

Session 6: Maintenance of Systems

Session 6: Maintenance of Systems

FAST Act Guardrail Training
Highway Barrier Installation, Inspection and
Maintenance Training

**Session 6:
Maintenance of Systems**

U.S. Department of Transportation
Federal Highway Administration

North Dakota
LEGISLATURE

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Session 6 Learning Outcomes

At the end of this session, you will be able to:

- Know when damaged barrier needs to be reset, repaired, rebuilt, or removed.
- Understand when a damaged barrier terminal is no longer functional, and know whether to repair, replace in-kind, or upgrade to a newer design.
- Effectively delineate damaged hardware prior to repair.

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Introduction

- Barriers need routine inspection and maintenance.
- Barrier may need to be repaired after crashes or long term exposure.



Chapter 4 – Traffic Operations

Desired Service Levels for Safety Appurtenances

	Yearly	Spring	Summer	Fall	Winter
Cable Guardrail		1		1	
W Beam Guardrail	2				
Attenuators		1		1	
Barrels		1	1	1	1
Signing	3				
Delineators		1		1	
Pavement Markings	8	4	4	4	
Light Standards	2				
Span Wire Traffic Signals/flashing beacons		1	1	1	1
Highmast Standards Electrical		5	5	5	5
Lighting/Highmast Standard Foundations	6				
Sign Bridges	6				
Clear Zone		5	5	5	5
Snow Gates				1	
Advance Warning Rumble Strip				7	

1. Inspect and Adjust

2. Inspect

3. Perform night inspection, including all stop signs. Poor warning and regulatory signs must be replaced. All warning and regulatory signs will be replaced on a 10 year cycle.
4. Re-stripe maintenance repair areas at the end of each work-week
5. On-going
6. Inspect every 2 years with Bridge Inspection
7. Re-install at patched areas if warranted
8. See Pavement Marking – Striping Section, in this manual, for Striping Schedule



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Barriers

CHAPTER 4 – TRAFFIC OPERATIONS

Desired Service Levels for Safety Appurtenances

	Yearly	Spring	Summer	Fall	Winter
Cable Guardrail		1		1	
W Beam Guardrail	2				

Guardrail Maintenance

Guardrail should be maintained as it was constructed. Refer to the plans, Department design standards, and manufacturer's installation manuals for proper installation of the various guardrails and end treatments. All guardrails should be inspected annually for broken, loose, or missing parts and proper operation of the end treatments using SFN 58523 Inspection Checklist – Cable Guardrail End Anchorage.

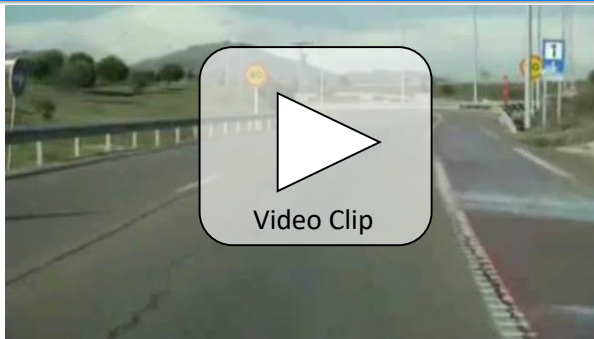
Guardrail should be repaired promptly after it has been damaged. Repair work should start in a few days and work should progress continuously until repairs are completed.



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Need To Repair



Video Clip



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Available for purchase	Available online

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Determine Extent of Damage



NCHRP Report 656 is intended to identify methods to better determine whether minor damage to W-Beam barriers poses a crash safety risk. It is intended to enable maintenance crews to prioritize repairs.

REF: NCHRP 656 – Criteria for Restoration of Longitudinal Barriers

U.S. Department of Transportation Federal Highway Administration North Dakota LEGENDARY Session 6 6-8

Modes of Barrier Damage

BARRIERS

(Based on experimental testing)

- Post and rail deflection
- *Rail deflection only*
- *Rail flattening*
- Posts separated from rail
- Missing/broken posts
- *Missing blockouts*
- *Twisted blockouts*
- Non-manufactured holes
- Damage at a rail splice
- Vertical tear
- Horizontal tear

End Treatments

(Based on Engineering Judgment)

- Damaged end post
- Anchor cable missing
- *Anchor cable loose*
- *Anchor cable bracket*
- Stub height
- Lag screws
- Bearing plate

Note: These evaluations were based on analysis of the G4 system and not on MGS system.

REF: NCHRP 656 – Criteria for Restoration of Longitudinal Barriers



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Low Speed Impact Prior to Damage



Video Clip

REF: NCHRP 656 – Criteria for Restoration of Longitudinal Barriers



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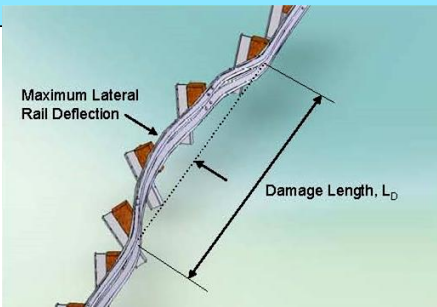
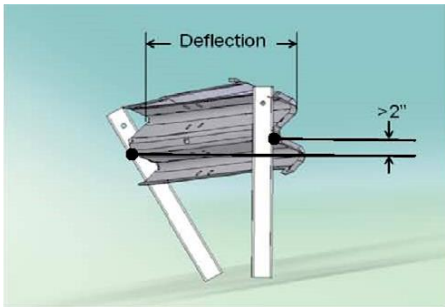
Test Level 3 After Damage




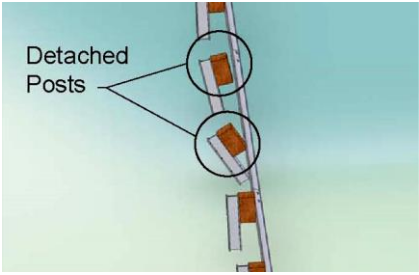
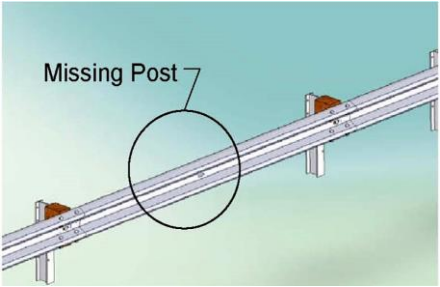
Video Clip

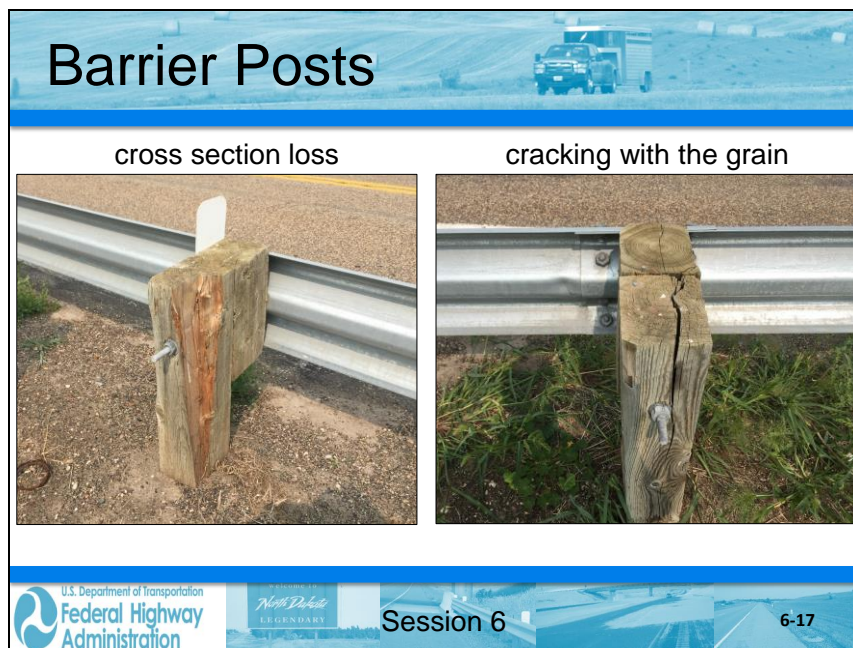
REF: NCHRP 656 – Criteria for Restoration of Longitudinal Barriers

Federal Highway Administration *John Glavin* Session 6 6-11


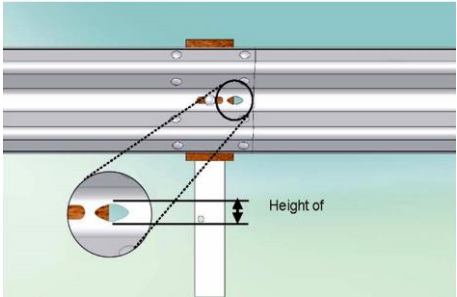
<div>Barriers</div> <div>  </div>			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Post and Rail Deflection	One or more of the following thresholds: <ul style="list-style-type: none"> More than <u>9 inches of lateral deflection</u> anywhere over a 25 ft length of rail. Top of rail height 2 or more inches lower than original top of rail height. 	High	
	<u>6-9 inches</u> lateral deflection anywhere over a 25 ft length of rail.	Medium	 <p>(Weak Post W-Beam Shown Only for Clarity. Each measurement taken at rail middle fold)</p>
	<u>Less than 6 inches</u> of lateral deflection over 25 ft length of rail.	Low	




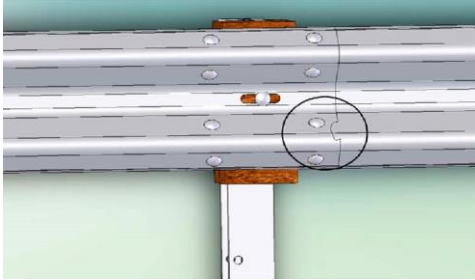
<div> <h1>Barriers</h1> <div>  <div> NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM </div> </div> </div>			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Posts Separated from Rail	<ul style="list-style-type: none"> 2 or more posts with blockout attached with post-rail separation less than <u>3 inches</u>. 1 or more post with post-rail separation which <u>exceeds 3 inches</u>. 	Medium	 <p>Note:</p> <ol style="list-style-type: none"> If the blockout is not firmly attached to the post, use the missing blockout guidelines. Damage should also be evaluated against post/rail deflection guidelines.
	<ul style="list-style-type: none"> 1 post with blockout attached with post-rail separation less than 3 inches. 	Low	
Missing/Broken Posts	1 or more posts <ul style="list-style-type: none"> Missing Cracked across the grain Broken Rotten With metal tears 	High	




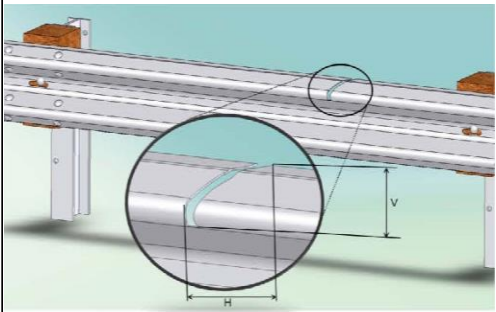
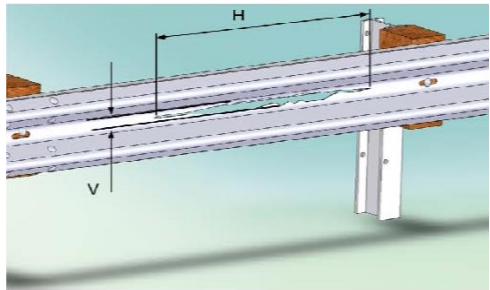


<div> <h1>Barriers</h1> <div>  </div> </div>			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Non-Manufactured holes (such as crash induced holes, lug-nut damage, or holes rusted-through the rail)	<ul style="list-style-type: none"> • <u>More than 2 holes less than 1"</u> in height in a 12.5' length of rail. • Any holes greater than 1" height. • Any hole which intersects either the top or bottom edge of the rail. 	High	
	1-2 holes less than 1" in height in a 12.5' length of rail.	Medium	

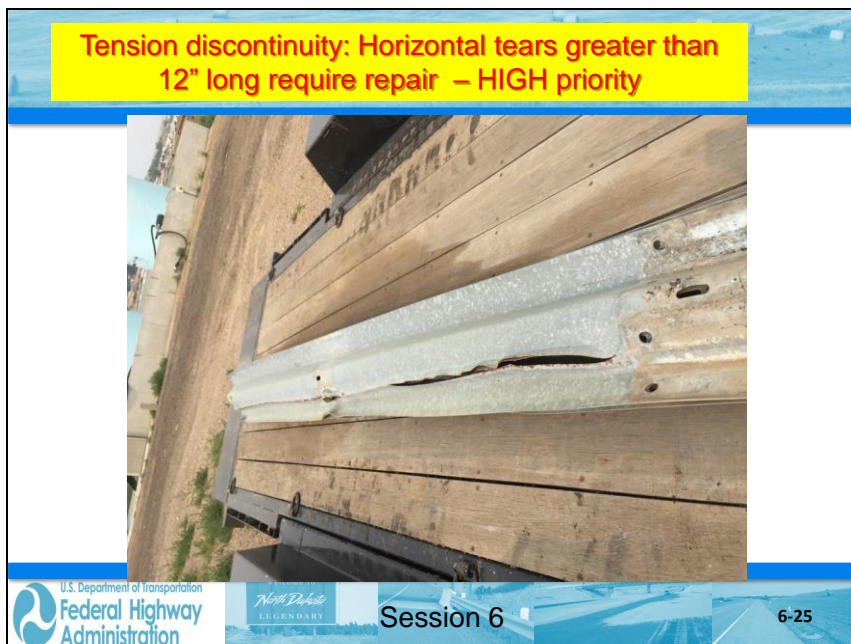


<div>Barriers</div> <div></div>			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Damage at a rail splice	<u>More than 1 splice bolt:</u> <ul style="list-style-type: none">• Missing• Damaged• Visibly missing any underlying rail• Torn through rail	High	
	1 splice bolt: <ul style="list-style-type: none">• Missing• Damaged• Visibly missing any underlying rail• Torn through rail	Medium	



<div> <h1>Barriers</h1> <div>  </div> </div>			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Vertical Tear	<u>Any length vertical (transverse) tear</u>	High	
Horizontal Tear	Horizontal (longitudinal) tears <u>greater than 12 inches</u> long or greater than 0.5 inches wide. Note: for horizontal tears less than 12 inches in length or less than 0.5 inches in height, use the non-manufactured holes guidelines.	Medium	

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Possible loss of tension continuity – Rail replacement required

Photo A





Photo B



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Barriers

How many things can you see that would require attention?



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NDDOT – Maintenance Checklist

INSPECTION CHECKLIST - BOX BEAM GUARDRAIL

North Dakota Department of Transportation, Maintenance
SFN 60792 (6-2018)

District*		Section*	
Highway Direction <input type="radio"/> North <input type="radio"/> South <input type="radio"/> East <input type="radio"/> West		Location of Roadside <input type="radio"/> Left <input type="radio"/> Right <input type="radio"/> Both	
Highway*	Beginning Mile Post*	Ending Mile Post*	In Median? <input type="radio"/> Yes <input type="radio"/> No

Damage

Are any I-beams bent or broken?	<input type="radio"/> Yes <input type="radio"/> No
Are all reflectors in place and in good condition?	<input type="radio"/> Yes <input type="radio"/> No
Box beam height correct? (27" to top of beam)	<input type="radio"/> Yes <input type="radio"/> No
Are I-beams attached to box beam?	<input type="radio"/> Yes <input type="radio"/> No



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NDDOT – Maintenance Checklist

INSPECTION CHECKLIST - CABLE GUARDRAIL

North Dakota Department of Transportation, Maintenance
SFN 58523 (6-2018)

District*		Section*	
Highway Direction <input type="radio"/> North <input type="radio"/> South <input type="radio"/> East <input type="radio"/> West		Location of Roadside <input type="radio"/> Left <input type="radio"/> Right <input type="radio"/> Both	
Highway*	Beginning Mile Post*	Ending Mile Post*	In Median? <input type="radio"/> Yes <input type="radio"/> No

Post	Cable
Sufficient soil behind post to prevent it from being pushed out? <input type="radio"/> Yes <input type="radio"/> No	Items that may cause vaulting? <input type="radio"/> Yes <input type="radio"/> No
Soil erosion around anchor and posts? <input type="radio"/> Yes <input type="radio"/> No	Are cables tensioned properly? <input type="radio"/> Yes <input type="radio"/> No
Are any posts cracked or broken? <input type="radio"/> Yes <input type="radio"/> No	Are cables frayed or cut? <input type="radio"/> Yes <input type="radio"/> No
Are all reflectors in place and in good condition? <input type="radio"/> Yes <input type="radio"/> No	Correct height? (28" to top cable) <input type="radio"/> Yes <input type="radio"/> No
	Rust on the cable? <input type="radio"/> Yes <input type="radio"/> No
	Are cables secured to anchorage base? <input type="radio"/> Yes <input type="radio"/> No



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NDDOT – Maintenance Checklist

INSPECTION CHECKLIST - W-BEAM GUARDRAIL AND END TREATMENT

North Dakota Department of Transportation, Maintenance
SFN 58530 (6-2018)

District*		Section*	
Highway Direction <input type="radio"/> North <input type="radio"/> South <input type="radio"/> East <input type="radio"/> West		Location of Roadside <input type="radio"/> Left <input type="radio"/> Right <input type="radio"/> Both	
Highway*	Beginning Mile Post*	Ending Mile Post*	In Median? <input type="radio"/> Yes <input type="radio"/> No

Type: ☐ Fleet ☐ SRT ☐ SKT ☐ Other

Items that may cause vaulting?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A	Connecting pieces to bridge or barrier damaged?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A
Damage to the end treatment, tension cable or rod and bracket?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A	Slotted rail been damaged?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A
Guardrail height correct 28" (to Top of rail)?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A	Slot guards in place?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A
Impact head attached to first post?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A	Any posts or spacer blocks cracked or broken?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A
Impact head chevron sticker faded or damaged?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A	Are all reflectors in place and in good condition?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A



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End Terminals

CHAPTER 4 – TRAFFIC OPERATIONS

Desired Service Levels for Safety Appurtenances

	Yearly	Spring	Summer	Fall	Winter
Cable Guardrail		1		1	
W Beam Guardrail	2				

Guardrail Maintenance

Guardrail should be maintained as it was constructed. Refer to the plans, Department design standards, and manufacturer's installation manuals for proper installation of the various guardrails and end treatments. All guardrails should be inspected annually for broken, loose, or missing parts and proper operation of the end treatments using [SFN 58523 Inspection Checklist – Cable Guardrail End Anchorage](#).


Guardrail should be repaired promptly after it has been damaged. Repair work should start in a few days and work should progress continuously until repairs are completed.





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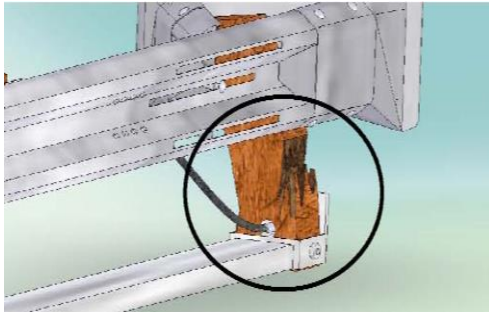
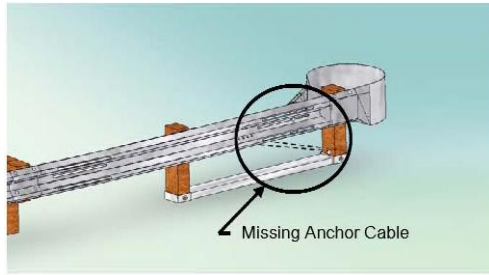
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End Terminals



You need and are required to have the manufacturer's installation manual to repair these systems.

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<div>End Terminals</div> <div>NCHRP REPORT 656 NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM</div>			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Damage End Post	<u>Not functional</u> (sheared, rotted, cracked across the grain)	High	
Anchor Cable	Missing	High	

End Terminals


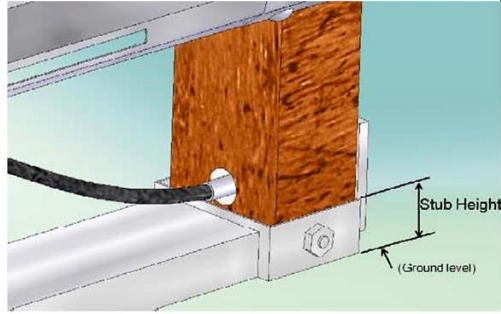
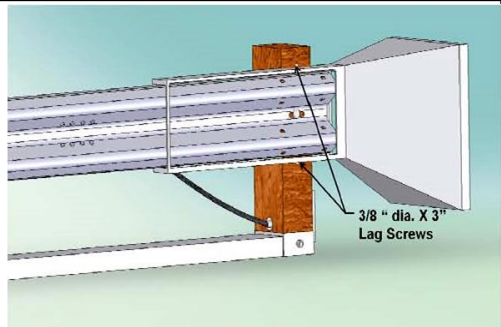
- Check for nuisance hits on terminals to be sure post #1 is not damaged.
- Even with claims of “reusability” – use best judgment and closely examine all salvageable parts.
- Impact Heads may be re-usable based on state policy and manufacturers recommendations (generally say no).



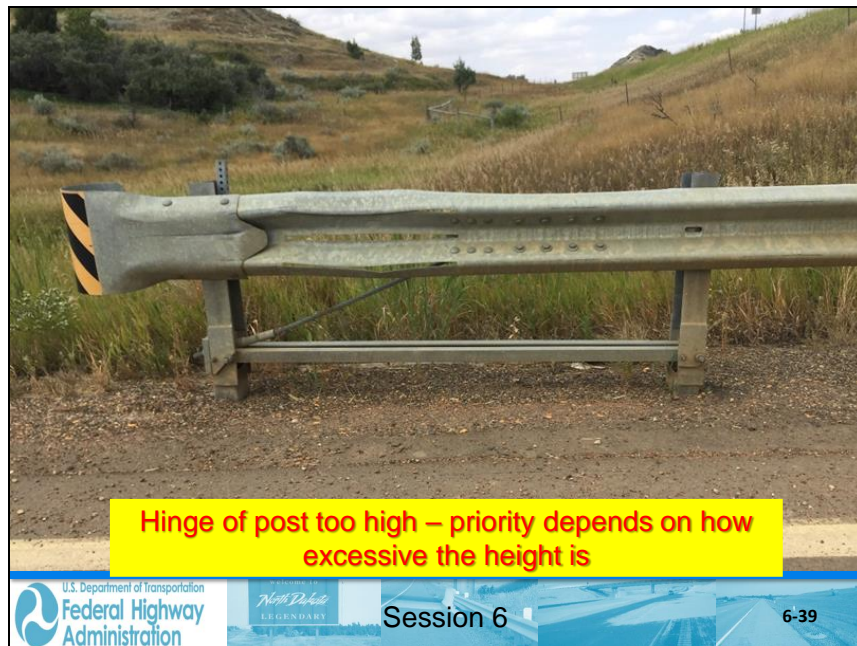
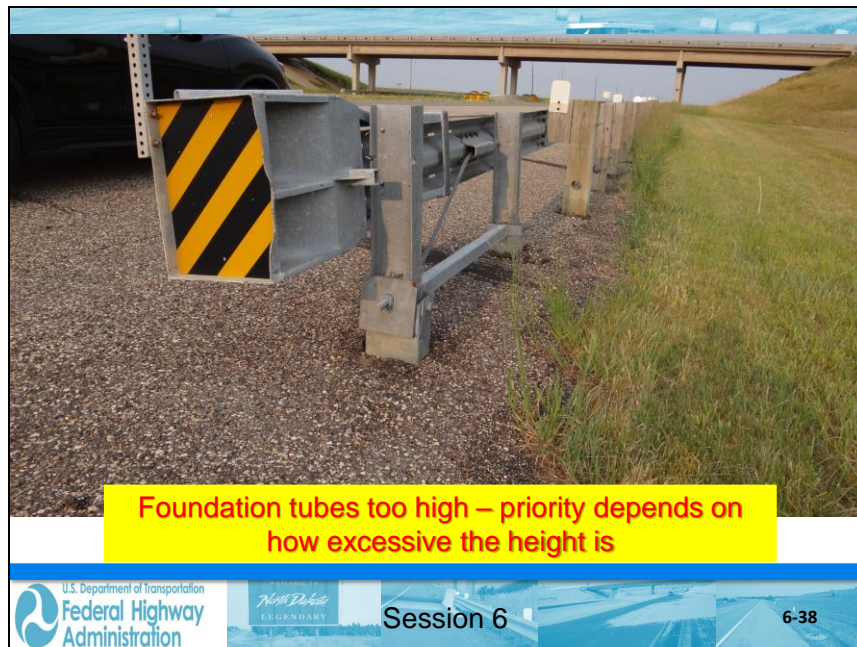
**Sheared end post -No tension
capability - HIGH**


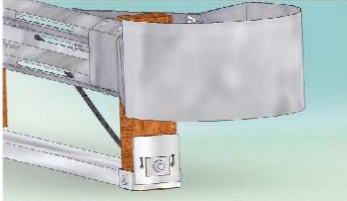
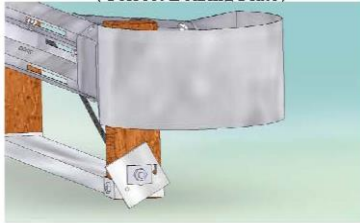
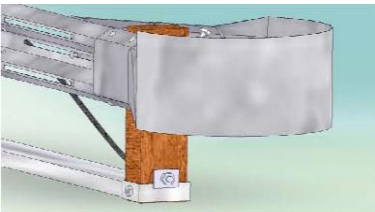





<div> <h1>End Terminals</h1> <div>  </div> </div>			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Stub Height	Height which exceeds 4"	Medium	
Lag Screws (Energy Absorbing Terminals Only)	<u>Missing or failed lag Screws</u>	High	

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<div> <div>End Treatments</div> <div>  </div> </div>			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Bearing Plate	Loose or Misaligned	Medium	 <p>(Correct Bearing Plate)</p>  <p>(Misaligned Bearing Plate)</p>
	Missing Bearing Plate	High	 <p>(Missing Bearing Plate)</p>

End Terminals



Bearing plate misaligned

Buried plate may not release

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Missing bearing plate and cable - No tension capability – (Also the head should be parallel to top of rail) - HIGH



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Cable Guardrail

Desired Service Levels for Safety Appurtenances

	Yearly	Spring	Summer	Fall	Winter
Cable Guardrail		1		1	



Cable Guardrail

Cable guardrail should be inspected and adjusted every spring and fall for proper tension of the cables. Refer to [Standard Specifications for Road and Bridge Construction](#) for details on cable tension.

Guardrail should be repaired promptly after it has been damaged. Repair work should start in a few days and work should progress continuously until repairs are completed.

Administration

Temporary Barrier Delineation

Delineate damaged areas while evaluating damage. Make repairs as soon as practical.



Temporary Barrier Delineation



Temporary Barrier Delineation

Removal of damaged posts will eliminate a spearing obstacle for opposing traffic.



Replacement In-Kind vs. Upgrade

➤ On-Call Guardrail Contract (example)

- Entire guardrail sections may also be removed and replaced to current standards, if the major portion of the section is damaged beyond repair and if directed by the Engineer.
- Damaged end treatments must be replaced with MASH TL-3 terminals.



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Timing of Repairs

➤ On-Call Guardrail Contract (example)

- Work to begin within 10 calendar days from receipt of work order, or
- Once started, repair work must be continuous until completed.



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Crash Cushions



**This is a blunt end until repaired.
Have manufacturer's Installation Manual available.**

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Crash Cushions



**Ensure all mounting hardware is correct,
in place & properly secured.**

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Crash Cushions



Typical QuadGuard Cartridges

Typical Universal TAU Cartridges



Place proper cartridges in the correct system & in the proper order



NDDOT – Maintenance Checklist

CRASH CUSHION INSPECTION
 North Dakota Department of Transportation, Maintenance
 SFN 58534 (6-2018)

District* ▼		Section* ▼	
Highway Direction <input type="radio"/> North <input type="radio"/> South <input type="radio"/> East <input type="radio"/> West		Location of Roadside <input type="radio"/> Left <input type="radio"/> Right <input type="radio"/> Both	
Highway*	Beginning Mile Post*	Ending Mile Post*	In Median? <input type="radio"/> Yes <input type="radio"/> No

Damage

Cartridges Damaged? <input type="radio"/> Yes <input type="radio"/> No	Items that may cause vaulting? <input type="radio"/> Yes <input type="radio"/> No
Nose cover in place and not damaged? <input type="radio"/> Yes <input type="radio"/> No	Slotted rail been damaged? <input type="radio"/> Yes <input type="radio"/> No
Bolts Tight <input type="radio"/> Yes <input type="radio"/> No	Slot guards in place: <input type="radio"/> Yes <input type="radio"/> No
Diaphragm legs straight: <input type="radio"/> Yes <input type="radio"/> No	Damage to the anchor cable and bracket: <input type="radio"/> Yes <input type="radio"/> No
Mushroom washers properly aligned and positioned: <input type="radio"/> Yes <input type="radio"/> No	Anchor cable securely fastened? <input type="radio"/> Yes <input type="radio"/> No
Fender and transition panels tight? <input type="radio"/> Yes <input type="radio"/> No	

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Crash Cushions



- Inspect sand-filled barrels to ensure lids are firmly in place and not dented.
- Make sure there is no moisture inside the modules.
- No damage or visible cracks in the outer shell.
- Check that each barrel is filled with the correct amount of dry pea gravel (Class 43 Aggregate). (See manufacturer's specifications.)

Crash Cushions



Place sand container in the correct position with the correct amount of pea gravel (CL 43 chip)



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NDDOT – Maintenance Checklist

ATTENUATION BARREL INSPECTION
 North Dakota Department of Transportation, Maintenance
 SFN 58527 (6-2018)

District* ▼		Section* ▼	
Highway Direction <input type="radio"/> North <input type="radio"/> South <input type="radio"/> East <input type="radio"/> West		Location of Roadside <input type="radio"/> Left <input type="radio"/> Right <input type="radio"/> Both	
Highway*	Beginning Mile Post*	Ending Mile Post*	In Median? <input type="radio"/> Yes <input type="radio"/> No

Lids

Lids firmly in place?	<input type="radio"/> Yes <input type="radio"/> No
Lids dished?	<input type="radio"/> Yes <input type="radio"/> No
Pedestals cracked or damaged?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A

Area

Debris around the barrels?	<input type="radio"/> Yes <input type="radio"/> No
Barrels in original design position?	<input type="radio"/> Yes <input type="radio"/> No
Items that may cause vaulting?	<input type="radio"/> Yes <input type="radio"/> No

Barrels

Barrels tilted or leaning?	<input type="radio"/> Yes <input type="radio"/> No
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Review Learning Outcomes

- Know how damaged barrier MAY BE assessed for maintenance response.
- Understand when a damaged barrier terminal MAY no longer function.
- Effectively delineate/treatment of damaged hardware prior to repair.

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