

Type CR stands for **vertical Sight Distance limitation.** It is an energy dissipator with redirective capability on two sides. It is used at an intersection where sight distance would be limited if a taller attenuator were used.

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**Type LS**

**LS** stands for **Low Speed energy dissipation device.** It has redirective capability on two sides, and shall be used in accordance with TL-1 criteria only. Type LS should be selected for a design speed of 30 mph or lower.

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**Type SD**

**SD** stands for vertical **Sight Distance limitation.** It is an energy dissipator with redirective capability on two sides. It is used at an intersection where sight distance would be limited if a taller attenuator were used.

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**Impact Attenuators**

- Since these are proprietary devices, they are chosen by the contractor from the Department's Approved List of Impact Attenuators.
Attenuator Width

- **Available Standard Widths**

  - **W1:** Obstruction ≤ 3 ft wide.
  - **W2:** 3 ft < Obstruction Width ≤ 6 ft.
  - **W3:** 6 ft < Obstruction Width ≤ 8 ft.

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**Attenuator Width**

- The attenuator width is based on the obstruction width.

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**Attenuator Width**

- Type ED is available as W1 only.
- Type R1 or R2 should be used if W2 or W3 is required.
- Type LS is available as W1 only.
- Type R2 or CR should be used if W2 or W3 is required.
Attenuator Width

- **If W3 is not sufficient,**
- attenuator with > 8 ft width must be designed and constructed;
- obstruction width must be altered to accommodate W3; or
- obstruction must be removed.