Session 5: Installation/Common Errors of System
Session 5: Installation/Common Errors of Systems

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
Session 5: Installation/Common Errors of System

Barrier Components

Key Components of Barrier Systems

1. Standard Run of Barrier
2. Transition to a Stiffer System
3. Terminal
4. Crash Cushion
1. Standard Run of Barrier
   a. Barrier Design Principles
   b. Height Measurement
   c. Tension Continuity
   d. Other Considerations
   e. Work Zone Barriers

a. Barrier Design Principles

Deflection

Soil Backing

Barriers and Curbs

Slope in Front of Barrier

Flare Rate
b. Height Measurement

- Concrete Barrier
  - Single Face or Median Barrier - 32"

- High Tension Cable Barrier
  - Typically dictated by manufacturer; meet manufacturer & agency standard
  - Many different configurations – even within a single manufacture’s systems
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

"Old" Guardrail
b. Height Measurement – Alternative

**ONLY** “Old”, “350” Guardrail

- Guardrail w/slope $6 \leq S < 10:1$

![Diagram showing guardrail installation on a slope]

b. Height Measurement

- **MGS W-Beam**

![Diagram showing MGS W-Beam installation]
b. Height Measurement

- Rail too high
- Rail too low

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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

- Horizontal bars maintain continuity for cast in place barrier
- Missing connection pin NO TENSION
**c. Tension Continuity**

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

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MUST MAINTAIN TENSION IN BARRIER SYSTEM
c. Tension Continuity

- Missing bolts
- No Structural connection

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.
d. Other Considerations

Incorrectly Lapped

Correctly Lapped

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d. Other Considerations

**NO WASHERS**

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d. Other Considerations

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

Manufacturers of working head terminals generally prohibit delineators within their systems.

Current MDT standard EXCELLENT

MDT standard application
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.
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.

e. Barriers in Work Zones

Barrier should be in GOOD condition
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 – “Old” W-beam
Is there a problem here???

3. Terminals

a. Manufacturers Manuals
b. Post types
c. Panel requirements
d. Breakaway Cable Anchorage
e. Grading
f. Other Considerations
g. Delineation
3. Terminal – Non-proprietary

Although the Buried-in-backslope (BIB) is the preferred (and best) terminal, it can be constructed incorrectly.

The point where the BIB crosses the toe of the backslope must be far enough upstream of the hazard. Top rail must capture vehicle.
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
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3. Terminal - Proprietary

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

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#### 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:

<table>
<thead>
<tr>
<th>Step</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Select the Option A, Option B, or Option C to install the rail panel without offset block at Post 2:</td>
</tr>
<tr>
<td></td>
<td>1. Insert a 7/16&quot; (16 mm) diameter x 10&quot; (255 mm) HGR Post Bolt (PN-3500G) through the rail and the wood post at location 2.</td>
</tr>
<tr>
<td></td>
<td>2. Place a 7/16&quot; (16 mm) Round Washer (PN-3300G) under a 5/8&quot; (16 mm) HGR Nut (PN-3340G) on the inserted bolt. Tighten the bolts. (There is no torque requirement for these bolts.)</td>
</tr>
<tr>
<td></td>
<td>Option B For SYTP™ 1. Insert a 7/16&quot; (16 mm) diameter x 1 1/2&quot; (31 mm) HGR Bolt (PN-3360G) through the rail panel and the hole in the SYTP™.</td>
</tr>
<tr>
<td></td>
<td>Note: If SYTP™ stubs are used, use the hole in the SYTP™ stub for securing the rail. If there are 2 (two) sets of holes in the SYTP™ stub for attaching the rail.</td>
</tr>
<tr>
<td></td>
<td>2. Place a 5/8&quot; (16 mm) Round Washer (PN-3300G) under a 7/8&quot; (19 mm) HGR Nut (PN-3340G) on the inserted bolt.</td>
</tr>
<tr>
<td></td>
<td>Option C For HBA™ Post 1. Do NOT bolt the rail panel to the HBA™ post at location 2.</td>
</tr>
</tbody>
</table>

**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.
BEAT and BEAT-MT Installation Inspection Checklist

State: ____________________________
Project #: ________________________
Inspection performed by: ________________
Location: __________________________

☐ The 6" x 6" end tube section is the special 1.0" thickness tube as supplied by the manufacturer with the corners cut at the approach and where the impact head is placed.

☐ Both the Roadside BEAT terminal and Median BEAT-MT terminal have at least one 15'-0" long 6" x 6" x 8'-0" standard tube section joining with the special 12'-0" long and tube section.

☐ The end tube section is bolted to the standard tube section with the special rail flare.

☐ The height of the 5" x 8" box beam tubing is in accordance with the plans:
  - Roadside BEAT rail height = 2'-0"
  - Median BEAT-MT rail height = 2'-0"

☐ The 6" x 6" box beam tubing is attached to rail support brackets with proper hardware:
  - Roadside BEAT post bolt = 5/16" x 1 1/4" bar bolt
  - Median BEAT-MT post bolt = 5/8" x 1 1/4" bar bolt

☐ The rail support brackets are attached to posts with proper hardware:
  - Roadside BEAT posts #1 & #2 support bracket bolt = 1/4" x 2" hex bolt
  - Median BEAT-MT posts #3 through #2 support bracket bolt = 7/16" x 1 1/4" bar bolt
  - Median BEAT-MT post #1 support bracket bolt = 3/8" x 2" hex bolt

☐ The upper and lower sections of post #1 are properly connected with a 5/8" x 1 1/4" hex bolt.

☐ The 3" web posts have the rail plate positioned the same direction as the rail:
  - Roadside BEAT has a 2" web post at post location #2 plus at least one more 2" web posts spaced at 6'-0" within the standard downstream 6'-0" box beam barrier.
  - Median BEAT-MT has a 2" web post at post location #2 through #7.

☐ 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 against the ground.

☐ The impact head is properly installed on the proper side of post #1 and stabilized with two bolts.

☐ The 5" x 6" bearing plate at post #1 is correctly positioned with the 5" dimension up & the 6" dimension down. The anchor cable is tight and correctly installed.

☐ The Median BEAT-MT has a wire cable properly attached to restrain the impact head.

☐ If the posts were exposed, be sure the backfill material around the posts is compacted.

Additional notes:

_______________________________
_____________________________
Although nicely separated from the guardrail, the exposed cable terminal will render the cable system ineffective if damaged.

3. Terminal – LTC or HTC Cable

The cable anchor is nicely hidden from potential impacts.
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.)

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

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

Run-Out Area (4:1 or flatter)

Adjacent Area (5 ft. preferred)

Advance Area (10:1 or flatter)

HAZARD

Guardrail

Terminal

(2 ft.)

10:1 or flatter
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3. Terminal

d. Grading

*Improper Grading*

A common error with all terminal types.
3. Terminal

d. Grading

*Improperly Compacted Grading*
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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

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
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

3. Terminal

e. Breakaway Cable Anchorage Assembly

Bearing Plate – Non-standard plate (hole in center)

Bearing Plate – Supposed to rest against welded angle bracket
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.

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.
3. Terminal

f. Breakaway Cable Anchorage Assembly

Same applies to box beam
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

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

SKT Impact Head
ET Plus Rail & Anchor Bracket
Post Installed Backwards

Great Job
3. Terminal

f. Other Common Errors

DISASTEROUS FOR HEAD-ON

Video Clip
3. Terminal

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

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

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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

Nuts on the bracket should be on the road side

Excessive flare or offset on a terminal

Only 1’ per Detailed Drawings
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3. Terminal

f. Other Common Errors

**Improper Application** – no deflection and within terminal

**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)

**e. Delineation**

Follow State standard
4. Crash Cushions

a. Manufacturers Manuals

b. Grading

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
   • Backup varies among systems.
   • May be connected to a barrier or may be a stand alone

   Must follow manufacturer’s installation instructions.

Acceptable

Unacceptable

4. Crash Cushions

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

   Must follow manufacturer’s installation instructions.
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

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

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