

Telecommunications Industry Association

# AD HOC GROUP 18

## U – BOLT CONNECTIONS

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# AGENDA

- Purpose of Ad Hoc Group
- Goals of Ad Hoc Group
- Potential Testing
  - Deformation Testing
  - Torsional Friction Coefficient Testing
- Other Considerations



# PURPOSE OF AD HOC GROUP

- To propose revisions as necessary and add clarity and depth to Section 4.9.11 *U-Bolt Connections* of TIA-222-H



# GOALS OF AD HOC GROUP

- Determine acceptable method for determining U-bolt pretension for both design and installation
- Investigate pipe crushing due to U-bolt tightening
- Investigate torsional resistance of U-bolted connections



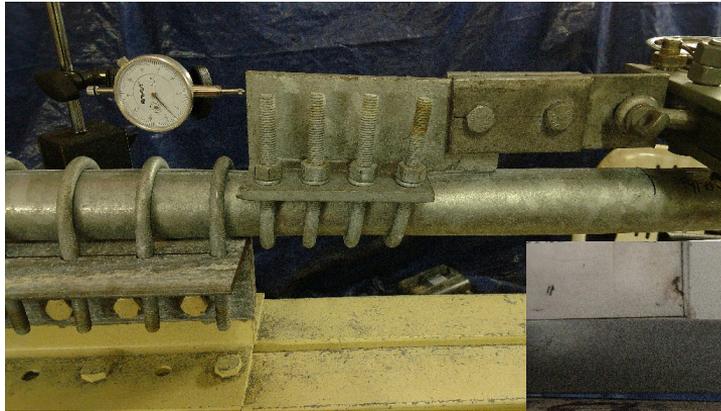
# TESTING PURPOSE

- **U-bolt Induced Deformation of Pipes Due to Tightening**
  - The purpose of this testing is to evaluate the magnitude of permanent deformation on pipe members due to different levels of torque / tightening forces of U-bolts, and establish reasonable installation torque values for U-bolt connections on various pipes.
- **Assessment of Torsional Friction Coefficient of U-Bolt Connections**
  - The purpose of this testing is to evaluate the nominal torsion resistance of u-bolts under different levels of torque / tightening forces, and determine applicability to structural connections.



# U-BOLT INDUCED DEFORMATION OF PIPES DUE TO TIGHTENING

- Observed during testing



# U-BOLT INDUCED DEFORMATION OF PIPES DUE TO TIGHTENING

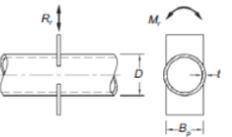
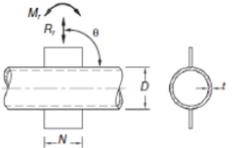
Seen in the field

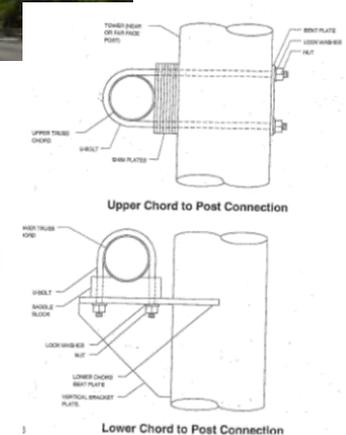


# U-BOLT INDUCED DEFORMATION OF PIPES DUE TO TIGHTENING

## Applicable Standards or Design Guidance

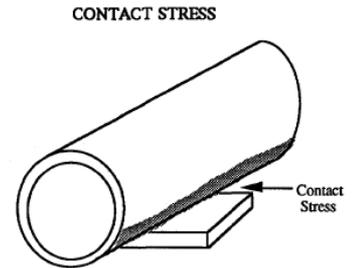
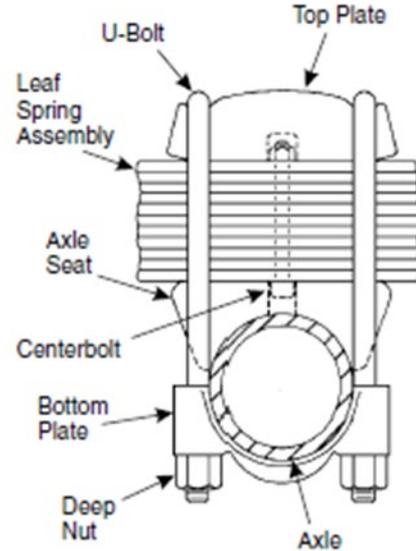
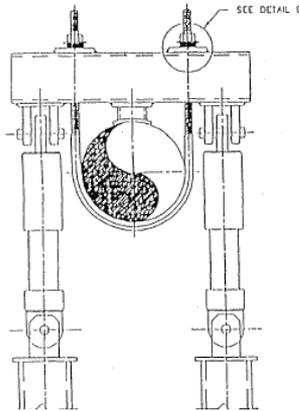
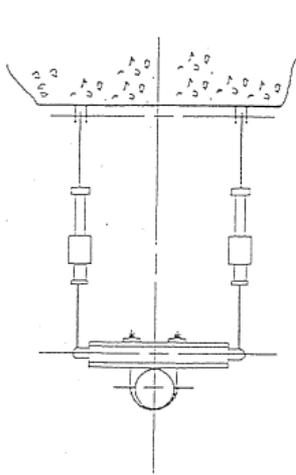
### 7.3 CONNECTION NOMINAL STRENGTH TABLES

Table 7-1. Nominal Strengths of Plate-to-Round HSS Connections			
Connection Type	Connection Nominal Strength*	Plate Bending	
		In-Plane	Out-of-Plane
Transverse-Plate T- and Cross-Connections 	Limit State: HSS Local Yielding Plate Axial Load $R_t = F_y t^2 \left( \frac{5.5}{1 - 0.81 \frac{B_p}{D}} \right) Q_t \quad (K1-1)$ $\phi = 0.90 \text{ (LRFD)} \quad \Omega = 1.67 \text{ (ASD)}$	—	$M_o = 0.5B_p R_o$
Longitudinal-Plate T-, Y- and Cross-Connections 	Limit State: HSS Plastification Plate Axial Load $R_o \sin \theta = 5.5 F_y t^2 \left( 1 + 0.25 \frac{N}{D} \right) Q_t \quad (K1-8)$ $\phi = 0.90 \text{ (LRFD)} \quad \Omega = 1.67 \text{ (ASD)}$	$M_o = N R_o$	—



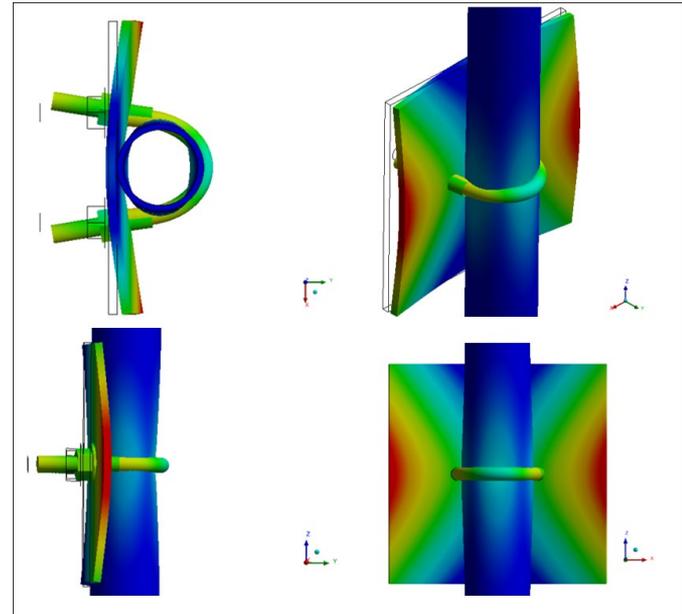
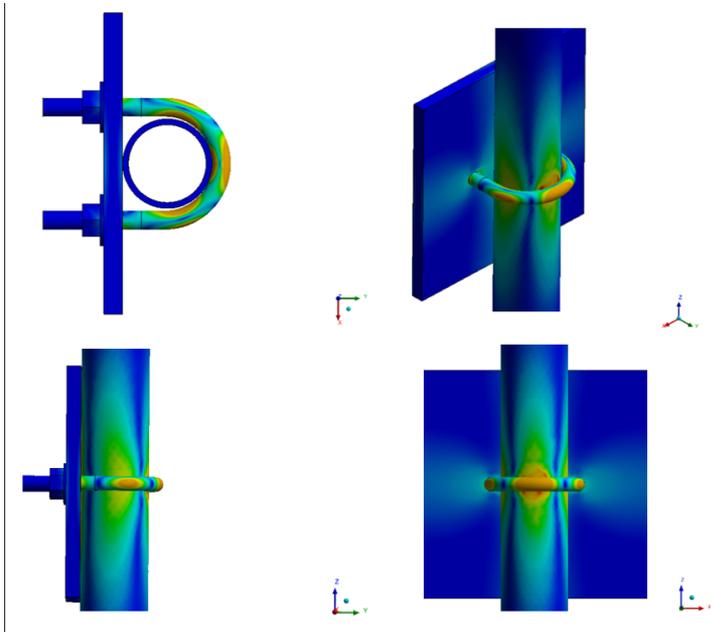
# U-BOLT INDUCED DEFORMATION OF PIPES DUE TO TIGHTENING

Other Industries and sources



# U-BOLT INDUCED DEFORMATION OF PIPES DUE TO TIGHTENING

FEA Study



# U-BOLT INDUCED DEFORMATION OF PIPES DUE TO TIGHTENING

## Test Population

**Table 2**

Test Type	Pipe Size (inch)	U-bolt Size (inch)*	# of Tests
Deformation Testing	2.375" x 0.154"	0.5	3
	3.500" x 0.216"	0.5	3
	4.500" x 0.237"	0.5	3
Total Number of Tests			9

\*U-Bolt Material Grade - A36/A307

# U-BOLT INDUCED DEFORMATION OF PIPES DUE TO TIGHTENING

## General Procedure

- U-bolts shall first be brought to a snug tight condition (Lock washer fully compressed). Note the U-bolt prong tension and installation torque at the snug tight condition. The U-bolt prong and nut shall then be matched marked.
- Next, torque to the specified value, alternating torque wrench frequently from one nut to the other nut in order to achieve uniform torque on both sides of the U-bolt. Record the bolt tension and amount of relative rotation of the match mark line (1/4 turn, 1/3<sup>rd</sup> turn, etc.) in 1/12<sup>th</sup> increments per each torque increment.



# U-BOLT INDUCED DEFORMATION OF PIPES DUE TO TIGHTENING

## General Procedure

- Increase the amount of torque by 5 to 10 ft-lb increments and observe and record the results, frequently alternating tightening on each leg of the U-bolt to achieve uniform torque on both sides of the U-bolt.
- Continue tightening test until excess deformation occurs in the pipe, the U-bolt snaps or yields, or unable to further tighten the U-bolt.
- Record incremental and final results, including: applied installation torque on U-bolt prongs, tension on U-bolt prongs at each installation torque, nut rotation at each installation torque, and measurable deformation of the pipe at each increment.



# U-BOLT INDUCED DEFORMATION OF PIPES DUE TO TIGHTENING

## General Requirements

- Room Temperature under Dry Conditions
- Galvanized Steel with a Single U-bolt Connection
- Tension measuring device (strain gage, load measuring washer, etc.)
- Deformation measuring with digital imaging

## Test Recordings

- Bolt installation torque per test increment
- Bolt tension per test increment
- Bolt markings (nut rotation) per test increment
- Noticeable / measurable deformation of pipe

Any other pertinent information or observations

# ASSESSMENT OF TORSIONAL FRICTION COEFFICIENT OF U-BOLT CONNECTIONS

The strength of a U-bolt connection in transferring forces parallel to the longitudinal axis of a supporting member (sliding) and moments about the longitudinal axis of a supporting member (torsion, applicable to appurtenance connections only) shall meet the following interaction equation:

$$\left( \frac{V_{us}}{\phi_u R_{ns}} \right)^2 + \left( \frac{T_{ur}}{\phi_u R_{nr}} \right)^2 \leq 1.0$$

where:

$V_{us}$  = shear force applied parallel to the supporting member (sliding) from factored loads

$T_{ur}$  = torsional moment applied about the longitudinal axis of the supporting member (twisting) from factored loads

$R_{ns}$  = nominal sliding strength in accordance with the following:

$$0.30(2T_p - T_{ut}) \geq 0$$

$R_{nr}$  = nominal torsional strength =  $0.5 D R_{ns}$

$T_p$  = installed pretension in each leg of U-bolt

$T_{ut}$  = exterior tension force applied to the U-bolt assembly due to factored loads

$D$  = diameter of supporting member

$\phi_u$  = 1.00

# ASSESSMENT OF TORSIONAL FRICTION COEFFICIENT OF U-BOLT CONNECTIONS

## Test Population

**Table 1**

Test Type	Pipe Size (inch)	U-bolt Size (inch)*	Torque Levels**	# of Trials per Torque	Total # of Tests
Torsional Resistance	2.375" x 0.154"	0.5	3	3	9
	3.500" x 0.216"	0.5	3	3	9
	4.500" x 0.237"	0.5	3	3	9
Total Number of Tests					27

\*U-Bolt Material Grade - A36/A307

\*\*Torque levels to be specified after the pipe deformation testing

# ASSESSMENT OF TORSIONAL FRICTION COEFFICIENT OF U-BOLT CONNECTIONS

## General Procedure

- U-bolts shall first be brought to a snug tight condition (Lock washer fully compressed). Note the U-bolt prong tension and installation torque at the snug tight condition. The U-bolt prong and nut shall then be matched marked.
- Next, torque to the specified value, alternating torque wrench frequently from one nut to the other nut in order to achieve uniform torque on both sides of the U-bolt. Record the bolt tension and amount of relative rotation of the match mark line (1/4 turn, 1/3<sup>rd</sup> turn, etc.) in 1/12<sup>th</sup> increments per each torque increment.



# ASSESSMENT OF TORSIONAL FRICTION COEFFICIENT OF U-BOLT CONNECTIONS

## General Procedure

- Perform the testing to identify where the rotation becomes a permanent rotational displacement (i.e. no rebound once the load is removed.) Looking for the value when the coefficient of torsion resistance is overcome.
- Continue testing, recording angular displacement vs load at intervals



# ASSESSMENT OF TORSIONAL FRICTION COEFFICIENT OF U-BOLT CONNECTIONS

## General Requirements

- Room Temperature under Dry Conditions
- Galvanized Steel with a Double U-bolt Connection
- Tension measuring device (strain gage, load measuring washer, etc.)
- Deformation measuring with digital imaging



# ASSESSMENT OF TORSIONAL FRICTION COEFFICIENT OF U-BOLT CONNECTIONS

## Test Recordings

- U-bolt installation torque per test
- Tension in U-bolt prongs (at snug tight and at designated installation torque)
- Bolt markings for relative rotation
- Note any deformation of the pipe due to U-bolt tightening or applied torsion on the apparatus.
- Applied Torsional Load vs angular displacement
- Any other pertinent information or observations



# ASSESSMENT OF TORSIONAL FRICTION COEFFICIENT OF U-BOLT CONNECTIONS

## Deliverables

- All data from test recordings with post processing and commentary on the results, indicating torsional slip coefficient of various U-bolted connections.



# STEPS

- Develop Testing Plan
- Obtain Pricing
- Review Alternatives
- Obtain Funding
- Perform Testing



# REQUEST FOR QUOTE

- Sent to 6 Universities
  - University of Alabama-Birmingham (UAB)
  - North Carolina State University (NCSU)
  - The Ohio State University (OSU)
  - University of Texas-Austin (UT-Austin)
  - University of Texas-Dallas (UT-Dallas)
  - University of Kentucky (UK)
- 1 Testing Company
  - Wiss, Janney, Elstner Associates, Inc (WJE)



# OTHER VARIABLES

## Additional Possible Testing

- Additional pipe sizes and thicknesses
- Additional U-bolt sizes
- Differing U-bolt spacing and quantities
- Other U-bolt and/or pipe material grades
- Different shapes of backing plates (e.g. flat vs. curved, or w/ shim rods)
- Pipes with wet vs. dry conditions and high or low temperatures
- The effects of the galvanization condition of the pipe (e.g. with patina)



# OTHER CONSIDERATIONS

**TIA**  
THE INSTITUTE OF TELEPHONE AND INFORMATION ENGINEERS

**TIA-322 CHANGE PROPOSAL DOCUMENTATION**

Change Proposal No. \_\_\_\_\_  
Proposed By \_\_\_\_\_  
Submitted On \_\_\_\_\_  
Submitted To \_\_\_\_\_  
Requested By \_\_\_\_\_  
Requested On \_\_\_\_\_  
Requested By \_\_\_\_\_  
Requested On \_\_\_\_\_

\_\_\_\_\_  
(Editorial Committee)

**Proposed Change**

No.	Description of Change

**Proposed For Change**

No.	Description of Change



## 4.9.11

### **4.9.11 U-Bolt Connections**

Nut locking devices shall be provided for all U-bolt connections.

Nuts and U-bolts shall be provided from the same source to insure compatibility of the nuts with the threads of the U-bolts after galvanizing.

Pretensioned U-bolts shall not be re-used once they have been placed in service.

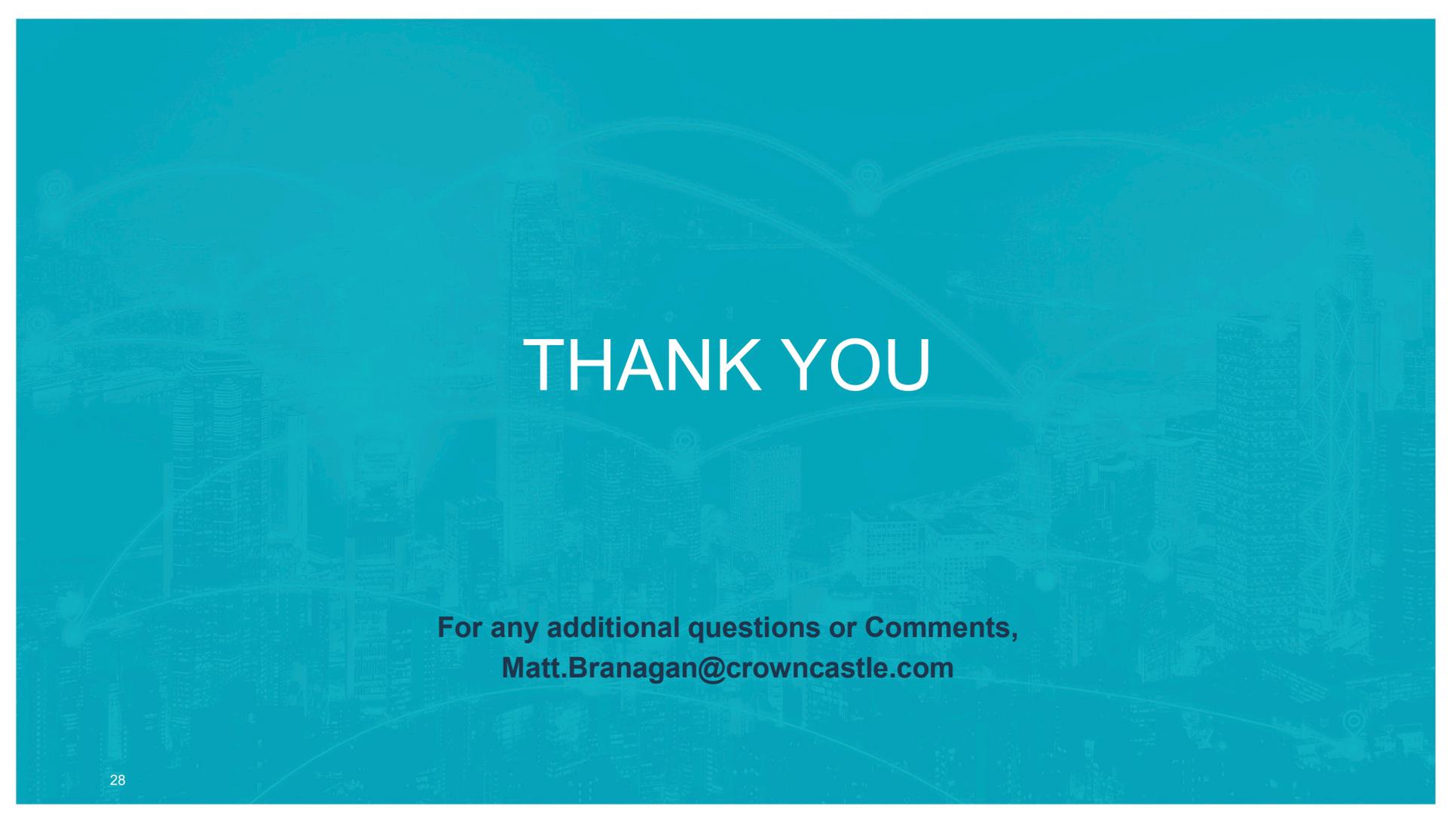
Heat treatment for U-bolts after forming shall be in accordance with the SAE AMS2759 Standard, "Heat Treatment of Steel Parts, General Requirements".

## 4.9.11.1

### 4.9.11.1 Round U-Bolts

Round U-bolts shall conform to one of the following pre-qualified material specifications: ASTM A36, A529, A572, A449, A193 Gr B7, A354 Gr BC, F1554, SAE J429 Gr 2 or 5. It shall be permissible to use other steel materials suitable for the application and site.

Round U-bolts shall be stress relieved after forming for a minimum of 1 hour or until the entire part reaches the stress relieving temperature. The stress relieving temperature shall be between 1,000 degrees Fahrenheit [538 degrees C] and 1,200 degrees Fahrenheit [649 degrees C] but no more than 50 degrees Fahrenheit [10 degrees C] below the tempering temperature for heat treated U-bolts. U-bolts shall be air cooled in still air.



# THANK YOU

For any additional questions or Comments,  
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