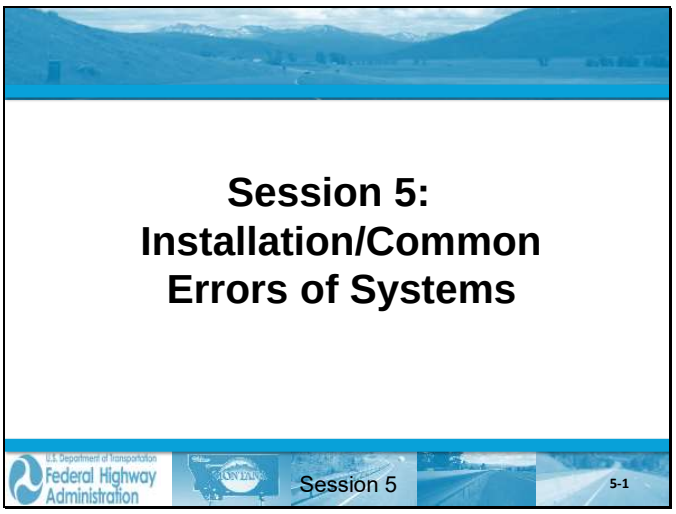
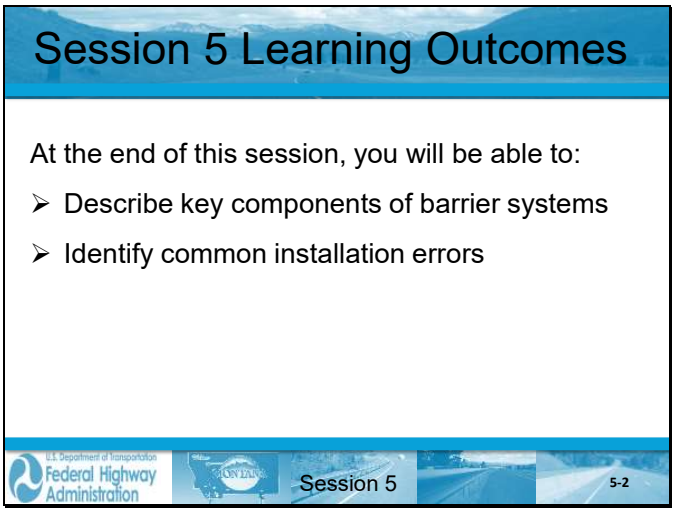
Session 5: Installation/Common Errors of System


Session 5:
Installation/Common
Errors of Systems
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-1


Session 5 Learning Outcomes
At the end of this session, you will be able to:
Describe key components of barrier systems
Identify common installation errors
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-2

Barrier Components

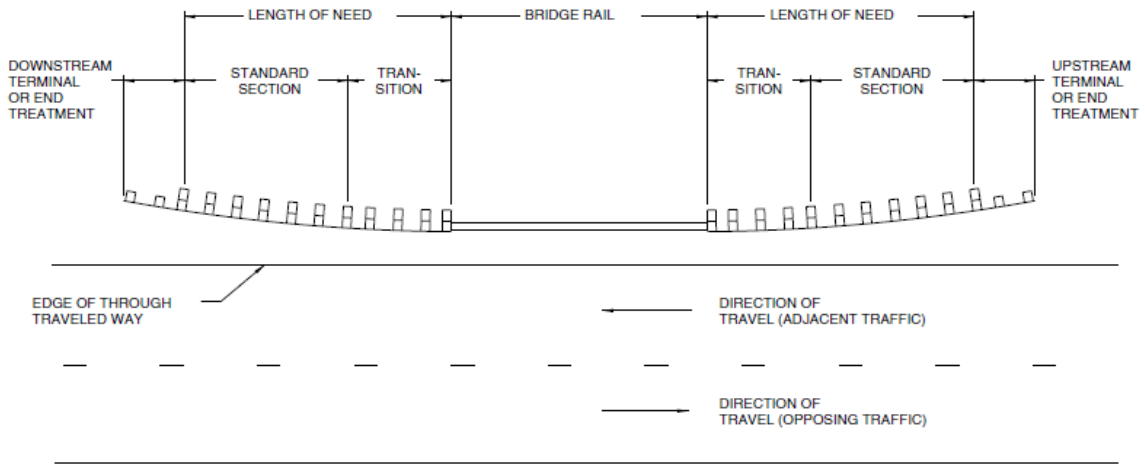


Figure 5-4. Definition of Roadside Barriers

REF: AASHTO Roadside Design Guide, 4th Edition, Figure 5-4

U.S. Department of Transportation Federal Highway Administration

Session 5

5-3

Key Components of Barrier Systems

1. Standard Run of Barrier
2. Transition to a Stiffer System
3. Terminal
4. Crash Cushion

U.S. Department of Transportation Federal Highway Administration

Session 5

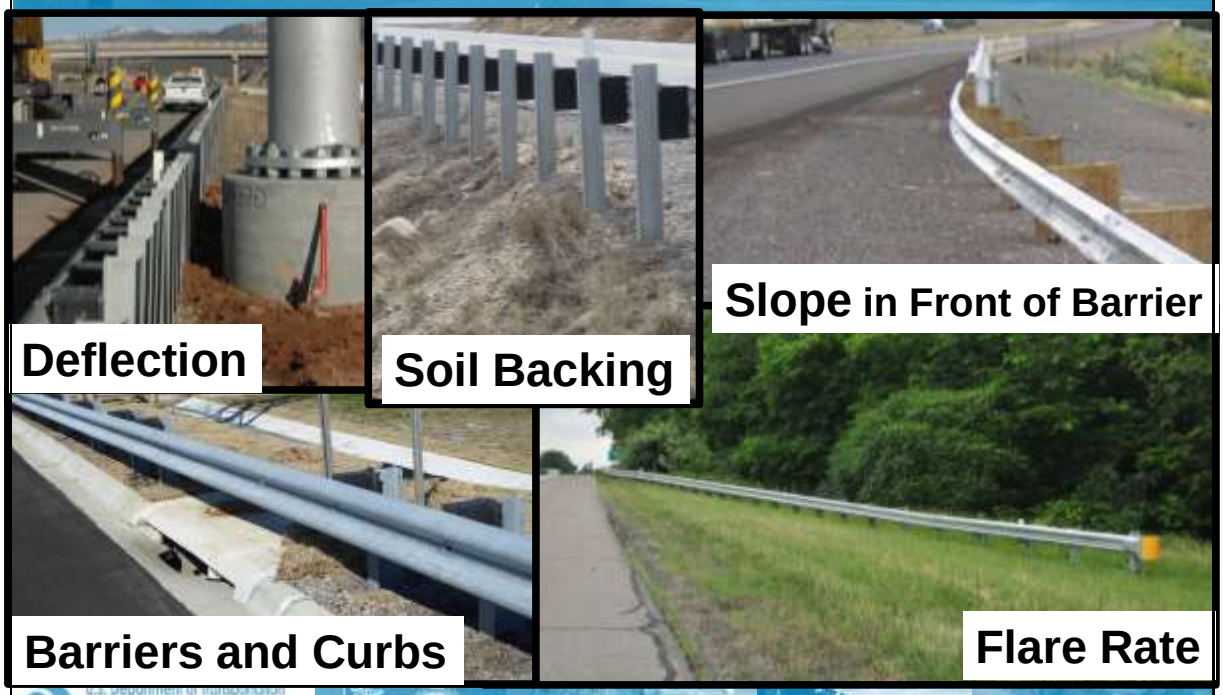
5-4

1. Standard Run of Barrier

a. Barrier Design Principles
b. Height Measurement
c. Tension Continuity
d. Other Considerations
e. Work Zone Barriers

Federal Highway Administration | Session 5 | 5-5

a. Barrier Design Principles

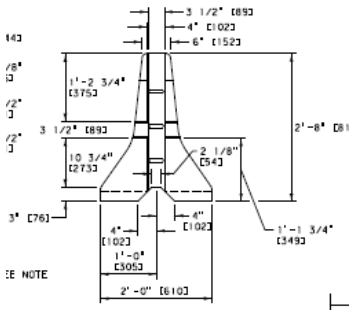


Federal Highway Administration | Session 5 | 5-6

b. Height Measurement

- Concrete Barrier

  Single Face or Median Barrier - 32”



U.S. Department of Transportation Federal Highway Administration

Session 5

5-7

b. Height Measurement

- High Tension Cable Barrier
  - Typically dictated by manufacturer; meet manufacturer & agency standard

Many different configurations – even within a single manufacture’s systems

U.S. Department of Transportation Federal Highway Administration

Session 5

5-8

b. Height Measurement

- High Tension Cable Barrier
  - Since MDT requires foundations, insure top is at proper height. This will effect the height of the cable.

Unacceptable

Unacceptable

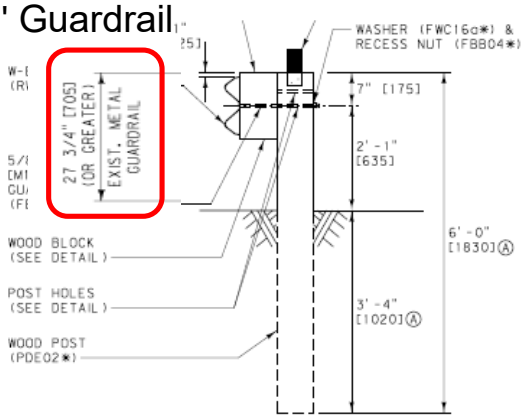
Federal Highway Administration

Session 5

5-9

b. Height Measurement

- "Old" Guardrail



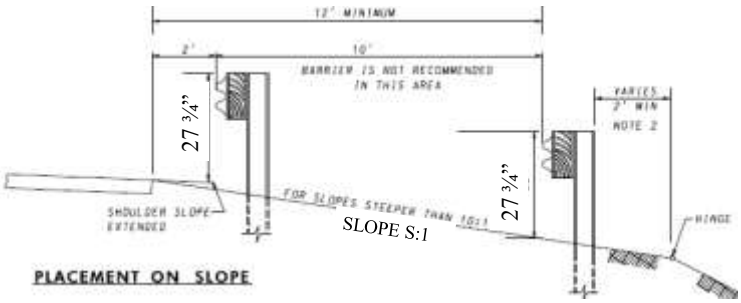
Federal Highway Administration

Session 5

5-10

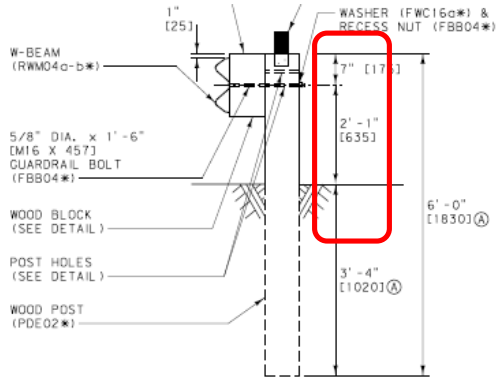
b. Height Measurement – Alternative **ONLY** "Old", "350" Guardrail

- Guardrail w/slope 6≤S<10:1



b. Height Measurement

- MGS W-Beam



b. Height Measurement

Rail too high

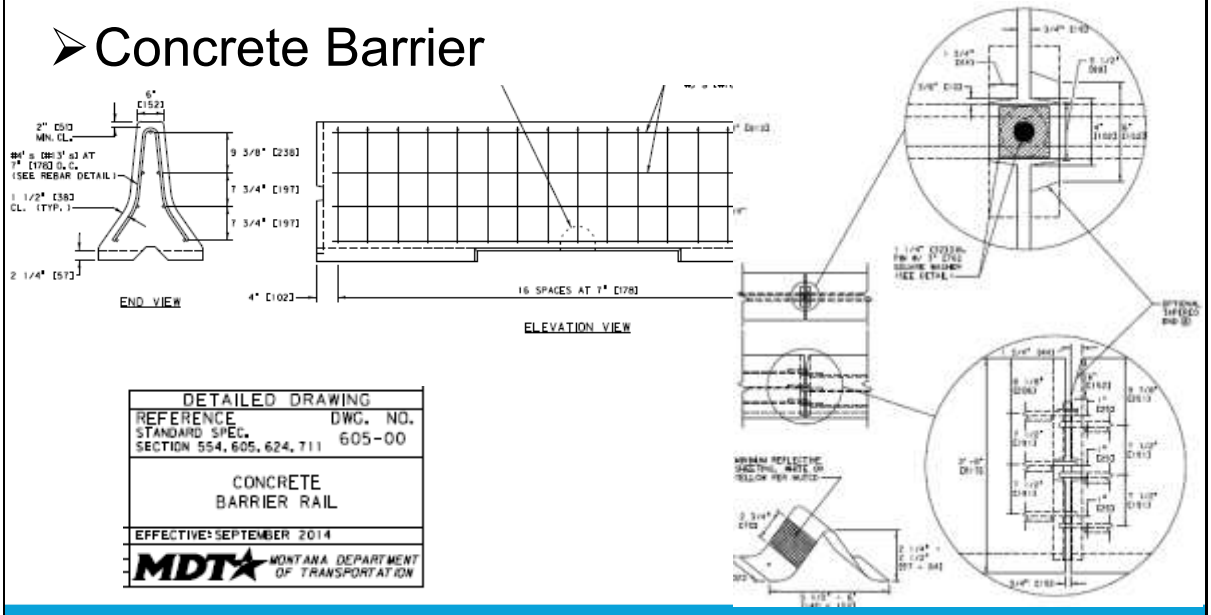
Rail too low

c. Tension Continuity

- Concrete Barrier
  - Continuous reinforcement and/or anchored to/in the pavement
- High Tension Cable
  - Proprietary systems typically use a type of turn buckle between successive cables and end terminal anchors.
- W-Beam
  - Splices with 8 bolts tying panels together, and some type of end anchor or structural tie to a rigid object/bridge rail (transition)

c. Tension Continuity

- Concrete Barrier

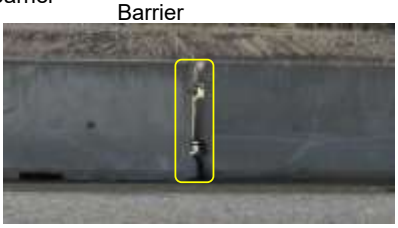


c. Tension Continuity

Cast In Place Concrete Barrier

Horizontal bars maintain continuity for cast in place barrier

Precast Concrete Barrier



Missing connection pin
NO TENSION

MUST MAINTAIN TENSION IN BARRIER SYSTEM

U.S. Department of Transportation Federal Highway Administration

Session 5

5-17

c. Tension Continuity

- W-Beam
  - Left: 8 bolts tying panels together
  - Right: structural connection to a rigid barrier

U.S. Department of Transportation Federal Highway Administration

Session 5

5-18

c. Tension Continuity

Missing bolts

No Structural connection

U.S. Department of Transportation Federal Highway Administration

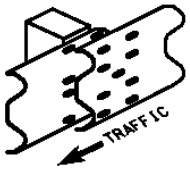
Session 5

5-19

d. Other Considerations

➢ Lapping

- For one-way traffic, all guardrail panels should be lapped in the direction of traffic with the upstream panel lapping the downstream panel including terminal elements and end sections. (Some exceptions, i.e. CAT)
- For two-way traffic always mount guardrail going with adjacent traffic, meaning rail laps will be opposite on each side of the road.



SPLICE LAP DETAIL

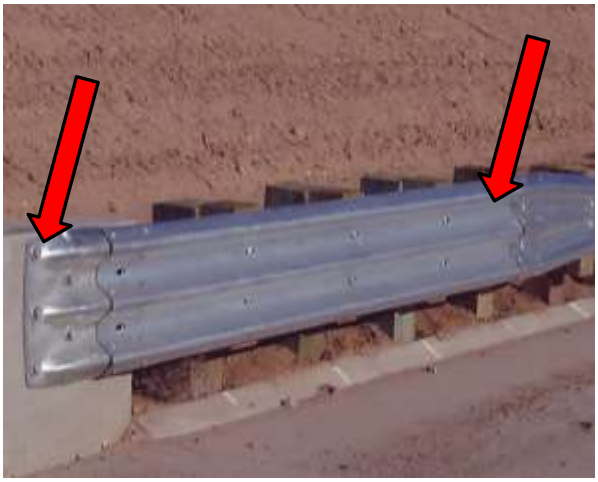
U.S. Department of Transportation Federal Highway Administration

Session 5

5-20

d. Other Considerations

Incorrectly Lapped



Correctly Lapped

U.S. Department of Transportation Federal Highway Administration

Session 5

5-21

d. Other Considerations

NO WASHERS

Federal Highway Administration

Session 5

5-22

d. Other Considerations

Use of delineators under rail to post bolts is discouraged as it can inhibit bolt pull through

Current MDT standard
EXCELLENT

Manufacturers of working head terminals generally prohibit delineators within their systems

d. Other Considerations

MDT standard application

d. Other Considerations

Above and beyond

U.S. Department of Transportation Federal Highway Administration

Session 5

5-25

d. Other Considerations

Drilling of holes into the rail for post bolt is NOT generally recommended

OPTION – Bolt only block to post, NOT through rail.
Probably OK for two posts, maybe even three.

U.S. Department of Transportation Federal Highway Administration

Session 5

5-26

d. Other Considerations

Cutting a slot, hole or a rail section with a torch is NOT PERMISSIBLE

Using a torch on the rail element may compromise the strength of the rail.

Tests results have shown this becomes a weak point in the rail and can cause ripping and rupturing.

Federal Highway Administration Session 5 5-27

e. Barriers in Work Zones

Barrier should be in GOOD condition

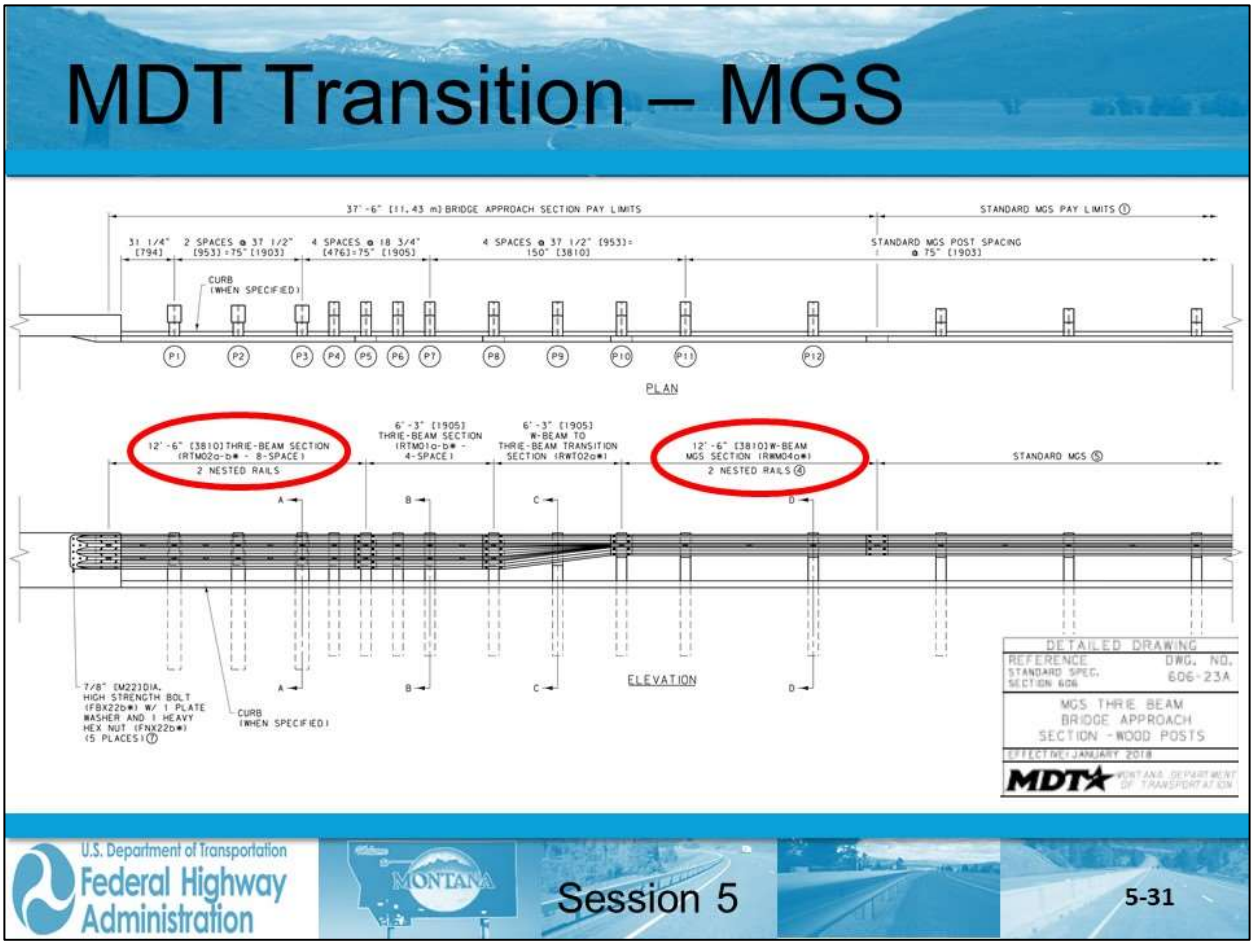
Federal Highway Administration Session 5 5-28

e. Barriers in Work Zones

Flare rate is too excessive here

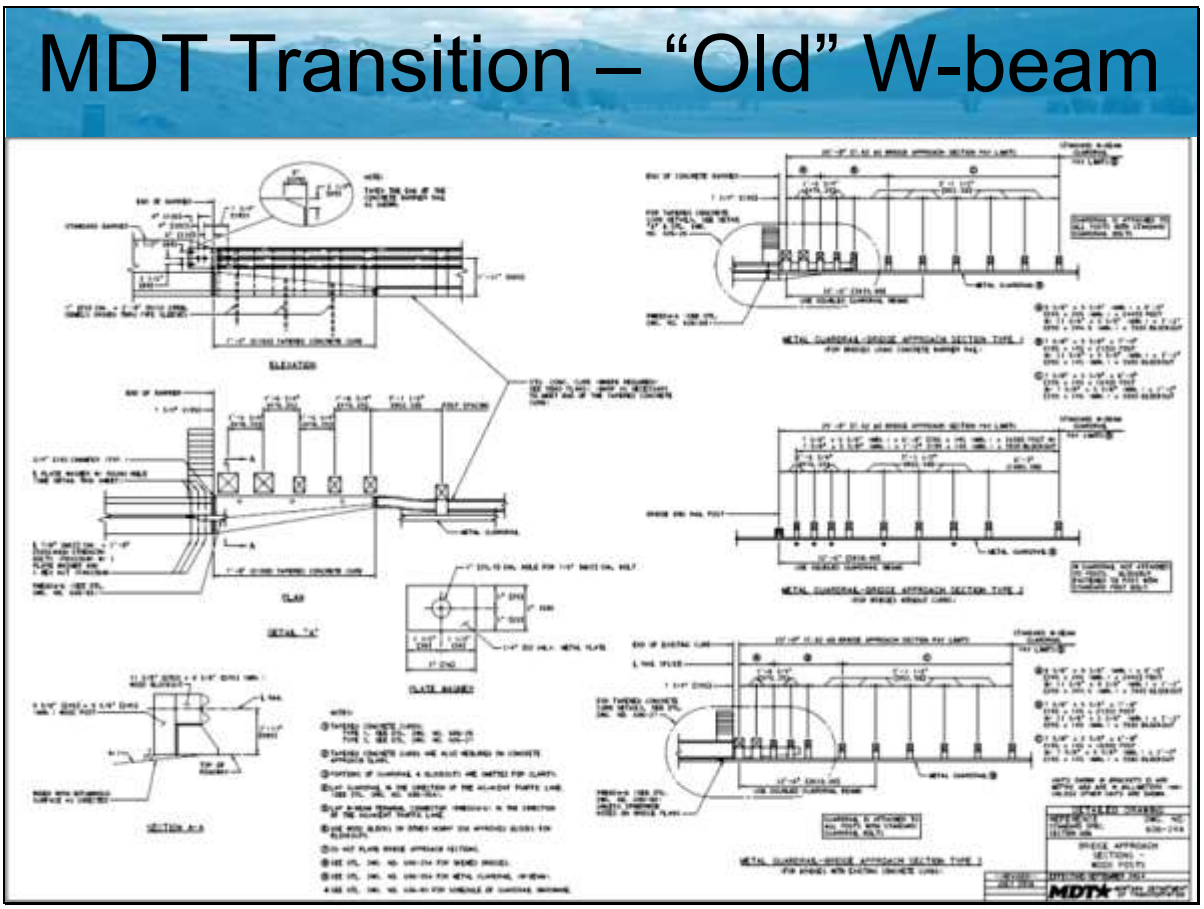
2. Transition to a Stiffer System

- When a softer (more flexible) barrier precedes a stiffer barrier, a gradual stiffening must occur between the two systems to prevent pocketing.
- An effective transition must provide the following:
  - Adequate connection (TENSION continuity)
  - Adequate length to gradually increase stiffness.


MDT Transition – MGS
PLAN
ELEVATION
DETAILED DRAWING
MGS THRIE BEAM BRIDGE APPROACH SECTION - WOOD POSTS
U.S. Department of Transportation
Federal Highway Administration
MONTANA
Session 5
5-31

_____

_____


MDT Transition – “Old” W-beam

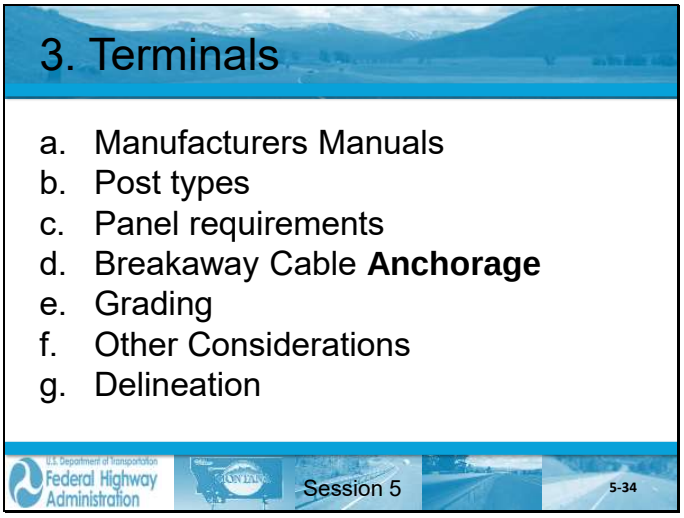
_____

_____


Is there a problem here???
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-33

_____

_____


3. Terminals
a. Manufacturers Manuals
b. Post types
c. Panel requirements
d. Breakaway Cable **Anchorage**
e. Grading
f. Other Considerations
g. Delineation
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-34

_____

_____

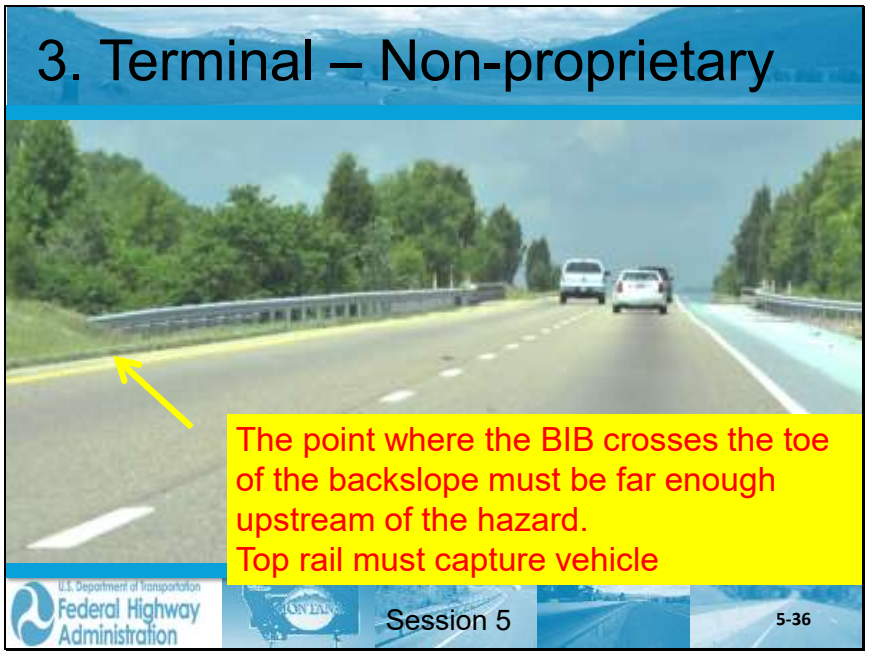
_____

_____

_____

_____


3. Terminal – Non-proprietary
Although the Buried-in-backslope (BIB) is the preferred (and best) terminal, it can be constructed incorrectly
Federal Highway Administration
Session 5
5-35


3. Terminal – Non-proprietary
The point where the BIB crosses the toe of the backslope must be far enough upstream of the hazard.
Top rail must capture vehicle
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-36

3. Terminal - Proprietary

RULE #1: Follow manufacturers instructions and standard plans.

3. Terminal - Proprietary

a. Manufacturers Manuals

Must follow manufacturer's installation instructions and State standards.

These are all readily available online

Example of installation manuals

3. Terminal - Proprietary

TAKE ADVANTAGE OF MANUFACTURER TRAINING FOR DETAILED INSTRUCTION ON INSTALLING ANY OF THE PROPRIETARY END TREATMENTS

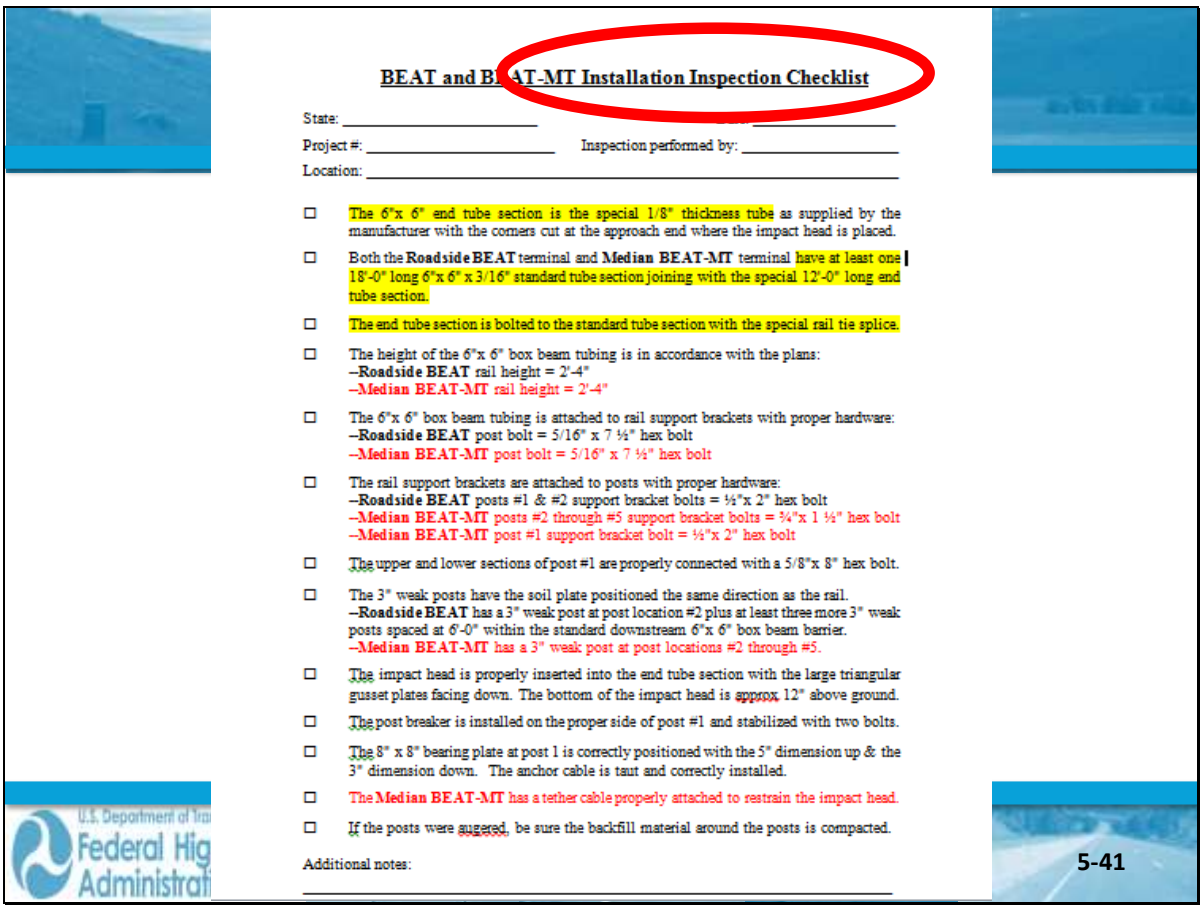
Federal Highway Administration | Session 5 | 5-39

INSTALLING THE RAIL PANEL TO THE POST WITHOUT OFFSET BLOCK AT POST 2

Complete the following steps to attach the rail panel to the post without offset block at **Post 2**:

Step	Actions
1.	Select the Option A, Option B, or Option C to install the rail panel without offset block at **Post 2**:
Option A For Wood Post	1. Insert a $^5/_8$" (16 mm) diameter x 10" (255 mm) HGR Post Bolt (PN-3500G) through the rail and the wood post at **location 2**. 2. Place a $^5/_8$" (16 mm) Round Washer (PN-3300G) under a $^5/_8$" (16 mm) HGR Nut (PN-3340G) on the inserted bolt. Tighten the bolts. (There is no torque requirement for these bolts.)
Option B For SYTP™	1. Insert a $^5/_8$" (16 mm) diameter x $1^1/_4$" (31 mm) HGR Blot (PN-3360G) through the rail panel and the hole in the SYTP™. **Note:** For SYTP stubs, use the hole in the SYTP™ that will place the rail at the correct height. (If there are two (2) sets of holes in the SYTP™ stub for attaching the rail.) 2. Place a $^5/_8$" (16 mm) Round Washer (PN-3300G) under a $^5/_8$" (16 mm) HGR Nut (PN-3340G) on the inserted bolt.
Option C For HBA™ Post	1. Do NOT bolt the rail panel to the HBA™ post at **location 2**. **WARNING:** Do NOT bolt the rail to the HBA™ post at **location 2**. Failure to follow this warning could result in serious injury or death in the event of a collision.

U.S. Department of Transportation Federal Highway Administration | 5-40



BEAT and BEAT-MT Installation Inspection Checklist

State: _____

Project #: _____ Inspection performed by: _____

Location: _____

- ☐ The 6"x 6" end tube section is the special 1/8" thickness tube as supplied by the manufacturer with the corners cut at the approach end where the impact head is placed.
- ☐ Both the **Roadside BEAT** terminal and **Median BEAT-MT** terminal have at least one 18'-0" long 6"x 6" x 3/16" standard tube section joining with the special 12'-0" long end tube section.
- ☐ The end tube section is bolted to the standard tube section with the special rail tie splice.
- ☐ The height of the 6"x 6" box beam tubing is in accordance with the plans:
  –**Roadside BEAT** rail height = 2'-4"
  –**Median BEAT-MT** rail height = 2'-4"
- ☐ The 6"x 6" box beam tubing is attached to rail support brackets with proper hardware:
  –**Roadside BEAT** post bolt = 5/16" x 7 ½" hex bolt
  –**Median BEAT-MT** post bolt = 5/16" x 7 ½" hex bolt
- ☐ The rail support brackets are attached to posts with proper hardware:
  –**Roadside BEAT** posts #1 & #2 support bracket bolts = ½"x 2" hex bolt
  –**Median BEAT-MT** posts #2 through #5 support bracket bolts = ¾"x 1 ½" hex bolt
  –**Median BEAT-MT** post #1 support bracket bolt = ½"x 2" hex bolt
- ☐ The upper and lower sections of post #1 are properly connected with a 5/8"x 8" hex bolt.
- ☐ The 3" weak posts have the soil plate positioned the same direction as the rail.
  –**Roadside BEAT** has a 3" weak post at post location #2 plus at least three more 3" weak posts spaced at 6'-0" within the standard downstream 6"x 6" box beam barrier.
  –**Median BEAT-MT** has a 3" weak post at post locations #2 through #5.
- ☐ The impact head is properly inserted into the end tube section with the large triangular gusset plates facing down. The bottom of the impact head is approx 12" above ground.
- ☐ The post breaker is installed on the proper side of post #1 and stabilized with two bolts.
- ☐ The 8" x 8" bearing plate at post 1 is correctly positioned with the 5" dimension up & the 3" dimension down. The anchor cable is taut and correctly installed.
- ☐ The **Median BEAT-MT** has a tether cable properly attached to restrain the impact head.
- ☐ If the posts were augered, be sure the backfill material around the posts is compacted.

Additional notes:

_____

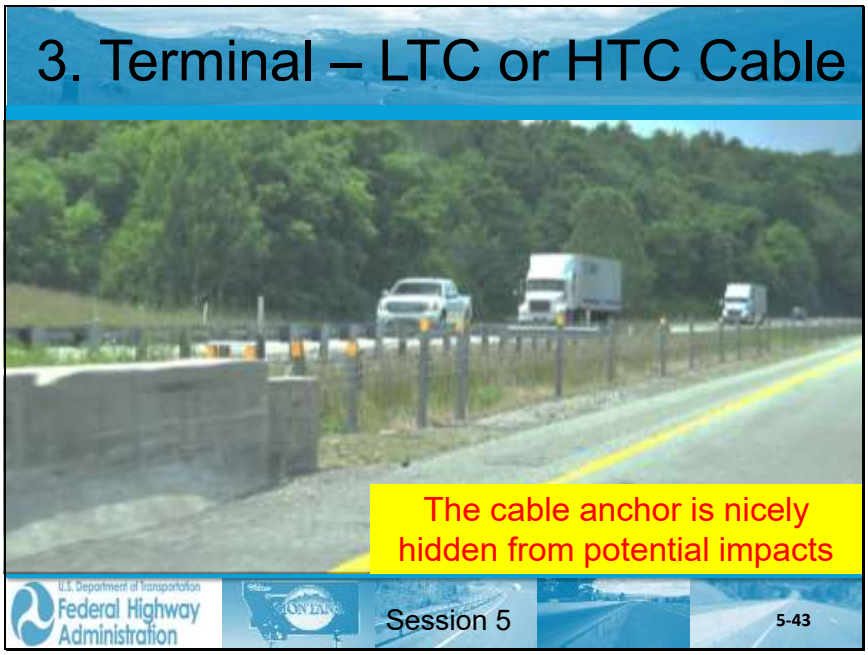
U.S. Department of Tra... Federal Hig... Administrati...

5-41

_____

_____


3. Terminal – LTC or HTC Cable
Although nicely separated from the guardrail, the exposed cable terminal will render the cable system ineffective if damaged
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-42


3. Terminal – LTC or HTC Cable
The cable anchor is nicely hidden from potential impacts
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-43

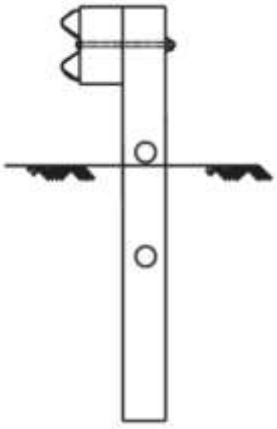
3. Terminal

b. Post Types

Each manufacturer may have several different types of post, even for the same system - both currently approved and previously used.

Must consult with the installation manual of the specific model being worked with for proper post type.

Only one generic special post for terminals – the CRT post with large holes to weaken it –



Controlled Release Terminal (CRT) Post

3. Terminal

c. Panel Types

Each system may have one or more different rail panels.

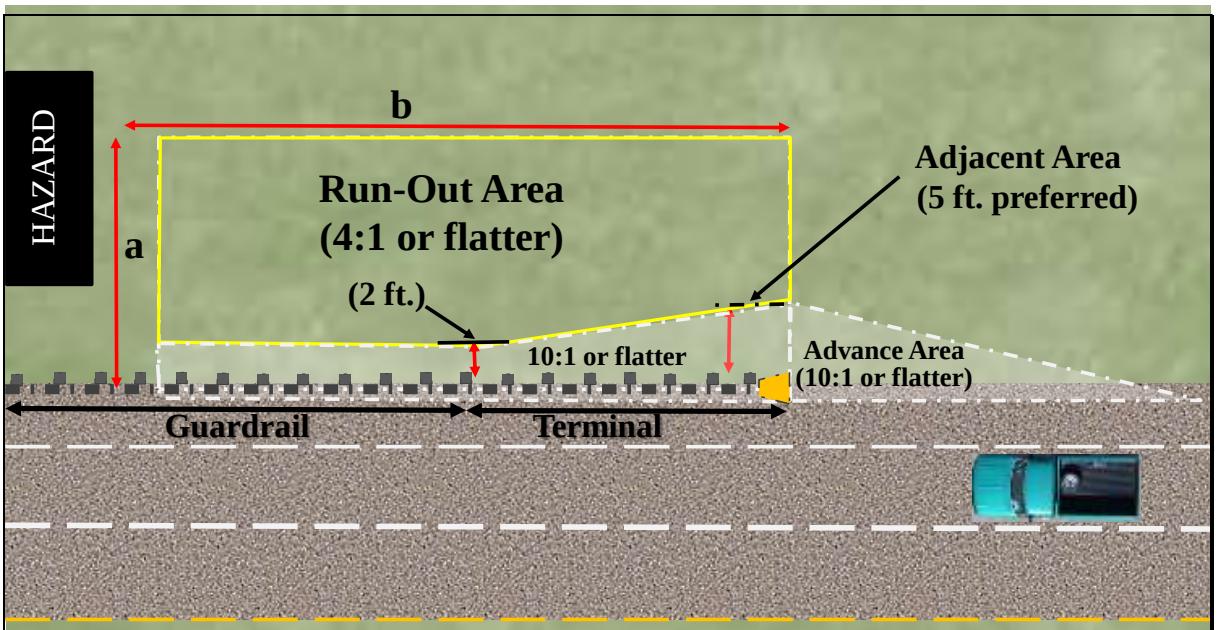
Must consult with the installation manual of the specific system for proper panel type

3. Terminal

d. Grading

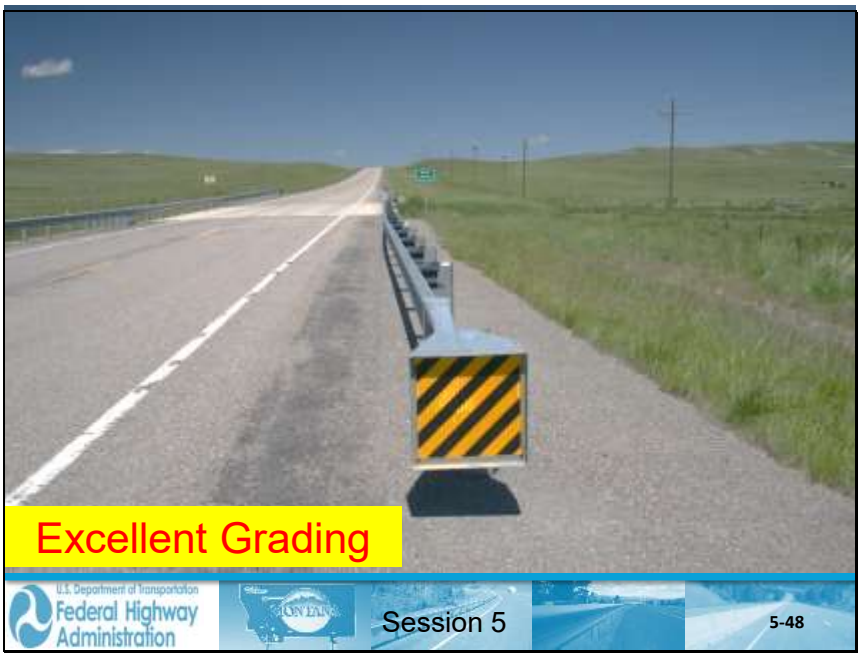
Check grading compliance with Detailed Drawing (or plan details). Manufacturers generally do not specify grading requirements.

Check grading material for proper density. (Material must be compacted so it won't erode.)



a – Extend out to clear zone when practical; if not, it should be at least as wide as area upstream of the terminal.

b – LON Required; when LON cannot be provided due to site conditions, a minimum of 75' from post one may be acceptable



3. Terminal

d. Grading

Improper Grading

A common error with all terminal types.

3. Terminal

d. Grading

Improperly Compacted Grading

3. Terminal

d. Grading — Telltales of poor grading

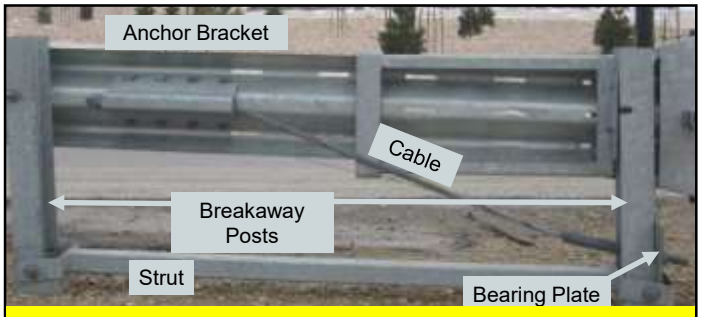
- Soil tubes/foundation posts installed too high
- Soil plates exposed
- Strut too high

Common Error applies to both energy absorbing and non energy absorbing terminals

3. Terminal

e. Breakaway Cable Anchorage Assembly

- Transfers tensile load for downstream side impact.
- Post #1 must separate on end-on impacts



Must follow manufacturer's installation instructions.

3. Terminal

e. Breakaway Cable Anchorage Assembly
Breakaway Post #1

- Proprietary steel posts.
- Must separate on end-on impacts

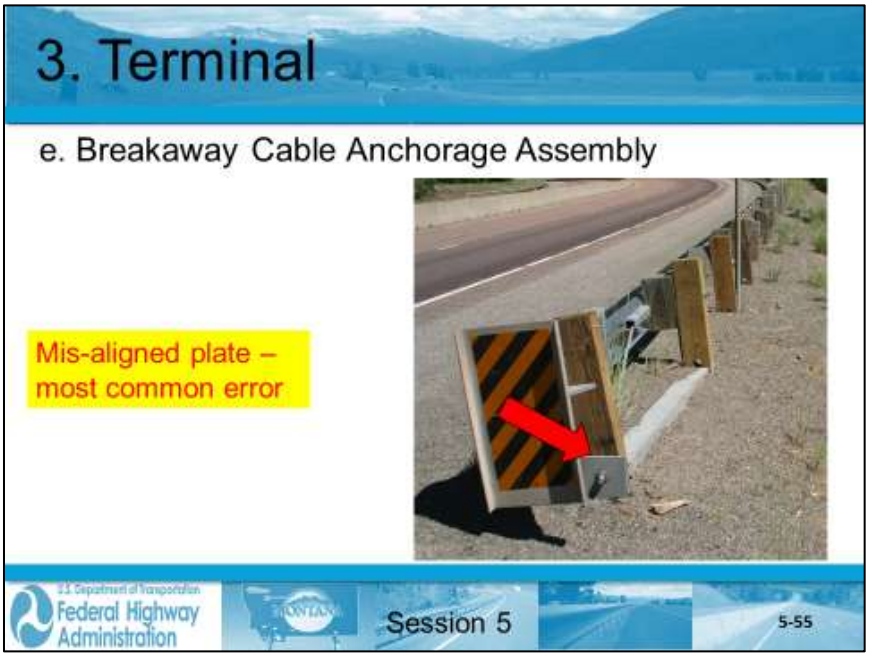


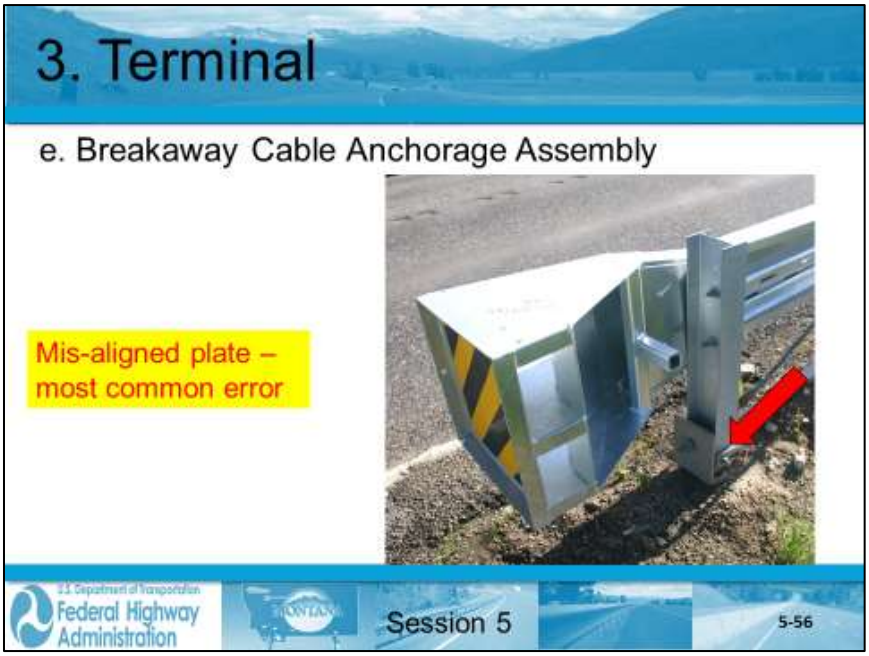
3. Terminal

e. Breakaway Cable Anchorage Assembly
Bearing Plate & Strut

- Plate should be in up position and secured to post.
- Strut secured at posts required locations.

Strut secured at breakaway posts 1 & 2


3. Terminal
e. Breakaway Cable Anchorage Assembly
Mis-aligned plate – most common error
Federal Highway Administration
Session 5
5-55


3. Terminal
e. Breakaway Cable Anchorage Assembly
Mis-aligned plate – most common error
Federal Highway Administration
Session 5
5-56

3. Terminal

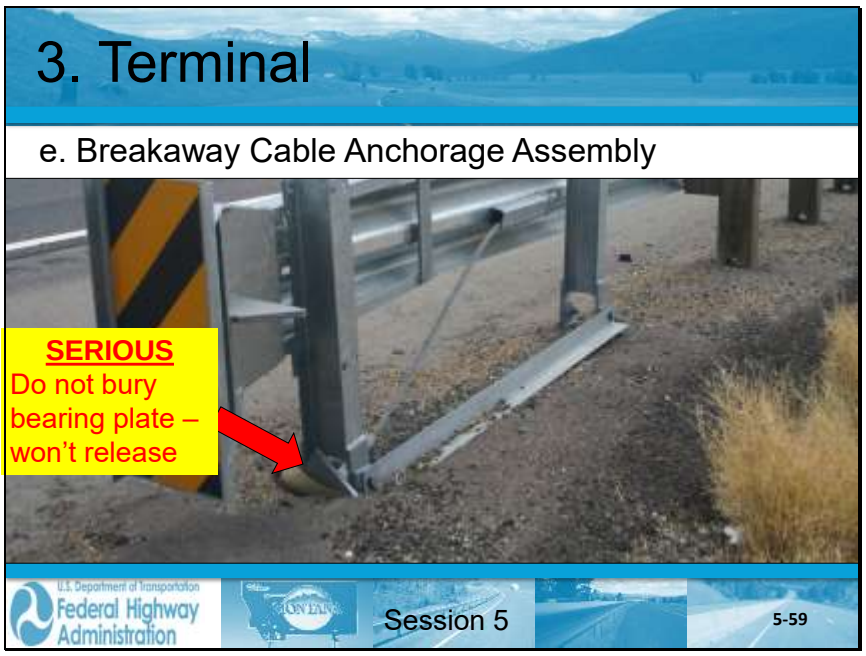
e. Breakaway Cable Anchorage Assembly

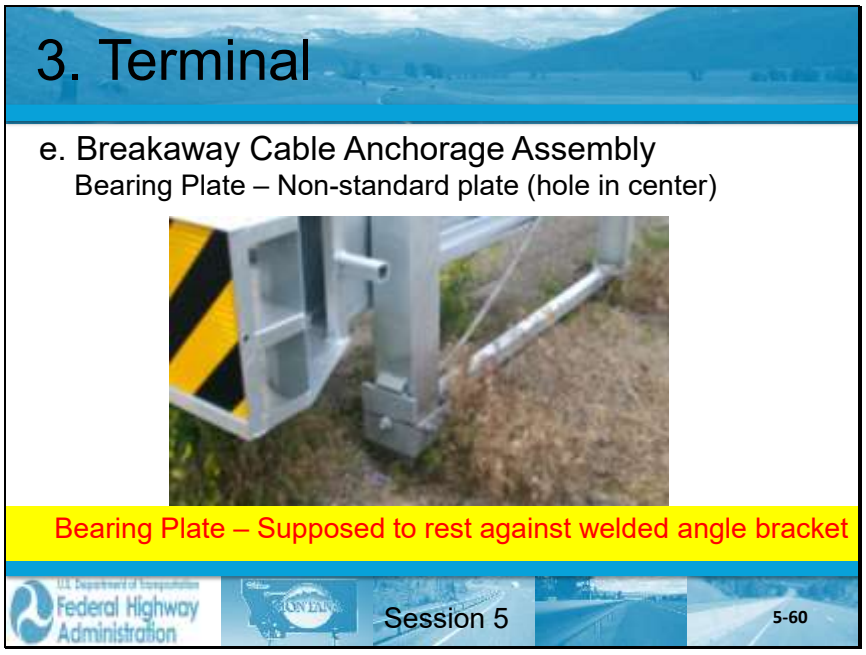
Attempt to prevent rotation – small ears

3. Terminal

e. Breakaway Cable Anchorage Assembly

Attempt to prevent rotation – small ears unsuccessful


3. Terminal
e. Breakaway Cable Anchorage Assembly
SERIOUS
Do not bury bearing plate – won't release
Federal Highway Administration
Session 5
5-59


3. Terminal
e. Breakaway Cable Anchorage Assembly
Bearing Plate – Non-standard plate (hole in center)
Bearing Plate – Supposed to rest against welded angle bracket
Federal Highway Administration
Session 5
5-60

3. Terminal

e. Breakaway Cable Anchorage Assembly

Most systems require an anchor bracket and anchor cable.

- Anchor bracket must release from rail if system has impact head
- Non-energy absorbing system does not have to release from rail.

Energy absorbing

Non-energy absorbing

3. Terminal

e. Breakaway Cable Anchorage Assembly

- Check the type and combination of breakaway posts against the State standards and the manufacturer's instructions.
- Not all posts in all terminals use a block-out.
- Check to see that the correct cable anchor bracket is used and it is properly attached to the rail.

Wrong anchor bracket

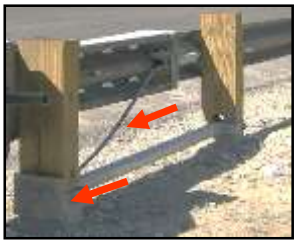
Anchor bracket not attached

3. Terminal

e. Breakaway Cable Anchorage Assembly

Anchor Cable

- Should be taut, lift up 1" or less (at installation)
- Tightened by holding cable at bottom, not allowing cable twist.



U.S. Department of Transportation Federal Highway Administration

Session 5

5-63

3. Terminal

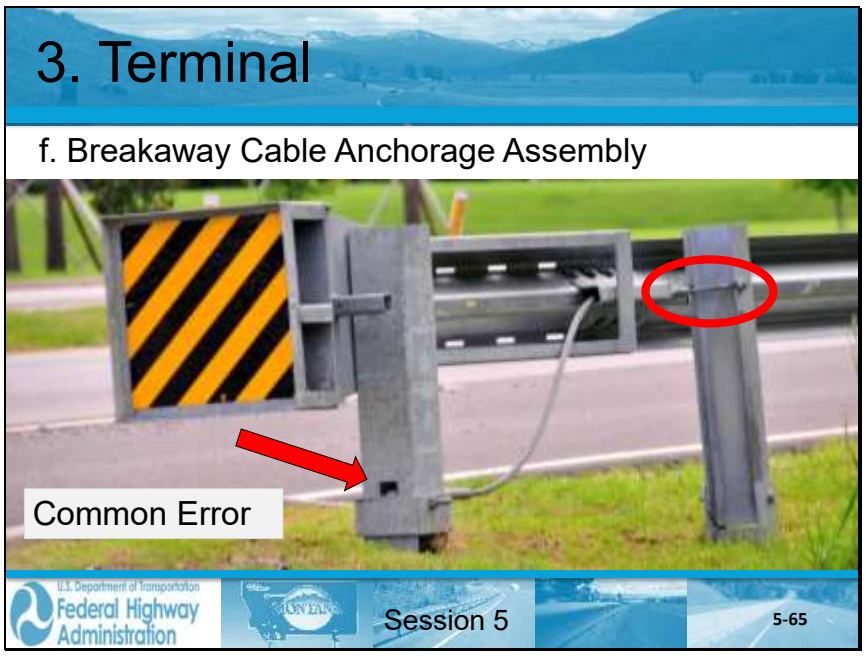
e. Breakaway Cable Anchorage Assembly

Errors

U.S. Department of Transportation Federal Highway Administration

Session 5

5-64


3. Terminal
f. Breakaway Cable Anchorage Assembly
Common Error
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-65


3. Terminal
f. Breakaway Cable Anchorage Assembly
Same applies to box beam
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-66

3. Terminal

f. Other Common Errors

Terminals with an impact head: the end of the first W-beam rail section should be pushed against the throat area of the impact head so the end of the rail cannot be seen.

FATAL FLAW

3. Terminal

f. Other Common Errors

Energy Absorbing (compression based) Terminals MUST be installed on a straight line

3. Terminal

f. Other Common Errors

Energy Absorbing (compression based) Terminals MUST be installed on a straight line

Great Job

3. Terminal

f. Other Common Errors


3. Terminal
f. Other Common Errors
DISASTEROUS
FOR HEAD-ON
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-71


3. Terminal
f. Other Common Errors
Video Clip
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-72

3. Terminal

f. Other Common Errors – How serious is this?????

3. Terminal

f. Other Common Errors

Bolt only impact head to post #1, NOT rail panel.

- Wood Post – Lag Screws (screwed in only)
- Steel Post – Hex Bolts

Refer to manufacturer's installation instructions.

3. Terminal

f. Other Common Errors

NO rail to post connection at post 1 of systems with impact heads

3. Terminal

f. Other Common Errors

DO NOT place any washers or delineators on the face of a guardrail terminal unless specifically called for or allowed in manufacturer's installation instructions

3. Terminal

f. Other Common Errors

U.S. Department of Transportation Federal Highway Administration
Session 5
5-77

3. Terminal

f. Other Common Errors

Excessive flare or offset on a terminal

Only 1' per Detailed Drawings

U.S. Department of Transportation Federal Highway Administration
Session 5
5-78

3. Terminal

f. Other Common Errors

Improper Application – no deflection and within terminal

3. Terminal

f. Other Common Errors

Improper Application – no runout for a non-energy absorbing terminal (as well as grading)

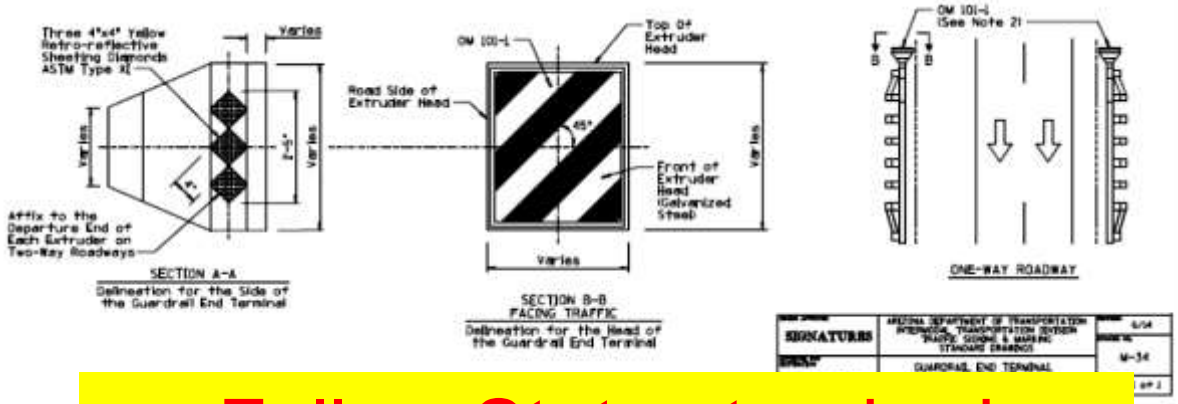
3. Terminal

f. Other Common Errors

Improper Application – Terminals should have 7' separation (and the sign should be beyond the terminal system)

3. Terminal

e. Delineation



Follow State standard

4. Crash Cushions

a. Manufacturers Manuals
b. Grading

4. Crash Cushions

a. Manufacturers Manuals

Must follow manufacturer's installation instructions and State standards.

Examples:
Neither on
MDT QPL

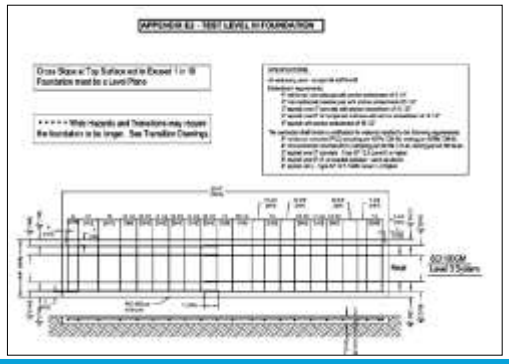
These are all readily available online

4. Crash Cushions

a. Manufacturers Manuals

Construct concrete pad if called for per manufacturer's requirements or state standards.

Clean out drilled holes WELL



4. Crash Cushions

a. Manufacturers Manuals

- Anchorage bolts are required to secure the system to concrete pad. Number of bolts and length of bolts vary with systems.
- Bolts are typically required to be epoxied into concrete pad.
- Bolts may have a torque value.

Full bolt depth required

Cutting bolt prohibited

Must follow manufacturer's installation instructions.

4. Crash Cushions

a. Manufacturers Manuals
- Backup varies among systems.
- May be connected to a barrier or may be a stand alone

Ex: Tension Strut Backup

Ex: Concrete Backup

Must follow manufacturer's installation instructions.

U.S. Department of Transportation Federal Highway Administration | Session 5 | 5-87

4. Crash Cushions

a. Manufacturers Manuals
- When system is placed in a bidirectional application a transition is required to prevent back side snagging

Acceptable

Unacceptable

Must follow manufacturer's installation instructions.

U.S. Department of Transportation Federal Highway Administration | Session 5 | 5-88

4. Crash Cushions

a. Manufacturers Manuals

- Place appropriate delineation on front of system



Must follow state standards and manufacturer's installation instructions and state guidance

4. Crash Cushions

b. Grading

Grading should be so an errant vehicle impacts the system in a stable condition – same as terminals

Suspect Grading

Must follow manufacturer's installation instructions.

4. Crash Cushion

Ex: results of improper torque values applied to fender panels.

Must follow manufacturer's installation instructions.

Review Learning Outcomes

- Describe key components of barrier systems
- Identify common installation errors