# RESEARCH COUNCIL ON STRUCTURAL CONNECTIONS (RCSC)
## MINUTES of SPECIFICATION COMMITTEE A.1
7 June 2012, 8:00AM, Glassboro, NJ

| | |
|---|---|
| **Members Present: (31)** | T. Anderson, P. Birkemoe, D. Bornstein, R. Brown, C. Curven, D. Droddy, D. Ferrell, P. Fortney, B. Germuga, R. Gibble, J. Greenslade, A. Harrold, C. Hundley, P. Kasper, L. Kruth, C. Larson, B. Lindley, C. Mayes, C. McGee, G. Miazga, G. Mitchell, G. Rassati, T. Schlafly, G. Schroeder, R. Shaw, V. Shneur, L. Shoemaker, J. Swanson, R. Tide, T. Helwig, F. Vissat |
| **Members Absent: (23)** | A. Astaneh-Asi, R. Baxter**,** D. Bogarty, B. Cornelissen, N. Deal, J. Fisher, K. Frank, J. Gialamas, M. Gilmor, C. Kanapicki, J. Kennedy, G. Kulak, K. Lohr, N. McMillan, J. Mehta, K. Menke, H. Mitchell, T.Tarpy, B. Tinney, W. Thornton, C. Wilson, A. Wong, J. Yura |
| **Guest: (9)** | D. Auer, G. Byrne, C. Carter, M. Friel, F. Gheno, B. Goldsmith, J. McGormley, A. Prchlik, T. Ude, |

## AGENDA

**ITEM 1.0 Chairman's Remarks: (Harrold)**

- Specification Committee Chairman Harrold introduced host Rich Brown from TurnaSure, LLC.
- Specification Committee A.1 meeting will conclude around 12:00 Noon.
- Task Groups can meet after lunch.
- Council Roster was circulated for verification and update of Email address, phone and fax numbers and any additional comments as required. Presently, there are fifty-four members on Specification Committee A.1; guests were also asked to sign-in.
- Discussions and voting shall be limited to Specification Committee A.1 members only.
- Discussions shall be limited only to agenda items listed.

**ITEM 2.0 Approval of Minutes of the June 2011 Meeting: (Harrold)**

- No additional comments, corrections and discussions took place. Tide motioned and Shaw seconded the motion to approve the minutes as written.

**ITEM 3.0 Approval of Agenda: (Harrold)**

- Changes to agenda are as follows: Resolution of Ballot Results, Item 5.4, will be resolved following Discussion of Proposed Specification Changes, Item 6.8. Task Group Report, Item 7.7, was completed last year. No additional agenda items were suggested; therefore Harrold concluded that the proposed agenda, with above changes incorporated, is approved as written.

**ITEM 4.0 Membership: (Harrold)**

- Roster was circulated for sign-in and updating of information.

- If guests are interested in joining Specification Committee A.1, they were asked to see Harrold during the break or after the meeting.

**ITEM 5.0 <u>Resolution of Ballot Results (Affirmative/Negative/Abstain):</u> (Harrold)**

5.1 S06-002B Turn-of-the-Nut Rotation Tolerances (Shaw): Discussed at length at the 2011 Specification Committee A.1 meeting in Oakland CA. The present RCSC Specification has no limit on bolt tension for the snug condition, hence no well-defined maximum "starting line" for pretensioning, it make little sense to reject a bolt because it exceeds the "finish line." A bolt is not too tight until it breaks.

Negative vote submitted by Tide suggested that referenced research materials, although significant in length for this proposed change, needs to be defined in the Commentary. Harrold indicated that references in the Commentary are not required and stated that Tides' negative is editorial in nature; Tide withdrew his negative.

Negative vote submitted by Mayes includes four comments:
1) Proposed -30° and +90° or even +120° rather than -30° and +60°. A broken fastener is the real limit here; installers will naturally avoid over-rotation, since it is more work to do so. Shaw indicated that higher values were discussed at the 2006 Specification Committee A.1 meeting with many committee members not in favor of the higher rotation values; thread run-out, more bolts will be broken. Further discussion followed (Larsen, Schlafly, Kasper, Curven, Mitchell, Shaw, Birkemoe). Larson presented test result curves from five tests conducted on 7/8-inch diameter by 6-inch long lubricated and un-lubricated ASTM A325 & A490 bolts (see attached). Un-lubricated fasteners are a concern with the upper limit rotation. Minimum tensile strength, minimum thread in the grip and the as installed condition verses a hydraulic load cell test would further exacerbate the test results shown.
Shaw moved and Kasper seconded the motion to find Mayes' negative vote for the balloted proposed change to be non-persuasive; Mayes withdrew his negative vote.
2) In the commentary near end of page 2, change the proposed term "twist-off" to "fastener failure". "Twist-off" implies TC bolt spline. Shaw indicated that Table 8.2 is for Turn-of-Nut pretensioning installation not for Twist-Off-Type Tension-Control Bolts. Mayes withdrew his negative vote.
3) In 2nd paragraph of page 3, proposed commentary, why would a high hardness nut have a tendency to crack with more rotation? The load is not significantly increasing as rotation increases in the inelastic range. Shaw mentioned that radial stress could be another failure mode for high-hardened nuts. Mayes withdrew his negative vote.
4) Refer to near end of page 6: Add commentary (or maybe even add something to the specification) that indicates that backing up the rotating element to get back down under a maximum rotation tolerance should never happen (unless the fastener will be completely removed). Shaw pointed out that this is addressed in the second to last sentence of Section 8.2.1. Mayes withdrew his negative vote.

Negative vote submitted by Connor includes two comments; Connor not present at specification committee meeting to defend his negative vote.
1) Suggested adding (1/12 turn) following the "minus 30 degrees" term in note 'a' of table 8.2 to be consistent with indicating (1/6 turn) associated with 60 deg. Shaw would accept the comment as editorial and an improvement to footnote 'a'.
2) It seems inconsistent to give a tolerance of 60 degrees in Table 8.2 and then in section 9.2.1 say you can exceed the tolerance. I don't believe it should be identified as a tolerance if you can exceed it. Root word of tolerance is "tolerate" I think. If the fastener can tolerate any

amount of rotation past the required minimum, why give any upper limit in Table 8.2? I see this raising a lot of issues with inspectors saying. Shaw considers Section 8.2 as a technique/workmanship installation tolerance; if failure of a fastener would occur, it would be during the installation process not afterwards. If last sentence (new language) in Section 9.2.1 were removed, the potential for installers backing-off over rotated nuts would create installation and inspection problems.

Shaw moved and Miazga seconded to find Conner's negative vote for the balloted proposed change to be non-persuasive.

Harrold requested a vote with results as follows:

17 for the vote to be non-persuasive
0 against the vote to be non-persuasive
0 abstained

**ACTION ITEM 2012-01 (A.1) (S06-002B)**: The as-balloted item with proposed change to the Specification was considered and adopted for inclusion into the next revision of the specification.

5.2 S11-033 Merge Appendix B with main spec (Harrold): Proposal is intended to blend Appendix B Allowable Stress Design (ASD) Alternative provisions into the body of the Specification. Negative vote submitted by Ude; technical context of the proposed change is not the issue, but questioned whether council supports continuing of the ASD format or embrace the LRFD format and delete Appendix B.

Harrold moved and Schlafly seconded to find Ude's negative vote for the balloted proposed change to be non-persuasive.

Harrold requested a vote with results as follows:

21 for the vote to be non-persuasive
0 against the vote to be non-persuasive
0 abstained

Proposed resolution to Ude's negative vote should be considered for discussion as new business.

**ACTION ITEM 2012-02 (A.1) (S11-033)**: The as-balloted item was considered and adopted for inclusion into the next revision of the specification.

5.3 S11-035 Hole Definitions (Shaw): Similar to the debate regarding the Joint Type for Section 4., it was determined that the RCSC Specification should not establish a default condition for Joint Types, leaving this to the governing specifications invoking the RCSC such as AISC 360, AISC 341 and CSA S16. The revision to the language proposed for Section 3.3 and in 3.3.1 through 3.3.4, continues with this same philosophy in that the RCSC Specification would not establish a default Hole Type. Dialog between interested parties has taken place without resolution. Further discussion followed (Carter, Ferrell, Ude, Schroeder, Harrold, Shneur, Kuth, Fortney). Suggest having a Task Group redefine the language which defines the Engineer, EOR and Connection Designer responsibilities. Contractual relationships should be left to the language presented in AISC Code of Standard Practice. EOR maintains final authority, but needs to provide the Engineer and Connection Designer the Joint and Hole Type in the design documents.

Ferrell withdrew his negative provided responsibility definition (Engineer, Connection Designer or EOR) and references the AISC Code of Standard Practice in the RCSC Commentary.

Negative vote submitted by Mayes: Does not see how this positively affects a final outcome of a project. Once the EOR imposes this level of thinking and specifies bolt hole types and slot directions into the contract documents, the EOR may be more resistant to the changes that the fabricator/erector may desire to implement. This is a negative consequence.

Negative vote submitted by Curven: Not sure why this change is needed. The current language is clear and forces any changes to be run through the Engineer of Record by stating, "when approved by the Engineer of Record" for Sections 3.3.2., 3.3.3., and 3.3.4. With the proposed changes, concerned that change to hole types (and connection design) will happen without the EOR being contacted as the fabricator or detailers or connection designers may take upon themselves. Does not see how the proposed changes forces changes to be brought to the EOR.

Negative vote submitted by Ude: As Sections 3.3.X are offering quite explicit and complete advice regarding what hole types the Council endorses based on what types of joints are in play, the Section 3.3 statement requiring EOR to specify hole type in the documents seems unnecessary. It seems only to create the opportunity for designers to trip up, either by forgetting to specify hole types, or worse, by specifying incompatible holes and joint types (e.g. oversize holes and snug-tightened joints). In cases where they do not forget, and they do get the hole type synced up correctly with joint type, they are basically just technicians, implementing the prescriptions of Sections 3.3.X.
Consider instead:

- Not adding the "EOR shall specify the hole type…" to opening of 3.3.
- Change the opening edit of 3.3.1 to "In the absence of requirement by the EOR for the use of other hole types, standard holes are permitted in all plies of bolted joints."
- Change the opening edit of 3.3.2 to "In the absence of requirement by the EOR for the use of other hole types, oversized holes are permitted in any or all plies of slip critical joints as defined in Section 4.3."
- Change the opening edit of 3.3.3 to "In the absence of requirement by the EOR for the use of other hole types, short slotted holes are permitted in any or all plies of snug-tightened joints …."
- Change the opening edit of 3.3.4 to "In the absence of requirement by the EOR for the use of other hole types, long slotted holes are permitted in only one ply at any individual faying surface of snug-tightened joints…." Change the mid-section edit of 3.3.4 to "In the absence of requirement by the EOR for the use of other hole types, long slotted holes are permitted in one ply only at any individual faying surface of slip-critical joints…."

This attempts to recognize the EOR's authority to control hole size if and when he/she wants to. But when the EOR is okay with the guidance implied by Sections 3.3.X, fabricators and their detailers are given usable direction and limited freedom for selecting hole types most conducive to their objectives.

Shaw moved and Ferrell seconded to find Mayes', Curvens' and Udes' negative vote to the balloted proposed change to be non-persuasive. Harrold suggested that if a Task Group is established to add language, which defines Engineer, Connection Designer and EOR, would the three withdraw their negative votes based on the present language as proposed. Ude withdrew his negative vote, Curven and Mayes did not withdraw their negative votes.
Harrold requested a vote with results as follows (Curven):

13 for negative vote to be non-persuasive
0 against the negative vote to be non-persuasive
0 abstained

Harrold requested a vote with results as follows (Mayes):

14 for the negative vote to be non-persuasive
2 against the negative vote to be non-persuasive

0 abstained

Task group was established, which is composed of Fortney (chair), Carter, Kurth, Ferrell, Shneur and Gibble.

**ACTION ITEM 2012-03 (A.1) (S11-035)**: The as-balloted item with proposed changes to the Specification were considered and adopted for inclusion into the next revision of the specification with the understanding that a Task Group would add language that defines Engineer, Connection Designer and EOR responsibilities.
During the Main Council meeting a proposed rewording of this section was approved for ballot. The current item (S11-035) will be replaced with the new proposal. See new change proposal S12-047.

5.4 S11-036 Pretension Definitions (Shaw): The term *pretension* (noun & verb) are regularly used throughout the specification, but do not have official definitions within the specification.
Connor voted affirmative with the following editorial changes:
Pretension (verb). The act of tightening a fastener assembly such that the minimum specified tensile force exists to a specific level of tension or higher.
Pretension (noun). A level of minimum specified tensile force remaining tension achieved in a fastener assembly through after its installation, as required for pretensioned and slip-critical joints. Further discussion followed (Shaw, Harrold). No action required since Connor voted affirmative with editorial language comments. No change to the pretension (noun) definition as Shaw presented.
Negative vote submitted by Hajjar suggested the definition for the verb should mirror the definition for the noun: "The act of tightening a fastener assembly to a level required for pretensioned and slip-critical joints." However, through the use of the word "pretension" (as an adjective) in both definitions, both the verb and noun definitions are a little circular.
Shaw moved and Ferrell seconded to find Hajjars' negative vote for the balloted proposed change to the verb to be persuasive as an editorial change.
Harrold requested a vote with results as follows:

26 for the vote to be persuasive
0 against the vote to be persuasive
0 abstained

**ACTION ITEM 2012-04 (A.1) (S11-036)**: The as-balloted item with proposed Hajjar editorial change to the Specification was considered and adopted for inclusion into the next revision of the specification.

**ITEM 6.0 Discussions of Proposed Specification Changes: (Harrold)**

- To make changes to the present specification, download from the RCSC web site a Proposed Change form, fill-out the proposed change, include rationale or justification for the change and add commentary as needed. The completed form needs to be submitted to the Chairman of the Executive Committee for consideration and assignment to the specification committee chair for creation of a task group or to become an agenda item at the next committee meeting. Proposed changes submitted after the Executive Committee meeting, typically in March, will not be acted on until the following year.

6.1 S11-038 Sections 8.2, 8.2.1, and 8.2.3 - Pre-installation Verification Testing Language (see attached RCSC Proposed Change: S11-038) (Curven): Sections 9.2.1 and 9.2.3 make reference to the pre-installation verification testing in Sections 8.2.1 and 8.2.3 respectively. Currently, there is no language in Sections 8.2.1 and 8.2.3 that refers to the pre-installation testing. The proposed change corrects the omission and makes all four subsections of Section 8.2 refer to Section 7 Pre-Installation Verification. The task group consisted of Curven, Carter, Birkemoe & Harrold. Proposed changes were considered technical in nature, therefore will need to be balloted.

**ACTION ITEM 2012-05 (A.1)**: Proposed changes were considered and adopted for inclusion into the next revision of the specification. In order for the proposed changes to be included in the next revision to the specification, the changes will need to be balloted.

6.2 S12-039 Table 2.1 – Delete Zn/Al coating from F1852 and F2280 assemblies (see attached RCSC Proposed Change: S12-039) (Schlafly): Presently, ASTM has not accepted the use of Zn/Al coatings on either ASTM F1852 or F2280 tension-control bolt assemblies. RCSC revised the 2009 Specification in anticipation that the ASTM balloting would approve Zn/Al coating, but ASTM balloting voted down the approval. Concerns have been raised regarding the proper fabrication of the assembly parts given the significantly different coefficient of friction generated by the Zn/Al coating in comparison with normal lubricate assemblies. Further discussion followed (Larson, Shaw, Mitchell, Hundley, Harrold, Birkemoe, Mayes, Curven, Kasper). TC assemblies have been specifically designed based on their normal lubrication to achieve defined tightening characteristics. No prohibition in ASTM to disallow other finishes (coatings) for ASTM A325/A490 bolts, but does not mention other coating for ASTM F1852/F2280 bolt assemblies. Functionality, endorsement & certification of the bolt assembly are the responsibility of the manufacturer. ASTM is a material specification and the RCSC is an installation specification. The RCSC specification should not be the place where coatings are listed, which does not comply with ASTM specification.

**ACTION ITEM 2012-06 (A.1)**: Proposed changes were considered and adopted for inclusion into the next revision of the specification. In order for the proposed changes to be included in the next revision to the specification, the changes will need to be balloted.

6.3 S12-041 Section 6.2.5 Commentary – Footnote reference (see attached RCSC Proposed Change: S12-041) (Schlafly): This proposal is a continuation of Proposed Change S09-028 that was approved in 2010, which added the applicability of Table 6.1 footnote "a" to the condition of A490 and F2280 bolts greater than 1" diameter when oversized or short-slotted holes exist in an outer ply. While the Specification language was updated, the inclusion of the footnote "a" reference in the supporting Commentary was missed.
Ferrell motioned and Kruth seconded the motion to forward the proposed specification change as editorial in nature.
Harrold requested a vote with results as follows:

27 for the changes
0 against the changes
0 abstained

**ACTION ITEM 2012-07 (A.1)**: Proposed changes were considered and adopted for inclusion into the next revision of the specification. The proposed changes will be presented to council for approval to be included in the next revision to the specification, the changes were considered editorial therefore need not be balloted.

6.4 S12-042 Section 5.4 – Slip Critical Equations (see attached RCSC Proposed Change: S12-042) (Schlafly): Modify RCSC Equations 5.6, 5.7 and B5.5 to reflect the most recent research on slip-critical connections. Three separate research reports funded by AISC, RCSC and CISC were published by Hajjar, Dusicka and Grondin support the changes to the formulation for slip resistance. The proposal results in reliability at levels acceptable for use in slip critical connections regardless of whether the slip limit state is considered to be a serviceability or strength limit. The basic slip coefficient μ for Class A and Class C were reduced from 0.33 and 0.35 respectfully to 0.30. The current RCSC equation considers one slip plane and all bolts. The proposed change considers any number of slip planes and one bolt. Further discussion followed (Harrold, Birkemoe). Research documents/reports should be posted on the RCSC website. Additionally, research documents need to be included with the proposed change ballot. No objections voiced in moving this proposed change to ballot.

**ACTION ITEM 2012-08 (A.1)**: Proposed changes were considered and adopted for inclusion into the next revision of the specification. In order for the proposed changes to be included in the next revision to the specification, the changes will need to be balloted.

6.5 S12-043 Section 8.1 Commentary – TC bolts in Snug Tight joints (see attached RCSC Proposed Change: S12-043) (Schlafly): Occasionally, inspectors require the removal of splines of Tension-Control bolts even where they are to be installed in a snug-tight condition. Commentary language provides the option for the splines of twist-off type Tension-Control bolts to be twisted off or left in place in snug-tightened joints. Further discussion followed (Curven, Harrold, Mitchell, Shaw, Miagza). Consider adding similar language to Section 9.1 Snug-Tightened Joints.

**ACTION ITEM 2012-09 (A.1)**: Proposed changes were considered and adopted for inclusion into the next revision of the specification. In order for the proposed changes to be included in the next revision to the specification, the changes will need to be balloted.

6.6 S12-044 Section 5.1 – Fillers (see attached RCSC Proposed Change: S12-044) (Schlafly): Tests conducted by Dr. Hajjar at the University of Illinois @ Urbana-Champaign indicated that the reduction in bolt shear strength in connections with filler as required in Section 5.1 (1) should be limited to 85%. Present language limits the fillers or shims to ¾-inch thick; fillers and shims can be greater than ¾-inch, without a reduction limit. The 85% shear strength limitation was not shown in the Proposed Change, but will be included when balloted.

**ACTION ITEM 2012-10 (A.1)**: Proposed changes were considered and adopted, with the 85% limitation identified in Section 5.1(1), for inclusion into the next revision of the specification. In order for the proposed changes to be included in the next revision to the specification, the changes will need to be balloted.

6.7 S12-045 Sections 8.2.3, 9.2.1, 9.2.2, 9.2.3 – Inspection Process (see attached RCSC Proposed Change: S12-045) (Curven): Clarification to the present language in Sections 9.2.1, 9.2.2 and 9.2.3 ensuring inspection verification by routine observation that the plies have been brought into firm contact prior to pretensioning method chosen. Clarification to the present language in Section 8.2.3 stating that the joint shall be considered tightened not until the splined-end shears off.

**ACTION ITEM 2012-11 (A.1)**: Proposed changes were considered and adopted for inclusion into the next revision of the specification. In order for the proposed changes to be included in the next revision to the specification, the changes will need to be balloted.

6.8 S12-046 Glossary – Torque, Tension Definitions (see attached RCSC Proposed Change: S12-046) (Curven): The terms Torque and Tension are regularly used in structural bolting, but do not have official definitions within the Specification. The presented language should be written in context as it relates to bolts, not in the physics definition as written in the proposed change. A task group composed of Curven (chair), Shneur, Mayes, Brown & Birkemoe shall propose new definitions for torque and tension which are germane to the RCSC type of work, not dictionary definitions.

**ACTION ITEM 2012-12 (A.1):** A task group composed of Curven, Carter & Birkemoe to propose new language and submit to Executive Board for review and consideration for Specification Committee action.

**ITEM 7.0 <u>Task Group (TG) Reports:</u>**

7.1 Turn-of-the-Nut Parameters - A325T (S08-020B) (Greenslade):
No progress to report from Nucor (Gialamas) testing program. Greenslade suggested that the TG be disbanded.

7.2 SI Specification (Greenslade): ASTM for metric structural bolts has been completed; limited interest in metric bolts. Greenslade suggested that the TG be disbanded.

7.3 S12-042 Slip Critical Connections (AISC) (Schlafly): See discussion in Section 6.4.

7.4 S12-043 Snug-Tight TC Bolts (Schlafly): See discussion in Section 6.5.

7.5 Shear Allowables (from Ballot S08-024) (Yura): Yura not present, no progress to report.

7.6 Oversize Holes - Slip Critical? (Shear Connections) (Yura): Yura not present, no progress to report.

7.7 Calibrated Wrench Installation (Vissat): TG report presented in 2011; removed from agenda.

7.8 Thick Coatings (Birkemoe): Long term creep effects on thick coatings. No progress to report.

7.9 Large standard hole sizes (Carter): For high strength bolts greater than 1-1/4-inch in diameter, the upper limit bolt fabrication tolerance (ASME B18.2.6) exceeds the standard bolt hole diameter listed in RCSC Table 3.1, therefore field installation is a problem. The tolerance problem is increased when galvanized bolts are introduced into painted/galvanized connections. Two options suggested to resolve the problem: change hole size for high strength bolts greater than 1-1/4-inch in diameter; not the preferred option; and work with ASME B18.2.6 specification committee to revise upper bound tolerance to 0.062-inch (currently at 0.09-inch). Further discussion followed (Greenslade, Larsen, Schlafly, Mitchell, Kasper, Miazga). ASME B18.2.8 specification committee is aware of the issue. Problem will not be resolved overnight; older bolts will be in inventory for years. The bolt manufacturing processes (hot/cold formed, cut/rolled threads, up-setting operation) will dictate if a secondary operation is required in order to meet the end user's needs. See attached Bolt Holes and Tolerances report by Drake & Hunt.

7.10 S11-038 Pre-installation Verification Testing Language (Curven): See discussion in Section 6.1.

**ITEM 8.0 <u>Old Business:</u> (Harrold)**

8.1 Length Tolerance on bolts (Lohr)
Looking for feedback from producers regarding bolt length tolerances specified in ASME B18.2.6. Lohr was not present and has not provided Greenslade with proposed change to the current ASME specification; no action taken.

**ACTION ITEM 2012-13 (A.1)**: Lohr to propose language change to ASME B18.2.6 regarding bolt length tolerance and present to Greenslade. Greenslade will present proposed change to ASME specification committee.

8.2 University of Cincinnati Bolt Research – Where do we go from here? (Swanson): Research completed; results did not suggest changes to the current specification. Unless someone wants to pursue the research for further discussion or propose changes to the specification, this topic will be dropped from future Old Business agenda.

**ACTION ITEM 2011-14 (A.1)**: Drop from Old Business agenda, unless someone wants to pursue this research for further discussion or propose changes to the current specification. Forward request to Harrold, so topic can be added to future New Business agenda.

8.3 Request to modify prohibition of non-steel items in grip of HS bolted joints (Schlafly): See attached report to committee, Thermal Bridging: Nonmetallic Materials in Bolted Joints.
Schlafly presented task group (Gibble, Schlafly, Yura) report. Present specification provision limits potential thermal bridging strategies; Section 3.1 Connected Plies, requires that "All connected plies that are within the grip of the bolt and any materials that are used under the head or nut shall be steel…Compressible materials shall not be placed within the grip of the bolt". To accommodate thermal bridging demands in bolted joints, research and a change to the present specification language needs to be considered: develop installation methods and design values for HS bolted joints within non-steel materials in the grip; develop material property requirements for non-steel materials that would be permitted in the grip of HS bolted joints. Funding from AISC and the Pankow Foundation has committed to having Dr. Hajjar at Northeastern University conduct a study on the subject.

**ACTION ITEM 2012-15 (A.1)**: As research funding or specification revisions by RCSC are requested, task group will send Harrold a reminder to add to future agenda.

**ITEM 9.0 <u>New Business:</u> (Harrold)**

9.1 Failures due to tightening bolts from the head side (Mitchell): Delayed failures of ASTM A325 galvanized and A490 black bolts on bridge work when tightened from the head side (Mitchell): Testing will be conducted within the next few weeks. Set-up similar to that of a compression slip test specimen: (3) ¾-inch Grade 50 steel plates, 7/8-inch diameter A325 bolts, hardened washer under the turned element, installed by turn-of-nut method. Checking torque values when bolt heads and nuts are turned with a load applied to the ¾-inch steel plates, which bears on the shank of the bolt. Further discussion followed (Birkemoe, Greenslade, Friel, Mayes, Curven, Kasper). Suggest testing both cold and hot form headed bolts (fins).

**ACTION ITEM 2012-16 (A.1)**: Harrold will add to 2013 agenda, G. Mitchell to report on testing results.

9.2 Appendix A creep tests at service load level (Yura): Yura not present for discussion. Related to proposed specification change S11-033; review Appendix A creep test using service load level in light of Appendix B merge into Main Specification.

**ACTION ITEM 2012-17 (A.1)**: Harrold will add to 2013 agenda, J. Yura to report on this topic.

9.3 EOR to specify actual hole size for oversize holes (Shaw): Shaw to provide input to Hole Definition (S11-035) Task Group; see discussion in Section 5.3. Further discussion was held-off pending Task Group report/recommendations; no additional progress to report.

9.4 Match-marking language for turn-of-nut (Kasper): Present language in the Specification does not require match-marking the nut and bolt position when pre-tensioning the assembly using the turn-of-nut method. In other parts of the world, match-marking is a requirement. Kasper suggested establishing a task group to draft language for inclusion into the Specification.

**ACTION ITEM 2012-18 (A.1):** A task group composed of Kasper (chair), Mayes, Mitchell & Shaw to propose new language and submit to Executive Committee for review and consideration for Specification Committee action.

9.5 Glossary Definition of Torque (Shaw, Curven): See discussion in Section 6.8.

**ITEM 10.0 <u>Liaison Reports:</u>**

10.1 AISC (Carter): Carter suggested that RCSC submit Specification changes approved and into AISC no later than end of year 2013; preferably by the 2013 annual meeting. AISC starts their balloting process January 2014. Schafly reported on two research projects: 1) AISC has teamed-up with the Pankow Foundation to study Thermal Bridging. 2) Proposal has been developed to study slip coefficient values on galvanized surfaces with respect to long term creep effects; decision to move forward is forth coming. Schafly would like to see RCSC support both research projects. Schafly reported on TC6 AISC Connection Task Committee activity: proposal submitted to look at the provisions for checking the strength of bolted materials; separate formula for bearing and tear-out; presently written as a duel function in a separate formula. Proposal considers concerns for deformation and non-deformation limit states.

10.2 S16 (Miazga): See attached report. The 2009 RCSC Specification was reviewed and compared with ANSI/AISC 360-2010, CSA S16-09, CSA S6-06 and AASHTO 4th edition. Highlights of differences between specifications:

- Equations to evaluate slip.
- Equations for evaluating the behavior of long joints.
- The effects of fillers on the behavior of lap joints.

Future efforts:

- Monitor development of major standards
- Stay familiar with research leading to changes in AISC, CSA & AASHTO

Anyone interested in joining this committee is to see Greg Miazga.

10.3 ASTM F16 (Greenslade): A new coating manufactured by Magni Products was approved for application to ASTM A490 bolts; variation to Zn/Al corrosion coating system. A proposal was presented to discuss combining several ASTM standards into one standard; A490/A325/A490M/A325M/F1852 & F2280. Also under a separate ASTM standard, a proposal to combine the following standards: A563/A563M/F959/F959M/F436 & F436M. The proposal will need to go thru the balloting process. Metric version for structural fastener standard, ASME B18.2.6M, passed the balloting process. ASTM F959 DTI heat treatment requirements; approved new language at the subcommittee level, needs to go to the main committee for balloting; hardness requirements to be optional to the manufacturer. Lots of discussions between RCSC, ASTM & AISC regarding the performance of Zn/Al coatings on fasteners; field fit-up problems, nuts and bolts can't be assembled. ASTM F2329 & F1136 committee members are looking for commentary from the manufactures regarding Zn/Al coatings such as Dacromet, Geomet & Magni are or are not to be considered as direct substitutes to hot dip galvanized coatings.

**ITEM 11.0 Date and time of next meeting:**

- To be coincident with the next annual meeting of the Research Council on Structural Connections

**ITEM 12.0 Adjournment:**

- No motion was presented, Harrold declared the Specification Committee A.1 meeting adjourned; meeting disbanded at 11:55am.

**ITEM 13.0 Attachments:**

13.1 Agenda (Item 3.0):

13.2 Tension/Torque/Degrees of Rotation curves (Item 5.0) (Larson)

13.3 Proposed Specification Changes (Item 6.0)

- S11-038
- S12-039
- S12-041
- S12-042
- S12-043
- S12-044
- S12-045
- S12-046

13.4 Task Group (TG) (Item 7.0)

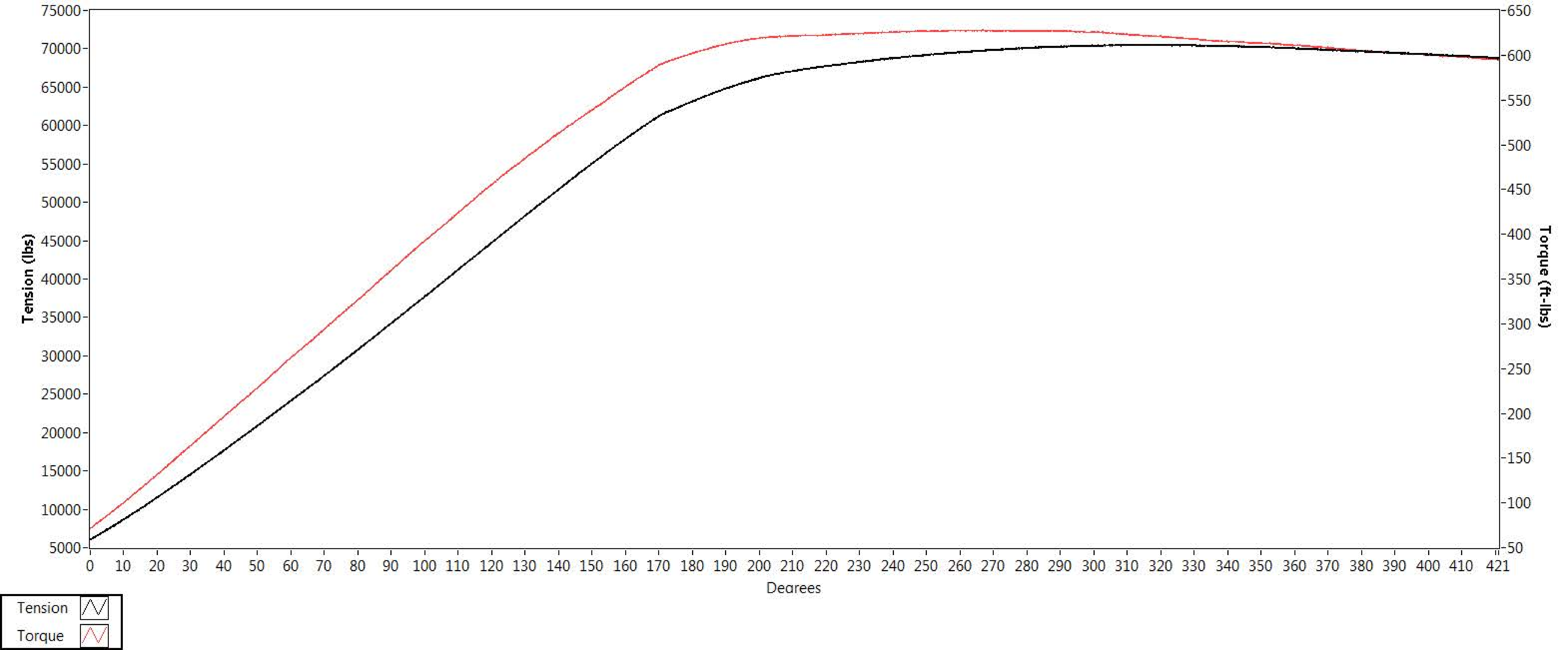
- Bolt Holes & Tolerances by Drake and Hunt)

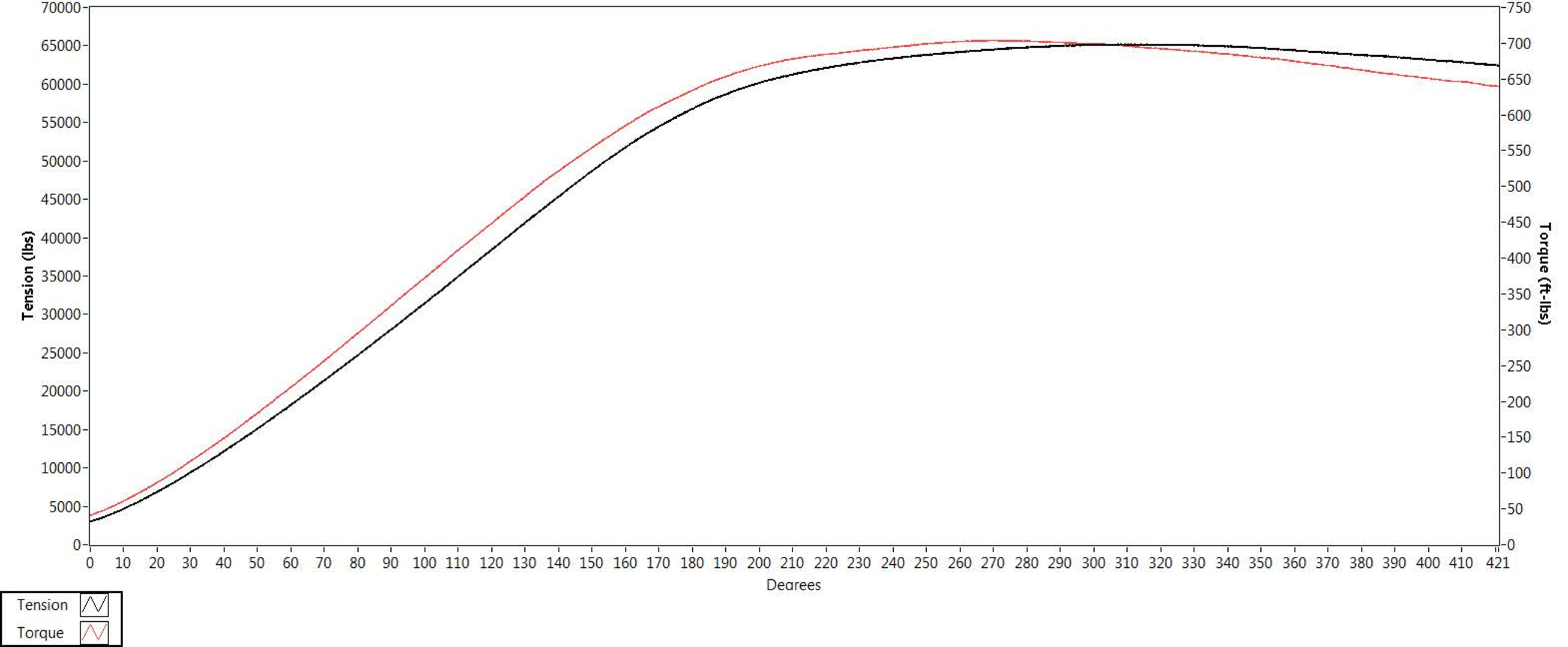
13.5 Old Business (Item 8.0):

- Thermal Bridging Report to the Committee (Schlafly)

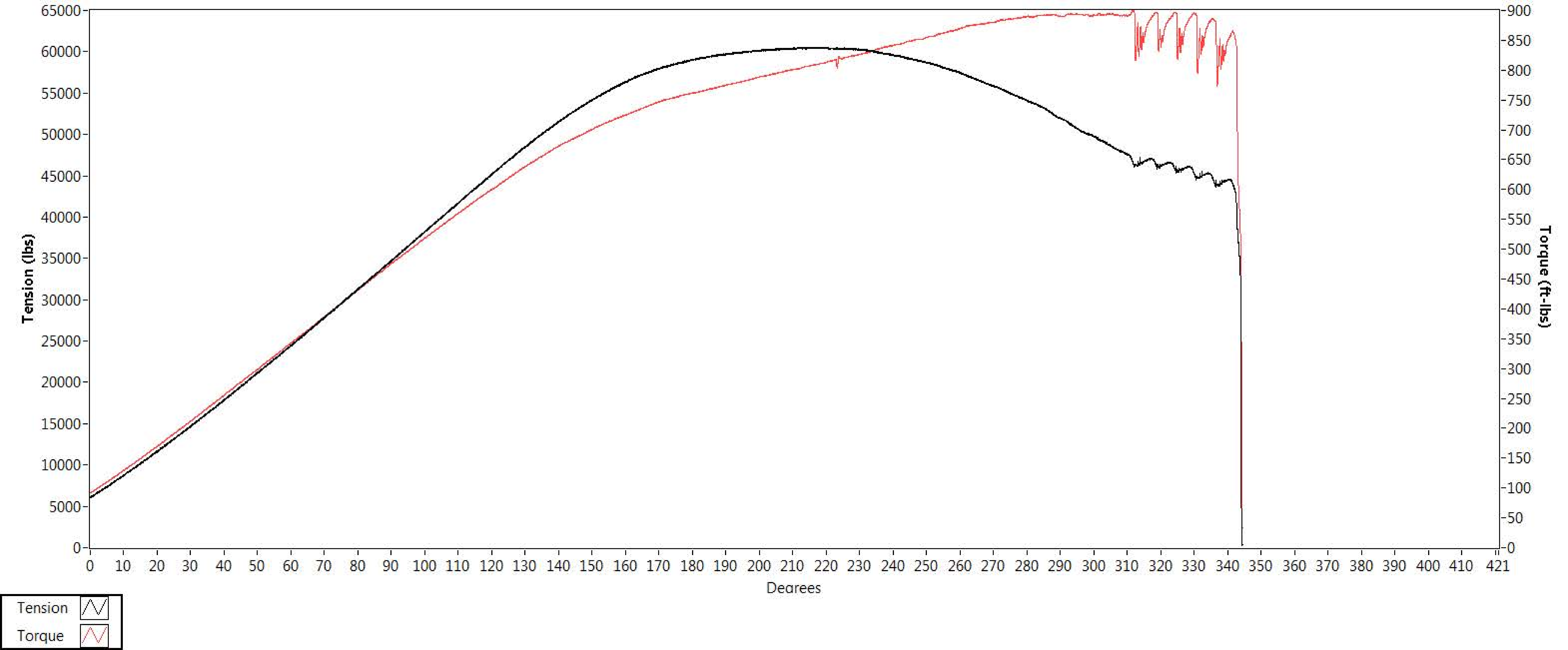
13.6 Liaison Reports (Item 10.0):

- RCSC Liaison Report (S16) (Miazga)

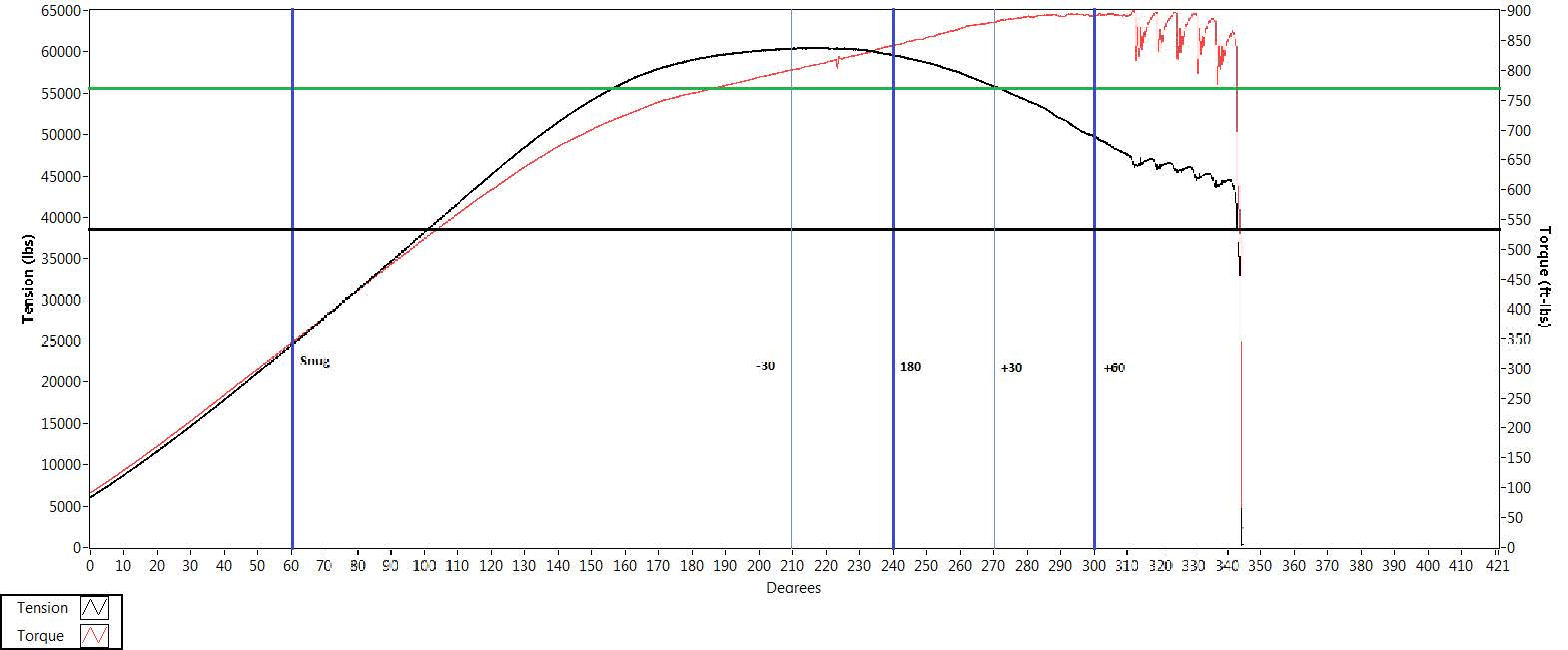

Tension (lbs)
Torque (ft-lbs)
Degrees
Tension
Torque
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
650
600
550
500
450
400
350
300
250
200
150
100
50
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390 400 410 421

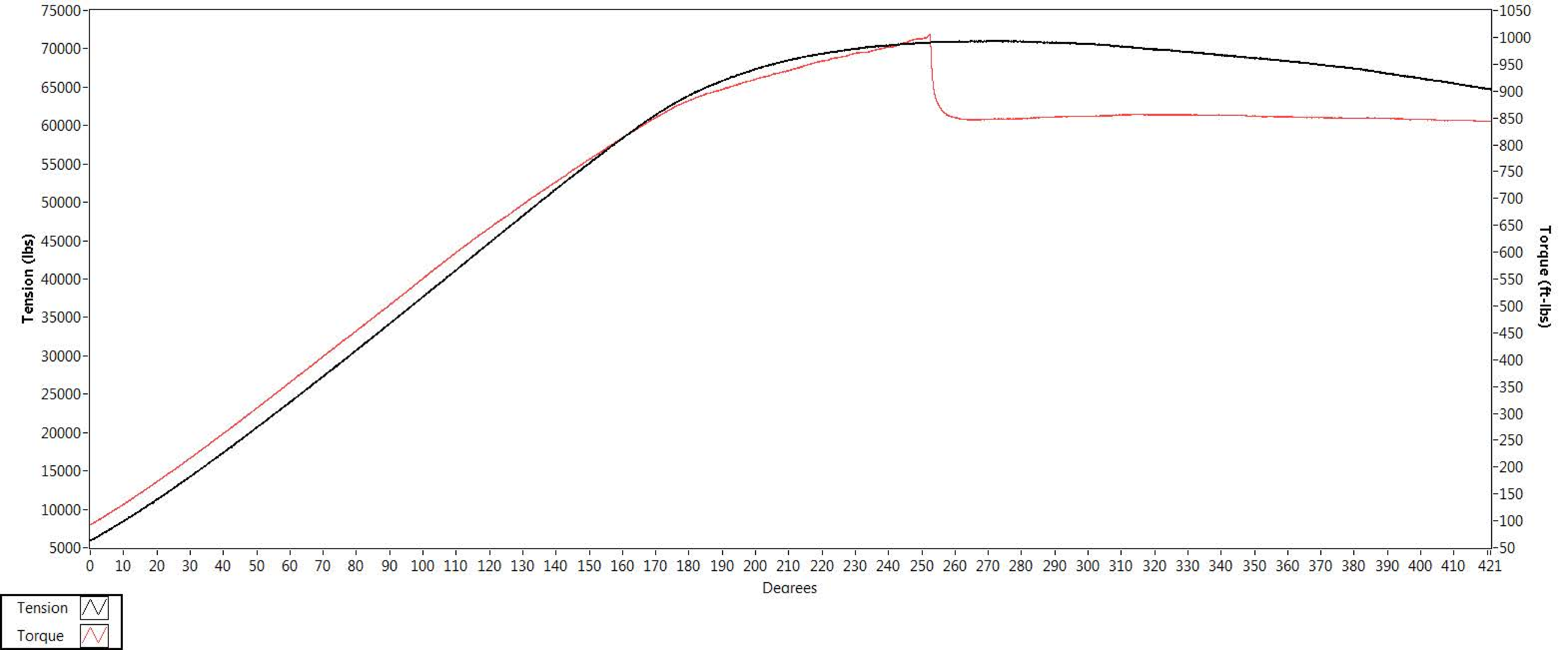


Tension (lbs)
Torque (ft-lbs)
Degrees
Tension
Torque
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
55000
60000
65000
70000
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390 400 410 421



Tension (lbs)
Torque (ft-lbs)
Degrees
Tension
Torque


Tension (lbs)
Torque (ft-lbs)
Degrees
Snug
-30
180
+30
+60
Tension
Torque



Tension (lbs)
Torque (ft-lbs)
Degrees
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
1050
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390 400 410 421
Tension
Torque

# RCSC Proposed Change:  S11-038

**Name:** Chris Curven **E-mail: chrisc@appliedbolting.com**

**Phone:** 802-460-3100______ **Fax:** ________________________________________

**Ballot History:**

**Proposed Change:**

**8.2. Pretensioned Joints and Slip-Critical Joints**

One of the pretensioning methods in Sections 8.2.1 through 8.2.4 shall be used, except when alternative-design fasteners that meet the requirements of Section 2.8 or alternative washer-type indicating devices that meet the requirements of Section 2.6.2 are used, in which case, installation instructions provided by the *manufacturer* and approved by the *Engineer of Record* shall be followed.

*{Table 8.1 "Minimum Bolt Pretension, Pretensioned and Slip-Critical Joints" is unchanged and will not be reproduced here.}*

When it is impractical to turn the nut, pretensioning by turning the bolt head is permitted while rotation of the nut is prevented, provided that the washer requirements in Section 6.2 are met. A pretension that is equal to or greater than the value in Table 8.1 shall be provided. The pre-installation verification procedures specified in Section 7 shall be performed as indicated in Sections 8.2.1 through 8.2.4, using *fastener assemblies* that are representative of the condition of those that will be pretensioned in the work.

The required p~~P~~re-installation testing shall be performed for each fastener assembly lot prior to the use of that assembly lot in the work. The testing shall be done at the start of the work. For calibrated wrench pretensioning, this testing shall be performed daily for the calibration of the installation wrench.

**Commentary:**
*{There are no proposed changes to the commentary for this subsection.}*

8.2.1. Turn-of-Nut Pretensioning: The pre-installation verification procedures specified in Section 7 shall demonstrate that the required rotation from snug-tight shall reach at least the minimum required tension in Table 7.1. All bolts shall be installed in accordance with the requirements in Section 8.1, with washers positioned as required in Section 6.2. Subsequently, the nut or head rotation specified in Table 8.2 shall be applied to all *fastener assemblies* in the *joint*,

-------------------------------------For Committee Use Below---------------------------------------------

Date Received: 6/10/11 Exec Com Meeting: _6/11___ Forwarded: Yes X /No □

Committee Assignment: Executive -A. □ Editorial -B. □ Nominating -C. □

Specifications -A.1 X Research -A.2 □ Membership & Funding -A.3 □ Education -A.4 □

Committee Chair: Harrold Task Group #: ___________ T.G. Chair: Curven

Date Sent to Main Committee: _______________Final Disposition: ______________________

progressing systematically from the most rigid part of the *joint* in a manner that will minimize relaxation of previously pretensioned bolts. The part not turned by the wrench shall be prevented from rotating during this operation. Upon completion of the application of the required nut rotation for pretensioning, it is not permitted to turn the nut in the loosening direction except for the purpose of complete removal of the individual fastener assembly. Such fastener assemblies shall not be reused except as permitted in Section 2.3.3.

*{Table 8.2 "Nut Rotation from Snug-Tight Condition for Turn-of-Nut Pretensioning" is unchanged and will not be reproduced here.}*

**Commentary:**
*{There are no proposed changes to the commentary for this subsection.}*

8.2.2. Calibrated Wrench Pretensioning:
*{There are no proposed changes to this subsection.}*

8.2.3. Twist-Off-Type Tension-Control Bolt Pretensioning: Twist-off-type tension-control bolt assemblies that meet the requirements of ASTM F1852 or F2280 shall be used. The pre-installation verification procedures specified in Section 7 shall demonstrate that, when the splined end is severed off with the required tool, the bolt tension shall be at least equal to that required in Table 7.1.

All *fastener assemblies* shall be installed in accordance with the requirements in Section 8.1 without severing the splined end and with washers positioned as required in Section 6.2. If a splined end is severed during this operation, the *fastener assembly* shall be removed and replaced. Subsequently, all bolts in the *joint* shall be pretensioned with the twist-off-type tension-control bolt installation wrench, progressing systematically from the most rigid part of the *joint* in a manner that will minimize relaxation of previously pretensioned bolts.

**Commentary:**
*{There are no proposed changes to the commentary for this subsection.}*

8.2.4. Direct-Tension-Indicator Pretensioning:
*{There are no proposed changes to this subsection.}*

**Rationale or Justification for Change (attach additional pages as needed):**

Sections 9.2.1 and 9.2.3 make a reference to the pre-installation verification testing in Sections 8.2.1 and 8.2.3 respectively. There is currently no language in Sections 8.2.1 and 8.2.3 that refer to the pre-installation testing.

This proposal corrects that omission and makes all four subsections of Section 8.2 refer to Chapter 7 pre-installation requirements in an equivalent manner.

# RCSC Proposed Change:  S12-039

**Name:** Tom Schlafly
**Phone:** 312-670-5412
**E-mail:** schlafly@aisc.org
**Fax:**

**Ballot History:**

**Proposed Change:**
**Table 2.1**

**Table 2.1. Acceptable ASTM A563 Nut Grade and Finish and ASTM F436 Washer Type and Finish**

| ASTM Desig. | Bolt Type | Bolt Finish[d] | ASTM A563 nut grade and finish[d] | ASTM F436 washer type and finish[a,d] |
|---|---|---|---|---|
| A325 | 1 | Plain (uncoated) | C, C3, D, DH[c] and DH3; plain | 1; plain |
| | | Galvanized | DH[c]; galvanized and lubricated | 1; galvanized |
| | | Zn/Al Inorganic, per ASTM F1136 Grade 3 | DH[c]; Zn/Al Inorganic, per ASTM F1136 Grade 5 | 1; Zn/Al Inorganic, per ASTM F1136 Grade 3[b] |
| | 3 | Plain | C3 and DH3; plain | 3; plain |
| F1852 | 1 | Plain (uncoated) | C, C3, DH[c] and DH3; plain | 1; plain[b] |
| | | Mechanically Galvanized | DH [c]; mechanically galvanized and lubricated | 1; mechanically galvanized[b] |
| | | ~~Zn/Al Inorganic, per ASTM F1136 Grade 3~~ | ~~DH[c]; Zn/Al Inorganic, per ASTM F1136 Grade 5~~ | ~~1; Zn/Al Inorganic, per ASTM F1136 Grade 3[b]~~ |
| | 3 | Plain | C3 and DH3; plain | 3; plain[b] |
| A490 | 1 | Plain | DH[c] and DH3; plain | 1; plain |
| | | Zn/Al Inorganic, per ASTM F1136 Grade 3 | DH[c]; Zn/Al Inorganic, per ASTM F1136 Grade 5 | 1; Zn/Al Inorganic, per ASTM F1136 Grade 3[b] |
| | 3 | Plain | DH3; plain | 3; plain |
| F2280 | 1 | Plain | DH[c] and DH3; plain | 1; plain |
| | 3 | Plain | DH3; plain | 3; plain |

-----------------------------------For Committee Use Below---------------------------------------------

Date Received:  1/05/12  Exec Com Meeting: 1/19/12 Forwarded: Yes X /No ☐

Committee Assignment:  Executive -A. ☐   Editorial -B. ☐   Nominating -C. ☐

Specifications -A.1  X   Research -A.2 ☐  Membership & Funding -A.3 ☐  Education -A.4 ☐

Committee Chair:  Harrold   Task Group #: ___________ T.G. Chair: ________________

Date Sent to Main Committee:  _______________Final Disposition: ______________________

[a] Applicable only if washer is required in Section 6.

[b] Required in all cases under nut per Section 6.

[c] The substitution of ASTM A194 grade 2H nuts in place of ASTM A563 grade DH nuts is permitted.

[d] "Galvanized" as used in this table refers to hot-dip galvanizing in accordance with ASTM F2329 or mechanical galvanizing in accordance with ASTM B695.

[e] "Zn/Al Inorganic" as used in this table refers to application of a Zn/Al Corrosion Protective Coating in accordance with ASTM F1136 which has met all the requirements of IFI-144.

**Section 2.3.3 Commentary**

*{Modification is to the fourth paragraph of the commentary. All other portions of the Commentary are unchanged.}*

An extensive investigation conducted in accordance with IFI-144 was completed in 2006 and presented to the ASTM F16 Committee on Fasteners (F16 Research Report RR: F16-1001). The investigation demonstrated that Zn/Al Inorganic Coating, when applied per ASTM F1136 Grade 3 to ASTM A490 bolts, does not cause delayed cracking by internal hydrogen embrittlement, nor does it accelerate environmental hydrogen embrittlement by cathodic hydrogen absorption. It was determined that this is an acceptable finish to be used on Type 1 ASTM A325 and A490 bolts~~ and F1852 and F2280 twist-off-type tension-control bolt assemblies~~.

**Rationale or Justification for Change (attach additional pages as needed):**

At the present time, ASTM has not accepted the use of the Zn/Al Inorganic coating on either the F1852 or F2280 tension-control bolt assemblies. There have been some concerns raised regarding the proper fabrication of the assembly parts given the significantly different coefficient of friction generated by the Zn/Al coating in comparison with normal lubricated assemblies. This difference could result in bolts that have not been properly tensioned.

# RCSC Proposed Change: S12-041

**Name:** Tom Schlafly **E-mail:** schalfly@aisc.org
**Phone:** 312-670-5412 **Fax:**

**Proposed Change:**

No changes proposed for the Specification itself.

**Section 6.2.5 Commentary**
***{Only the third paragraph of the commentary has a change proposed.}***

Heat-treated washers not less than 5/16 in. thick are required to cover oversized and short-slotted holes in external plies, when ASTM A490 or F2280 bolts of diameter larger than 1 in. are used, except as permitted by ~~per~~ Table 6.1 footnotes a and d. This was found necessary to distribute the high clamping pressure so as to prevent collapse of the hole perimeter and enable the development of the desired clamping force. Preliminary investigation has shown that a similar but less severe deformation occurs when oversized or slotted holes are in the interior plies. The reduction in clamping force may be offset by "keying," which tends to increase the resistance to slip. These effects are accentuated in *joints* of thin plies. When long-slotted holes occur in an outer ply, ⅜ in. thick plate washers or continuous bars and one ASTM F436 washer are required in Table 6.1. This requirement can be satisfied with material of any structural grade. Alternatively, either of the following options can be used:

**Rationale or Justification for Change (attach additional pages as needed):**
This is a continuation of change S09-028 that was approved in 2010 that added the applicability of Table 6.1 footnote "a" to the condition of A490 or F2280 bolts greater than 1" diameter when oversized or short-slotted holes exist in an outer ply. While the Specification language was updated, the inclusion of the footnote "a" reference in the supporting Commentary was missed.

------------------------------------For Committee Use Below----------------------------------------------

Date Received: 5/3/2012 Exec Com Meeting: _______ Forwarded: Yes ☐ /No ☐

Committee Assignment: Executive -A. ☐ Editorial -B. ☐ Nominating -C. ☐

Specifications -A.1 ☐ Research -A.2 ☐ Membership & Funding -A.3 ☐ Education -A.4 ☐
Committee Chair: ____________ Task Group #: ___________ T.G. Chair: ________________
Date Sent to Main Committee: _______________Final Disposition: ______________________

# RCSC Proposed Change: S12-042

**Name:** Tom Schlafly
**Phone:** 312-670-5412
**E-mail:** schlafly@aisc.org
**Fax:**

**Ballot Actions:**

**Proposed Change:**

## 5.4. Design Slip Resistance

Slip-critical connections shall be designed to prevent slip and for the limit states of bearing-type connections. When slip-critical bolts pass through fillers, all *faying surfaces* subject to slip shall be prepared to achieve design slip resistance.

At US LRFD or Canadian LSD load levels the design slip resistance is $\phi R_n$ and at ASD load levels the allowable slip resistance is $R_n/\Omega$ where $R_n$,, $\phi$ and $\Omega$ are defined below.

The available slip resistance for the limit state of slip shall be determined as follows:

$$R_n = \mu D_u h_f T_b n_s k_{sc} \qquad \text{Equation 5.6}$$

For standard size and short-slotted holes perpendicular to the direction of the load

$\phi = 1.00$ (LRFD, LSD) $\Omega = 1.50$ (ASD)

For oversized and short-slotted holes parallel to the direction of the load

$\phi = 0.85$ (LRFD, LSD) $\Omega = 1.76$ (ASD)

For long-slotted holes

$\phi = 0.70$ (LRFD, LSD) $\Omega = 2.14$ (ASD)

where

$\mu$ = mean slip coefficient for Class A or B surfaces, as applicable, and determined as follows, or as established by tests:

(1) For Class A surfaces (unpainted clean mill scale steel surfaces or surfaces with Class A coatings on blast-cleaned steel or hot-dipped galvanized and roughened surfaces)

$\mu = 0.30$

(2) For Class B surfaces (unpainted blast-cleaned steel surfaces or surfaces with Class B coatings on blast-cleaned steel)

------------------------------------For Committee Use Below-----------------------------------------------

Date Received: ______ Exec Com Meeting: _______ Forwarded: Yes ☐ /No ☐

Committee Assignment: Executive -A. ☐ Editorial -B. ☐ Nominating -C. ☐

Specifications -A.1 X Research -A.2 ☐ Membership & Funding -A.3 ☐ Education -A.4 ☐

Committee Chair: Harrold Task Group #: ___________ T.G. Chair: Schlafly

Date Sent to Main Committee: _______________Final Disposition: ______________________

$\mu = 0.50$

$D_u$ = 1.13; a multiplier that reflects the ratio of the mean installed bolt pretension to the specified minimum bolt pretension; the use of other values may be approved by the engineer of record.

$T_b$ = minimum fastener tension given in Table 8.1, kips

$h_f$ = factor for fillers, determined as follows:

(1) Where there are no fillers or bolts have been added to distribute loads in the filler

$h_f = 1.0$

(2) Where bolts have not been added to distribute the load in the filler:

(i) For one filler between connected parts

$h_f = 1.0$

(ii) For two or more fillers between connected parts

$h_f = 0.85$

$n_s$ = number of slip planes required to permit the connection to slip

$$k_{sc} = 1 - \frac{T_u}{D_u T_b n_b} \quad \text{(LRFD, LSD)}$$

$$= 1 - \frac{1.5 T_a}{D_u T_b n_b} \quad \text{(ASD)}$$

where

$T_a$ = required tension force using *ASD load combinations*, kips
$T_u$ = required tension force using US *LRFD or Canadian LSD load combinations*, kips
$n_b$ = number of bolts carrying the applied tension

~~5.4.1. At the Factored-Load Level: The design slip resistance is $\phi R_n$, where $\phi$ is as defined below and:~~

$$\cancel{R_n = \mu D_u T_m N_b \left(1 - \frac{T_u}{D_u T_m N_b}\right)} \quad \text{~~(Equation 5.6)~~}$$

~~where~~

~~$\phi$ = 1.0 for standard holes~~

~~= 0.85 for oversized and short-slotted holes~~

~~= 0.70 for long-slotted holes perpendicular to the direction of load~~

~~= 0.60 for long-slotted holes parallel to the direction of load;~~

~~$R_n$ = *nominal strength* (slip resistance) of a slip plane, kips;~~

~~$\mu$ = *mean slip coefficient* for Class A, B or C *faying surfaces*, as applicable, or as established by testing in accordance with Appendix A (see Section 3.2.2(b))~~

~~= 0.33 for Class A *faying surfaces* (uncoated clean mill scale steel surfaces or surfaces with Class A coatings on blast-cleaned steel)~~

~~= 0.50 for Class B surfaces (uncoated blast-cleaned steel surfaces or surfaces with Class B coatings on blast-cleaned steel)~~

~~= 0.35 for Class C surfaces (roughened hot-dip galvanized surfaces);~~

~~$D_u$ = 1.13, a multiplier that reflects the ratio of the mean installed bolt pretension to the specified minimum bolt pretension $T_m$; the use of other values of $D_u$ shall be approved by the *Engineer of Record;*~~

~~$T_m$ = specified minimum bolt pretension (for *pretensioned joints* as specified in Table 8.1), kips;~~

~~$N_b$ = number of bolts in the *joint*; and,~~

~~$T_u$ = *required strength* in tension (tensile component of applied factored load for combined shear and tension loading), kips~~

~~= zero if the *joint* is subject to shear only~~

~~5.4.2. At the Service-Load Level: The service-load slip resistance is $\phi R_s$, where $\phi$ is as defined in Section 5.4.1 and:~~

$$R_n = \mu D T_m N_b \left(1 - \frac{T}{D T_m N_b}\right) \qquad \text{(Equation 5.7)}$$

~~where~~

~~$D$ = 0.80, a slip probability factor that reflects the distribution of actual slip coefficient values about the mean, the ratio of mean installed bolt pretension to the specified minimum bolt pretension, $T_m$, and a slip probability level; the use of other values of $D$ must be approved by the *Engineer of Record*; and,~~

~~$T$ = applied service load in tension (tensile component of applied service load for combined shear and tension loading), kips~~

~~= zero if the *joint* is subject to shear only~~

~~and all other variables are as defined for Equation 5.6.~~

**Commentary:**

~~The design check for slip resistance can be made either at the factored-load level (Section 5.4.1) or at the service-load level (Section 5.4.2). These alternatives are based upon different design philosophies, which are discussed below. They have been calibrated to produce results that are essentially the same. The factored-load level approach is~~

~~provided for the expedience of only working with factored loads. Irrespective of the approach, the limit state is based upon the prevention of slip at service-load levels.~~

~~If the factored-load provision is used, the~~ The *nominal strength* $R_n$ represents the mean resistance, which is a function of the *mean slip coefficient* μ and the specified minimum bolt pretension (clamping force) $T_m$. The 1.13 multiplier in Equation 5.6 accounts for the ~~expected 13 percent higher mean value of the installed bolt pretension provided by the calibrated wrench pretensioning method compared to the specified minimum bolt pretension $T_m$ used in the calculation.~~ statistical relationship between calculated slip resistance and historical measured test results. In the absence of other field test data, this value is used for all methods.

~~If the service-load approach is used, a probability of slip is identified. It implies that there is 90 percent reliability that slip will not occur at the calculated slip load if the calibrated wrench pretensioning method is used, or that there is 95 percent reliability that slip will not occur at the calculated slip load if the turn-of-nut pretensioning method is used. The probability of loading occurrence was not considered in developing these slip probabilities (Kulak et al., 1987; p. 135).~~

For most applications, the assumption that the slip resistance at each fastener is equal and additive with that at the other fasteners is based on the fact that all locations must develop the slip force before a total *joint* slip can occur at that plane. Similarly, the forces developed at various slip planes do not necessarily develop simultaneously, but one can assume that the full slip resistances must be mobilized at each plane before full *joint* slip can occur. ~~Equations 5.6 and 5.7 are formulated for the general case of a single slip plane. The total slip resistance of a *joint* with multiple slip planes can be calculated as that for a single slip plane multiplied by the number of slip planes.~~

The nominal resistance in 5.4 results in a reliability consistent with the reliability of structural member design. The engineer should not need to design to a higher reliability in normal structural applications. ~~Only the *Engineer of Record* can determine whether the potential slippage of a *joint* is critical at the service-load level as a serviceability consideration only or whether slippage could result in distortions of the frame such that the ability of the frame to resist the factored loads would be reduced.~~ The following comments reflect the collective thinking of the Council and are provided as guidance and an indication of the intent of the Specification (see also the Commentary to Sections 4.2 and 4.3):

(1) If *joints* with standard holes have only one or two bolts in the direction of the applied load, a small slip may occur. In this case, *joints* subject to vibration should be proportioned to resist slip ~~at the service-load level~~;

(2) In built-up compression members, such as double-angle struts in trusses, a small relative slip between the elements especially at the end *connections* can increase the effective length of the combined cross-section to that of the individual components and significantly reduce the compressive strength of the strut. Therefore, the *connection* between the elements at the ends of built-up members should be checked ~~at the factored-load level~~to prevent slip, whether or not a *slip-critical joint* is required for serviceability. As given by Sherman and Yura (1998), the required slip resistance is $0.008P_uLQ/I$, where $P_u$ is the axial compressive force in the built-up member, kips, $L$ is the total length of the built-up member, in., $Q$ is the first moment of area of one

component about the axis of buckling of the built-up member, in.$^3$, and $I$ is the moment of inertia of the built-up member about the axis of buckling, in.$^4$;

(3) In *joints* with long-slotted holes that are parallel to the direction of the applied load, the ~~designer has two alternatives. The~~ *joint* can be designed to prevent slip ~~in the service-load range using either the factored-load-level provision in Section 5.4.1 or the service-load-level provision in Section 5.4.2. In either case~~, however, the effect of the factored loads acting on the deformed structure (deformed by the maximum amount of slip in the long slots at all locations) must be included in the structural analysis; and,

(4) In *joints* subject to fatigue, design should be based upon service-load criteria and the design slip resistance of ~~Section 5.4.2~~ the governing cyclic design specification because fatigue is a function of the service load performance rather than that of the factored load.

Extensive data developed through research sponsored by the Council and others during the past twenty years has been statistically analyzed to provide improved information on slip probability of *joints* in which the bolts have been pretensioned to the requirements of Table 8.1. Two variables, the *mean slip coefficient* of the *faying surfaces* and the bolt pretension, were found to affect the slip resistance of *joints*. Field studies (Kulak and Birkemoe, 1993) of installed bolts in various structural applications indicate that the Table 8.1 pretensions have been achieved as anticipated in the laboratory research.

An examination of the slip-coefficient data for a wide range of surface conditions indicates that the data are distributed normally and the standard deviation is essentially the same for each surface condition class. This means that different reduction factors should be applied to classes of surfaces with different *mean slip coefficients*—the smaller the mean value of the coefficient of friction, the smaller (more severe) the appropriate reduction factor—to provide equivalent reliability of slip resistance.

The bolt clamping force data indicate that bolt pretensions are distributed normally for each pretensioning method. However, the data also indicate that the mean value of the bolt pretension is different for each method. ~~As noted previously, if~~ If the calibrated wrench method is used to pretension ASTM A325 bolts, the mean value of bolt pretension is about 1.13 times the specified minimum pretension in Table 8.1. If the turn-of-nut pretensioning method is used, the mean pretension is about 1.35 times the specified minimum pretension for ASTM A325 bolts and about 1.26 for ASTM A490 bolts.

The combined effects of the variability of the *mean slip coefficient* and bolt pretension have been accounted for approximately in the single value of the slip probability factor ~~$D$~~$D_u$ in the equation for nominal slip resistance ~~in Section 5.4.2~~. This implies ~~90 percent reliability~~ that slip will not occur ~~if the calibrated wrench pretensioning method is used and 95 percent reliability if the turn-of-nut pretensioning method is used. For values of *D* that are appropriate for other *mean slip coefficients* and slip probabilities, refer to the *Guide* (Kulak et al., 1987; p. 135). The values given therein are suitable for direct substitution into the formula for slip resistance in Section 5.4.2.~~with a beta of at least 2.6 regardless of the method of pretensioning.

The calibrated wrench installation method targets a specific bolt pretension, which is 5 percent greater than the specified minimum value given in Table 8.1. Thus, regardless of the actual strength of production bolts, this target value is unique for a given fastener grade. On the other hand, the turn-of-nut installation method imposes an elongation on the fastener. Consequently, the inherent strength of the bolts being installed will be reflected in the resulting pretension because this elongation will bring the fastener to its proportional limit under combined torsion and tension. As a result of these differences, the mean value and nature of the frequency distribution of pretensions for the two installation methods differ. Turn-of-nut installations result in higher mean levels of pretension than do calibrated wrench installations. <u>Twist-off type tension control bolt and direct tension indicator pretensions are similar to those of calibrated wrench.</u> These differences were taken into account when the design criteria for *slip-critical joints* were developed.

~~Statistical information on the pretension characteristics of bolts installed in the field using direct tension indicators and twist-off-type tension-control bolts is limited.~~

In any of the foregoing installation methods, it can be expected that a portion of the bolt assembly (the threaded portion of the bolt within the *grip* length and/or the engaged threads of the nut and bolt) will reach the inelastic region of behavior. This permanent distortion has no undesirable effect on the subsequent performance of the bolt.

Because of the greater likelihood that significant deformation can occur in *joints* with oversized or slotted holes, lower values of design slip resistance are provided for *joints* with these hole types through a modification of the resistance factor $\phi$. For the case of long-slotted holes, even though the slip load is the same for loading transverse or parallel to the axis of the slot, the value for loading parallel to the axis has been further reduced, based upon judgment, in recognition of the greater consequences of slip.

Although the design philosophy for *slip-critical joints* presumes that they do not slip into bearing when subject to loads in the service range, it is mandatory that *slip-critical joints* also meet the requirements of Sections 5.1, 5.2 and 5.3. Thus, they must meet the strength requirements to resist the factored loads as *shear/bearing joints*.

Section 3.2.2(b) permits the *Engineer of Record* to authorize the use of *faying surfaces* with a *mean slip coefficient* $\mu$ that is less than 0.50 (Class B) and other than ~~0.33~~ <u>0.30</u> (Class A). This authorization requires that the <u>*mean slip coefficient* $\mu$ must be determined in accordance with Appendix A.</u> ~~following restrictions are met:~~

~~(1) The *mean slip coefficient* μ must be determined in accordance with Appendix A; and,~~
~~(2) The appropriate slip probability factor *D* must be selected from the *Guide* (Kulak et al., 1987) for design at the service-load level.~~

Prior to the 1994 edition of this Specification, $\mu$ for ~~Class C~~ <u>galvanized</u> surfaces was taken as 0.40. This value was reduced to 0.35 in the 1994 edition for better agreement with the available research (Kulak et al., 1987; pp. 78-82)<u> and to 0.30 in the 2014 edition to be consistent with slip coefficients cited previously</u>.

**Rationale or Justification for Change (attach additional pages as needed):**

Modify the RCSC equations to reflect the information that is contained in the AISC 2010 Specification. This reflects the most recent research on the subject.

Recent research by Hajjar et al, Dusicka et al and Grondin support changes to the formulation for slip resistance. The proposal results in reliability at levels acceptable for use in slip critical connections regardless of whether the slip limit state is considered to be a serviceability or strength limit.
Significant changes from the current specification include:

- The current specification includes three formulae for slip resistance
  - $R_n = \mu D_u T_m N_b \left(1 - \frac{T_u}{D_u T_m N_b}\right)$ *(Equation 5.6)*
  - $R_n = \mu D T_m N_b \left(1 - \frac{T}{D T_m N_b}\right)$ (Equation 5.7)
  - $R_n = H \mu D T_m N_b \left(1 - \frac{T}{D T_m N_b}\right)$ (Equation B5.5)

  All three equations should lead to the same number of bolts. Eq 5.6 uses LRFD loads. Eqs 5.7 and B5.5 use ASD loads. Bolt limit states can be formulated as a nominal resistance factored by a resistance factor (phi) or a safety factor (omega). This method is clear and concise and recommended as (near) future business. But it has not been adopted by RCSC so for consistency this proposal uses the nominal resistance formulation in the text and refers to it in Annex B.
- The basic slip coefficient is 0.30 instead of 0.33. This results in more uniform reliability across bolt strength levels and faying surface slip classes
- The current RCSC equation is for one slip plane but all bolts. The proposed is for any number of slip planes but one bolt.
- Caution has been added to commentary regarding galvanized surfaces because no research has been done subsequent to finding some surfaces with a low coefficient.

# RCSC Proposed Change: S12-043

**Name:** Tom Schlafly
**Phone:** 312-670-5412
**E-mail:** schlafly@aisc.org
**Fax:**

**Ballot Actions:**

**Proposed Change:**

## 8.1. Snug-Tightened Joints

All bolt holes shall be aligned to permit insertion of the bolts without undue damage to the threads. Bolts shall be placed in all holes with washers positioned as required in Section 6.1 and nuts threaded to complete the assembly. Compacting the *joint* to the snug-tight condition shall progress systematically from the most rigid part of the *joint*. Snug tight is the condition that exists when all of the plies in a *connection* have been pulled into *firm contact* by the bolts in the *joint* and all of the bolts in the *joint* have been tightened sufficiently to prevent the removal of the nuts without the use of a wrench.

**Commentary:**
As discussed in the Commentary to Section 4, the bolted *joints* in most shear *connections* and in many tension *connections* can be specified as *snug-tightened joints*. The snug tightened condition is typically achieved with a few impacts of an impact wrench, application of an electric torque wrench until the wrench begins to slow or the full effort of a worker on an ordinary spud wrench. More than one cycle through the bolt pattern may be required to achieve the *snug-tightened joint*. <u>The splines on twist-off type tension-control bolts may be twisted off or left in place in snug tightened joints.</u>

The actual pretensions that result in individual fasteners in *snug-tightened joints* will vary from *joint* to *joint* depending upon the thickness, flatness, and degree of parallelism of the connected plies, as well as the effort applied. In most *joints*, plies of *joints* involving material of ordinary thickness and flatness can be drawn into complete contact at relatively low levels of pretension. However, in some *joints* in thick material or in material with large burrs, it may not be possible to reach continuous contact throughout the *faying surface* area as is commonly achieved in *joints* of thinner plates. This is generally not detrimental to the performance of the *joint*.

As used in Section 8.1, the term “undue damage” is intended to mean damage that would be sufficient to render the product unfit for its intended use.

-----------------------------------For Committee Use Below----------------------------------------------

Date Received: 5/29/12 Exec Com Meeting: _______ Forwarded: Yes ☐ /No ☐

Committee Assignment: Executive -A. ☐ Editorial -B. ☐ Nominating -C. ☐

Specifications -A.1 ☐ Research -A.2 ☐ Membership & Funding -A.3 ☐ Education -A.4 ☐
Committee Chair: ____________ Task Group #: ___________ T.G. Chair: ________________
Date Sent to Main Committee: ________________Final Disposition: ______________________

**Rationale or Justification for Change (attach additional pages as needed):**

The proposed revision is in response to occasional inspector requirements to remove the splines of TC bolts even where they are to be snug tight.

# RCSC Proposed Change:  S12-044

**Name:** Tom Schlafly  **E-mail:** schlafly@aisc.org
**Phone:** 312-670-5412  **Fax:**

**Ballot Actions:**

**Proposed Change:**
*{Note: Proposed Change S11-033 also makes modifications to this section.  The proposed changes are mutually exclusive and should not impact technical decisions on this item.}*

## 5.1. Design Shear and Tensile Strengths

Shear and tensile strengths shall not be reduced by the installed bolt pretension. For *joints*, the design shear and tensile strengths shall be taken as the sum of the strengths of the individual bolts.

The design strength in shear or the design strength in tension for an ASTM A325, A490, F1852 or F2280 bolt is $\phi R_n$, where $\phi$= 0.75 and:

$$R_n = F_n A_b \qquad \text{(Equation 5.1)}$$

where

$R_n$ = nominal strength (shear strength per shear plane or tensile strength) of a bolt, kips;

### Table 5.1. Nominal Strengths per Unit Area of Bolts

| Applied Load Condition | | | *Nominal Strength* per Unit Area, $F_n$, ksi | |
|---|---|---|---|---|
| | | | ASTM A325 or F1852 | ASTM A490 or F2280 |
| Tension [a] | Static | | 90 | 113 |
| | Fatigue | | See Section 5.5 | |
| Shear [a,b] | Threads included in shear plane | $L_s \le 38$ in. | 54 | 68 |
| | | $L_s > 38$ in. | 45 | 56 |
| | Threads excluded from shear plane | $L_s \le 38$ in. | 68 | 84 |
| | | $L_s > 38$ in. | 56 | 70 |

[a] Except as required in Section 5.2.
[b] Reduction for values for $L_s > 38$ in. applies only when the joint is end loaded, such as splice plates on a beam or column flange.

-----------------------------------For Committee Use Below----------------------------------------------

Date Received: 5/31/12 Exec Com Meeting: 6/6/12 Forwarded: Yes ☐ /No ☐

Committee Assignment: Executive -A. ☐ Editorial -B. ☐ Nominating -C. ☐

Specifications -A.1 ☐ Research -A.2 ☐ Membership & Funding -A.3 ☐ Education -A.4 ☐
Committee Chair: _____________ Task Group #: ____________ T.G. Chair: _________________
Date Sent to Main Committee: ________________Final Disposition: ________________________

$F_n$ = nominal strength per unit area from Table 5.1 for the appropriate applied load conditions, ksi, adjusted for the presence of fillers as required below, and,

$A_b$ = cross-sectional area based upon the nominal diameter of bolt, in.$^2$

When a bolt that carries load passes through fillers or shims in a shear plane that are equal to or less than 1/4 in. thick, $F_n$ from Table 5.1 shall be used without reduction. When a bolt that carries load passes through fillers or shims that are greater than 1/4 in. thick, they shall be designed in accordance with one of the following procedures:

(1) ~~For fillers or shims that are equal to or less than 3/4 in. thick,~~ $F_n$ from Table 5.1 shall be multiplied by the factor [1 - 0.4($t'$ - 0.25)], where $t'$ is the total thickness of fillers or shims, in~~., up to 3/4 in~~.;
(2) The fillers or shims shall be extended beyond the *joint* and the filler or shim extension shall be secured with enough bolts to uniformly distribute the total force in the connected element over the combined cross-section of the connected element and the fillers or shims;
(3) The size of the *joint* shall be increased to accommodate a number of bolts that is equivalent to the total number required in (2) above; or,
(4) The *joint* shall be designed as a *slip-critical joint* using Class A surfaces with Turn-of-Nut pretensioning or Class B surfaces. ~~The slip resistance of the *joint* shall not be reduced for the presence of fillers or shims.~~

**Commentary:**
The nominal shear and tensile strengths of ASTM A325, F1852, A490 and F2280 bolts are given in Table 5.1. These values are based upon the work of a large number of researchers throughout the world, as reported in the *Guide* (Kulak et al., 1987; Tide, 2010). The *design strength* equals the *nominal strength* multiplied by a resistance factor $\phi$.

The nominal shear strength is based upon the observation that the shear strength of a single *high-strength bolt* is about 0.62 times the tensile strength of that bolt (Kulak et al., 1987; pp. 44-50). In addition, a reduction factor of 0.90 is applied to joints up to 38 in. in length to account for an increase in bolt force due to minor secondary effects resulting from simplifying assumptions made in the modeling of structures that are commonly accepted in practice (e.g. truss bolted connections assumed pinned in the analysis model). Second order effects such as those resulting from the action of the applied loads on the deformed structure, should be accounted for through a second order analysis of the structure. As noted in Table 5.1, the average shear strength of bolts in *joints* longer than 38 in. in length is reduced by a factor of 0.75 instead of 0.90. This factor accounts for both the non-uniform force distribution between the bolts in a long joint and the minor secondary effects discussed above. Note that the 0.75 reduction factor does not apply in cases where the distribution of force is essentially uniform along the *joint*, such as the bolted *joints* in a shear *connection* at the end of a deep plate girder.

The average ratio of nominal shear strength for bolts with threads included in the shear plane to the nominal shear strength for bolts with threads excluded from the shear plane is 0.83 with a standard deviation of 0.03 (Frank and Yura, 1981). Conservatively, a reduction factor of 0.80 is used to account for the reduction in shear strength for a bolt with threads included in the shear plane but calculated with the area corresponding to the nominal bolt diameter. The case of a bolt in double shear with a non-threaded section in one shear plane and a threaded section in the other shear plane is not covered in this Specification for two reasons. First, the manner in which load is shared between these two dissimilar shear areas is uncertain. Second, the detailer's lack of certainty as to the orientation of the bolt placement might leave both shear planes in the threaded section. Thus, if threads are included in one shear plane, the conservative assumption is made that threads are included in all shear planes.

The tensile strength of a *high-strength bolt* is the product of its ultimate tensile strength per unit area and some area through the threaded portion. This area, called the tensile stress area, is a derived quantity that is a function of the relative thread size and pitch. For the usual sizes of structural bolts, it is about 75 percent of the nominal cross-sectional area of the bolt. Hence, the nominal tensile strengths per unit area given in Table 5.1 are 0.75 times the tensile strength of the bolt material. According to Equation 5.1, the nominal area of the bolt is then used to calculate the *design strength* in tension. The *nominal strengths* so-calculated are intended to form the basis for comparison with the externally applied bolt tension plus any additional tension that results from *prying action* that is produced by deformation of the connected elements.

If pretensioned bolts are used in a *joint* that loads the bolts in tension, the question arises as to whether the pretension and the applied tension are additive. Because the compressed parts are being unloaded during the application of the external tensile force, the increase in bolt tension is minimal until the parts separate (Kulak et al., 1987; pp. 263-266). Thus, there will be little increase in bolt force above the pretension load under service loads. After the parts separate, the bolt acts as a tension member, as expected, and its *design strength* is that given in Equation 5.1 multiplied by the resistance factor $\phi$.

Pretensioned bolts have torsion present during the installation process. Once the installation is completed, any residual torsion is quite small and will disappear entirely when the fastener is loaded to the point of plate separation. Hence, there is no question of torsion-tension interaction when considering the ultimate tensile strength of a *high-strength bolt* (Kulak et al., 1987; pp. 41-47).

When required, pretension is induced in a bolt by imposing a small axial elongation during installation, as described in the Commentary to Section 8. When the *joint* is subsequently loaded in shear, tension or combined shear and tension, the bolts will undergo significant deformations prior to failure that have the effect of overriding the small axial elongation that was introduced during installation, thereby removing the pretension. Measurements taken in laboratory tests confirm that the pretension that would be sustained if the applied load were removed is essentially zero before the bolt fails in shear (Kulak et al., 1987; pp. 93-94). Thus, the shear and tensile strengths of a bolt are not affected by the presence of an initial pretension in the bolt.

See also the Commentary to Section 5.5.

Tests of 24 bolt A490 1 1/8 diameter connections indicated the reduction in bolt shear strength in connections with filler as required in section 5.1 (1) is limited to 85%. (Borello, Denavit, Hajjar Behavior of Bolted Steel Slip Critical Connections with Fillers UIUC August 2009) . Review of available data on slip critical connections revealed that connections with Class A surfaces pretensioned by Turn-of-Nut and connections with Class B surfaces provide a sufficient reliability against slip to eliminate the need to fasten the fills outside the connection or reduce the bolt shear capacity. Grondin, Ming, Josi Slip Critical Bolted Connections - A Reliability Analysis for Design at the Ultimate Limit State. University of Alberta, April 2008.

**Rationale or Justification for Change (attach additional pages as needed):**

The provisions governing fillers in Section 5.1 have limits and may be incorrect. Example issues include: The equation in (1) stops at ¾ in. Fillers can be thicker. There is a question about whether (4) can be considered valid if slip critical joints need to be checked for bearing. Dr Hajjar conducted a study of the effect of fillers on SC joints. Dr Grondin performed a statistical review of slip critical connections. The proposal is an outcome of those studies.

# RCSC Proposed Change: S12-045

**Name:** Chris Curven
**E-mail:** chrisc@appliedbolting.com
**Phone:** 802-460-3100
**Fax:**

**Ballot Actions:**

**Proposed Changes:**

8.2.3. Twist-Off-Type Tension-Control Bolt Pretensioning: Twist-off-type tension-control bolt assemblies that meet the requirements of ASTM F1852 or F2280 shall be used.

All *fastener assemblies* shall be installed in accordance with the requirements in Section 8.1 without severing the splined end and with washers positioned as required in Section 6.2. If a splined end is severed during this operation, the *fastener assembly* shall be removed and replaced. Subsequently, all bolts in the *joint* shall be ~~pretensioned~~ tightened with the twist-off-type tension-control bolt installation wrench until the splined-end shears off, progressing systematically from the most rigid part of the *joint* in a manner that will minimize relaxation of previously pretensioned bolts.

**Commentary:**

ASTM F1852 and F2280 twist-off-type tension-control bolt assemblies have a splined end that extends beyond the threaded portion of the bolt. During installation, this splined end is gripped by a specially designed wrench chuck and provides a means for turning the nut relative to the bolt. This product is, in fact, based upon a torque-controlled installation method to which the *fastener assembly* variables affecting torque that were discussed in the Commentary to Section 8.2.2 apply, except for wrench calibration, because torque is controlled within the *fastener assembly*.

Twist-off-type tension-control bolt assemblies must be used in the as-delivered, clean, lubricated condition as specified in Section 2. Adherence to the requirements in this Specification, especially those for storage, cleanliness and verification, is necessary for their proper use.

9.2.1. Turn-of-Nut Pretensioning: The *inspector* shall observe the pre-installation verification testing required in Section 8.2.1. Subsequently, but prior to pretensioning and optional match-marking, it shall be ensured by *routine observation* that the plies have been brought into *firm contact*. Subsequently, it shall be ensured by *routine observation* that the bolting crew properly rotates the turned element relative to the unturned element by the amount specified in Table 8.2. Alternatively, when *fastener assemblies* are match-marked after the initial

------------------------------------For Committee Use Below---------------------------------------------

Date Received: 5/31/12 Exec Com Meeting: 6/6/12 Forwarded: Yes ☐ /No ☐

Committee Assignment: Executive -A. ☐ Editorial -B. ☐ Nominating -C. ☐

Specifications -A.1 ☐ Research -A.2 ☐ Membership & Funding -A.3 ☐ Education -A.4 ☐
Committee Chair: ____________ Task Group #: ___________ T.G. Chair: ________________
Date Sent to Main Committee: _______________Final Disposition: ______________________

fit-up of the *joint* but prior to pretensioning, visual inspection after pretensioning is permitted in lieu of routine observation. No further evidence of conformity is required. A pretension that is greater than the value specified in Table 8.1 shall not be cause for rejection.

**Commentary:**
Match-marking of the assembly during installation as discussed in the Commentary to Section 8.2.1 improves the ability to inspect bolts that have been pretensioned with the turn-of-nut pretensioning method. The sides of nuts and bolt heads that have been impacted sufficiently to induce the Table 8.1 minimum pretension will appear slightly peened.

The turn-of-nut pretensioning method, when properly applied and verified during the construction, provides more reliable installed pretensions than after-the-fact *inspection* testing. Therefore, proper inspection of the method is for the inspector to observe the required pre-installation verification testing of the *fastener assemblies* and the method to be used, followed by monitoring of the work in progress to ensure that the method is routinely and properly applied, or visual inspection of match-marked assemblies.

Some problems with the turn-of-nut pretensioning method have been encountered with hot-dip galvanized bolts. In some cases, the problems have been attributed to an especially effective lubricant applied by the *manufacturer* to ensure that bolts and nuts from stock will meet the ASTM Specification requirements for minimum turns testing of galvanized fasteners. Job-site testing in the *tension calibrator* demonstrated that the lubricant reduced the coefficient of friction between the bolt and nut to the degree that “the full effort of an ironworker using an ordinary spud wrench” to snug-tighten the *joint* actually induced the full required pretension. Also, because the nuts could be removed with an ordinary spud wrench, they were erroneously judged by the *inspector* to be improperly pretensioned. Excessively lubricated *high-strength bolts* may require significantly less torque to induce the specified pretension. The required pre-installation verification will reveal this potential problem.

Conversely, the absence of lubrication or lack of proper over-tapping can cause seizing of the nut and bolt threads, which will result in a twist failure of the bolt at less than the specified pretension. For such situations, the use of a *tension calibrator* to check the bolt assemblies to be installed will be helpful in establishing the need for lubrication.

9.2.2. Calibrated Wrench Pretensioning: The *inspector* shall observe the daily pre-installation verification testing required in Section 8.2.2. Subsequently, but prior to pretensioning, it shall be ensured by *routine observation* that the plies have been brought into *firm contact*. Subsequently, it shall be ensured by *routine observation* that the bolting crew properly applies the calibrated wrench to the turned element. No further evidence of conformity is required. A pretension that is greater than the value specified in Table 8.1 shall not be cause for rejection.

**Commentary:**

For proper inspection of the method, it is necessary for the *inspector* to observe the required pre-installation verification testing of the *fastener assemblies* and the method to be used, followed by monitoring of the work in progress to ensure that the method is routinely and properly applied within the limits on time between removal from *protected storage* and final pretensioning.

9.2.3. Twist-Off-Type Tension-Control Bolt Pretensioning: The *inspector* shall observe the pre-installation verification testing required in Section 8.2.3. Subsequently, but prior to pretensioning, it shall be ensured by *routine observation* that the plies have been brought into *firm contact* without the splined ends being severed. If the splined end is severed, the bolt must be removed and replaced. Subsequently, it shall be ensured by *routine observation* that the splined ends are properly severed during installation by the bolting crew. No further evidence of conformity is required. A pretension that is greater than the value specified in Table 8.1 shall not be cause for rejection.

**Commentary:**
The sheared-off splined end of an installed twist-off-type tension-control bolt assembly merely signifies that at some time the bolt was subjected to a torque that was adequate to cause the shearing. If in fact all fasteners are individually pretensioned in a single continuous operation without first properly snug-tightening all fasteners, they may give a misleading indication that the bolts have been properly pretensioned. Therefore, it is necessary that the *inspector* observe the required pre-installation verification testing of the *fastener assemblies*, and the ability to apply partial tension prior to twist-off is demonstrated. This is followed by monitoring of the work in progress to ensure that the method is routinely and properly applied within the limits on time between removal from *protected storage* and final twist-off of the splined end.

**Rationale or Justification for Change (attach additional pages as needed):**

8.2.3 does not actually state when the installer is to stop tightening or when the bolt is deemed tight. It states what type of installation tool to be used, but not what the installer is looking for.
For example, 8.2.1. states to rotate the head or nut as specified in table 8.2., 8.2.2. states to apply the installation torque determined by the pre-installation verification, and 8.2.4. has the installer making sure the achieved gap is less than the job inspection gap.

Also, Section 9.2.4. is the only installation method that has the inspector verify that snugging of the bolts and plies have taken place before the chosen pretensioning method takes place. 9.2.1., 9.2.2.,and 9.2.3. would obviously like to have inspection of the snug condition, but it is not listed.
For example, 9.2.4. …All bolts shall be installed in accordance with the requirements in Section 8.1, with washers positioned as required in Section 6.2. The installer shall verify that the direct-tension-indicator protrusions have not been compressed to a gap that is less than the job inspection gap during this operation, and if this has occurred, the direct tension indicator shall be removed and replaced….

# RCSC Proposed Change: S12-046

**Name:** Chris Curven **E-mail:** _chrisc@appliedbolting.com
**Phone:** 802-460-3100 **Fax:**

**Ballot History:**

**Proposed Change:**

**Glossary**
*{All existing terms in Glossary remain unchanged.}*
*Torque* (noun). **1.** The moment of a force; the measure of a force's tendency to produce torsion and rotation about an axis, equal to the vector product of the radius vector from the axis of rotation to the point of application of the force and the force vector.
**2.** A turning or twisting force.
*(Both copied from The Free Dictionary by Farlex)*
3. A rotational moment; it is a measure of how much twisting is applied to a fastener.
*(Copied from boltscience.com)*

*Torque* (verb). to impart a twisting force. *(copied from The Free Dictionary by Farlex)*

*Tension.* A bolt resistance to elongation that provides a clamping in a bolted connection.

**Rationale or Justification for Change:**

Torque and tension are the two basic terms used in structural bolting with the term torque being used predominantly. However, in the field and in offices, their definitions and physical differences are not understood. The users of this specification would be well served if we provide them with a definition.

I am not committed to any of the definitions I have offered, but merely would like to use them as a starting point so we CAN include them in the glossary of the specification.

-----------------------------------For Committee Use Below---------------------------------------------

Date Received: 5/31/12 Exec Com Meeting: 6/6/12 Forwarded: Yes ☐ /No ☐

Committee Assignment: Executive -A. ☐ Editorial -B. ☐ Nominating -C. ☐

Specifications -A.1 ☐ Research -A.2 ☐ Membership & Funding -A.3 ☐ Education -A.4 ☐
Committee Chair: ____________ Task Group #: ___________ T.G. Chair: ________________
Date Sent to Main Committee: _______________Final Disposition: ______________________

BOLT HOLES AND TOLERANCE

Rick Drake, SE, Member AISC, Fluor Enterprises, Inc.
Tom Hunt, SE, Member AISC, Fluor Enterprises, Inc.

## INTRODUCTION

I have been associated with several industrial projects over the years with highly loaded members and connections that require larger diameter high strength bolts. It is quite common to have RFI's from the field where the 1-1/2 inch diameter bolts do not fit in the bolt holes. This involves both ASTM A325 and ASTM 490 bolts. QA measurements typically indicate that the bolts meet the ASTM Specification and the holes meet the AISC specification.


**Photo courtesy of Fluor Constructors, Inc.**

## Bolt Tolerances

Production of high strength bolts are in accordance with either ASTM A325 or ASTM A490. Both specifications refer to ASME B18.2.6 for geometry.

ASME B18.6.2 Table defines the bolt body diameter, including plus or minus tolerances.

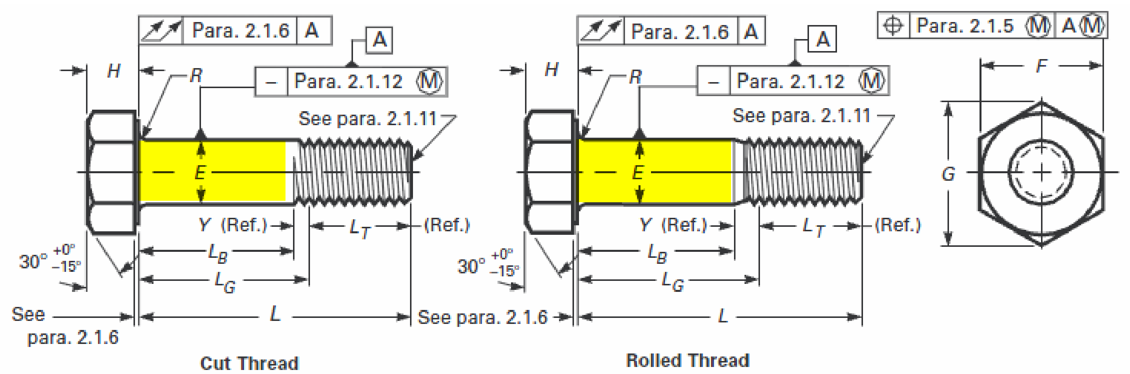



**Table 1 Dimensions of Heavy Hex Structural Bolts**

| Nominal Size or Basic Product Diameter [Note (1)] | | Body Diameter, *E* [Note (2)] Max. | Body Diameter, *E* Min. | Width Across Flats, *F* [Note (3)] Nominal | *F* Max. | *F* Min. | Width Across Corners, *G* Max. | *G* Min. | Head Height, *H* [Note (4)] Nominal | *H* Max. | *H* Min. | Radius of Fillet, *R* Max. | *R* Min. | Thread Length, $L_T$ [Note (5)] Ref. | Transition Thread Length, *Y* [Note (5)] Ref. | Total Runout of Bearing Surface FIM [Note (6)] Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/2 | 0.500 | 0.515 | 0.482 | 7/8 | 0.875 | 0.850 | 1.010 | 0.969 | 5/16 | 0.323 | 0.302 | 0.031 | 0.009 | 1.00 | 0.19 | 0.016 |
| 5/8 | 0.625 | 0.642 | 0.605 | 1 1/16 | 1.062 | 1.031 | 1.227 | 1.175 | 25/64 | 0.403 | 0.378 | 0.062 | 0.021 | 1.25 | 0.22 | 0.019 |
| 3/4 | 0.750 | 0.768 | 0.729 | 1 1/4 | 1.250 | 1.212 | 1.443 | 1.383 | 15/32 | 0.483 | 0.455 | 0.062 | 0.021 | 1.38 | 0.25 | 0.022 |
| 7/8 | 0.875 | 0.895 | 0.852 | 1 7/16 | 1.438 | 1.394 | 1.660 | 1.589 | 35/64 | 0.563 | 0.531 | 0.062 | 0.031 | 1.50 | 0.28 | 0.025 |
| 1 | 1.000 | 1.022 | 0.976 | 1 5/8 | 1.625 | 1.575 | 1.876 | 1.796 | 39/64 | 0.627 | 0.591 | 0.093 | 0.062 | 1.75 | 0.31 | 0.028 |
| 1 1/8 | 1.125 | 1.149 | 1.098 | 1 13/16 | 1.812 | 1.756 | 2.093 | 2.002 | 11/16 | 0.718 | 0.658 | 0.093 | 0.062 | 2.00 | 0.34 | 0.032 |
| 1 1/4 | 1.250 | 1.277 | 1.223 | 2 | 2.000 | 1.938 | 2.309 | 2.209 | 25/32 | 0.813 | 0.749 | 0.093 | 0.062 | 2.00 | 0.38 | 0.035 |
| 1 3/8 | 1.375 | 1.404 | 1.345 | 2 3/16 | 2.188 | 2.119 | 2.526 | 2.416 | 27/32 | 0.878 | 0.810 | 0.093 | 0.062 | 2.25 | 0.44 | 0.038 |
| 1 1/2 | 1.500 | 1.531 | 1.470 | 2 3/8 | 2.375 | 2.300 | 2.742 | 2.622 | 15/16 | 0.974 | 0.902 | 0.093 | 0.062 | 2.25 | 0.44 | 0.041 |

GENERAL NOTE: See additional requirements in section 2.

NOTES:
(1) See para. 2.4.1.
(2) See para. 2.1.7.
(3) See paras. 2.1.2 and 2.1.3.
(4) See para. 2.1.4.
(5) See para. 2.1.10.2.
(6) See para. 2.1.6.

Note (2) is applicable to the Body Diameter and refers to Section 2.1.7.

**2.1.7 Body Diameter.** The body diameter limits are shown in Table 1. Any swell or fin under the head or any die seam on the body shall not exceed the basic bolt diameter by the following:

*(a)* 0.030 in. for sizes ½ in.

*(b)* 0.050 in. for sizes ⅝ in. and ¾ in.

*(c)* 0.060 in. for sizes over ¾ in. through 1¼ in.

*(d)* 0.090 in. for sizes over 1¼ in.

Section 2.1.7 allows an increase in body diameter at the "swell" under the head or at any die seam. Notice that the increase is proportional to the bolt diameter.

Working Table 1 and Section 2.1.7 together for 1-1/2 inch diameter bolts:

$$d_{\min} = 1.470\, inch$$
$$d_{\max} = 1.590\, inch$$

## BOLT HOLE TOLERANCES

Bolt hole tolerances are defined in Table 3.1 of the RCSC High Strength Bolt Specification.

**Table 3.1. Nominal Bolt Hole Dimensions**

| Nominal Bolt Diameter, $d_b$, in. | Nominal Bolt Hole Dimensions[a,b], in. | | | |
|---|---|---|---|---|
| | Standard (diameter) | Oversized (diameter) | Short-slotted (width × length) | Long-slotted (width × length) |
| $^1/_2$ | $^9/_{16}$ | $^5/_8$ | $^9/_{16} \times {}^{11}/_{16}$ | $^9/_{16} \times 1^1/_4$ |
| $^5/_8$ | $^{11}/_{16}$ | $^{13}/_{16}$ | $^{11}/_{16} \times {}^7/_8$ | $^{11}/_{16} \times 1^9/_{16}$ |
| $^3/_4$ | $^{13}/_{16}$ | $^{15}/_{16}$ | $^{13}/_{16} \times 1$ | $^{13}/_{16} \times 1^7/_8$ |
| $^7/_8$ | $^{15}/_{16}$ | $1^1/_{16}$ | $^{15}/_{16} \times 1^1/_8$ | $^{15}/_{16} \times 2^3/_{16}$ |
| 1 | $1^1/_{16}$ | $1^1/_4$ | $1^1/_{16} \times 1^5/_{16}$ | $1^1/_{16} \times 2^1/_2$ |
| $\geq 1^1/_8$ | $d_b + {}^1/_{16}$ | $d_b + {}^5/_{16}$ | $(d_b + {}^1/_{16}) \times (d_b + {}^3/_8)$ | $(d_b + {}^1/_{16}) \times (2.5 d_b)$ |

[a] The upper tolerance on the tabulated nominal dimensions shall not exceed $^1/_{32}$-in. Exception: In the width of slotted holes, gouges not more than $^1/_{16}$-in. deep are permitted.

[b] The slightly conical hole that naturally results from punching operations with properly matched punches and dies is acceptable.

Notice that the bolt hole size is constant regardless of bolt diameter. This means that the percentage difference between the bolt diameter and the bolt hole size is decreasing with increased bolt diameter. Also note that the table provides a plus tolerance $\left(+\frac{1}{32}inch\right)$, but is silent about negative tolerances.

Interpreting Table 3.1 for 1-1/2 inch diameter standard bolt holes:

$$h_{\min} = undefined$$
$$h_{\max} = 1.5937\,inch$$

Because the HSB Specification is not an ANSI approved document, AISC provides a bolt hole table, invoked by AISC 360 Section J3.2.

**2. Size and Use of Holes**

The maximum sizes of holes for bolts are given in Table J3.3 or J3.3M, except that larger holes, required for tolerance on location of anchor rods in concrete foundations, are permitted in *column* base details.

**TABLE J3.3**
**Nominal Hole Dimensions, in.**

| Bolt Diameter | Hole Dimensions | | | |
|---|---|---|---|---|
| | Standard (Dia.) | Oversize (Dia.) | Short-Slot (Width × Length) | Long-slot (Width × Length) |
| 1/2 | 9/16 | 5/8 | 9/16 × 11/16 | 9/16 × 1 1/4 |
| 5/8 | 11/16 | 13/16 | 11/16 × 7/8 | 11/16 × 1 9/16 |
| 3/4 | 13/16 | 15/16 | 13/16 × 1 | 13/16 × 1 7/8 |
| 7/8 | 15/16 | 1 1/16 | 15/16 × 1 1/8 | 15/16 × 2 3/16 |
| 1 | 1 1/16 | 1 1/4 | 1 1/16 × 1 5/16 | 1 1/16 × 2 1/2 |
| ≥1 1/8 | $d$ + 1/16 | $d$ + 5/16 | ($d$ + 1/16) × ($d$ + 3/8) | ($d$ + 1/16) × (2.5 × $d$) |

Notice that the tolerance footnotes were not copied from the RCSC Specification; in lieu of a plus tolerance the bolt holes sizes are defined as a maximum. The Specification is also silent about negative tolerances.

Interpreting Section J3.2 and Table J3.3 for 1-1/2 inch diameter standard bolt holes:

$$h_{\min} = undefined$$
$$h_{\max} = 1.5625\,inch$$

## CONCLUSION

Putting the bolt and bolt tolerances together for 1-1/2 inch diameter bolts with standard bolt holes:

$$d_{\max} = 1.590\,inch$$
$$h_{\min} = undefined$$
$$h_{\max} = 1.5625\,inch$$

The bolts at their maximum diameter tolerance won't fit in to the bolt holes with the maximum tolerance, much less at the minimum undefined tolerance.

***How has this been resolved in the past?***

Old timers (who prefer to remain anonymous) indicate that the shops fabricated the bolt holes $\frac{1}{32}$ to $\frac{1}{16}$ inch bigger without telling the engineer. This was the original "Don't Ask; Don't Tell", adopted more recently by the military.

***How is this resolved now?***

With the increased attention by AISC to Quality Assurance (a good thing), the fabricators are now fabricating holes within the defined maximum hole sizes. They can't afford to let inspectors measure bolt holes that are oversized, even if it facilitates construction.

This now increases the occurrence of large diameter high strength that do not fit in the bolt holes. Typically, the resolution is for the Engineer-Of-Record (EOR) on the project to approve reaming the existing bolt holes and allowing larger bolt hole tolerances.

***How could it be resolved in the future?***

To minimize the occurrences where the EOR is forced to approve a project-specific deviation from AISC 360, the Specification should be revised. I recommend that Table J3.3 of AISC 360 be revised to (1) define both plus and minus tolerances on bolt hole sizes, and (2) redefine standard bolt holes for the larger diameter bolts.

## COMMITTEE CORRESPONDENCE

**TO:** A HARROLD

**FROM:** TOM SCHLAFLY (312) 670 5412 SCHLAFLY@AISC.ORG

**COMMITTEE:** RCSC SPEC

**SUBJECT:** THERMAL BRIDGING: NONMETALIC MATERIALS IN BOLTED JOINTS

**DATE:** 6/1/2012

**CC:** J HAJJAR

---

### REPORT TO THE COMMITTEE

Dr Yura, Mr. Gibble and I elected to work on strategies to accommodate the design of thermal bridge connections. Thermal bridging is for our purposes the characteristic of connecting two elements to resist structural loads while achieving a useful level of thermal isolation between the connected parts. Thermal bridging has been an issue relevant to building serviceability for many years. One incentive to provide thermal bridging in the past was condensation forming inside a building where heat was conducted out of interior structural elements connected to exterior elements. The heat loss due to thermal bridging is now a concern of designers seeking to improve building energy efficiency.

The RCSC Specification limits potential thermal bridging strategies. One significant limit is Section 3.1 Connected Plies "All connected plies that are within the grip of the bolt and any materials that are used under the head or nut shall be steel.... Compressible materials shall not be placed within the grip of the bolt." This prohibition prevents including a thermal insulation material in a structural bolted joint.

Dr Yura, Mr. Gibble and I did speak over the course of the previous year and we discussed two potential strategies to overcome the limits of the cited provision: Develop installation methods and design values for high strength fasteners with non-steel materials in the grip; develop material property requirements for non-steel materials that would be permitted in the grip of HS fastener connections. The optimum solution may be a combination of the two strategies.

Over the course of the year, MSC published a 'pull-out' flyer on Thermal bridging with an ASCE committee evaluating the subject. The Pankow Foundation and AISC have committed to have Dr Hajjar at Northeastern University conduct a study of the subject. (Dr Hajjar will be looking to members of RCSC to provide input on the structural connection aspects of this study) Fabreeka has published advertisements expressing part of a solution to thermal bridging showing isolation pads in bolted joints. Others have submitted proposals to AISC to study and develop thermal bridging solutions.

There are no current responses or activities needed by RCSC. Dr Y, Mr. G and I will request time on the agenda when any activities or revision by RCSC are requested.

# RCSC LIAISON COMMITTEE SUMMARY

# JUNE 2012

P. Birkemoe, G. Grondin, L. Kloiber, L. Kruth, G. Miazga (Chair), T. Schlafly, T. Ude

# Why have this Committee?

With many RCSC members also members of technical committees of various standards, the goal is to ‘formally’ monitor current and future directions of other standards (and related research) and summarize this regularly for the RCSC:

- To allow RCSC to maintain leadership
- Possibly harmonize research efforts (at least not duplicate or be unaware)

# Standards Reviewed/Compared

A full report prepared comparing the 2009 RCSC Specification with:

- ANSI/AISC 360-2010
- CSA S16-09 (Steel Structures)
- CSA S6-06 (Bridges)
- AASHTO ($4^{th}$ edition)

# Highlights of Major Differences

1. Equations to evaluate slip:
   - Slip coefficients (new work by AISC)
   - Connector types (i.e. c1 factor for 5% probability of slip varies in S16 for A325, A490, F959 & F1852 & F2280)
   - Galvanized faying surfaces (0.3 to 0.4: research needed?)
2. Equations for evaluating the behavior of long joints:
   - The work of Tide, Grondin (presented at 2010 RCSC, slightly different)

# Highlights of Major Differences

3. The effect of fillers on the behavior of lap joints (e.g. the work of various researchers: Dusicka, Hajjar, Yura and Frank, etc). AISC has new provisions regarding:

- Thick fillers
- Multiple filler plies

# Future Efforts

1. Continue to monitor development of major standards
2. Become more familiar with research leading to changes in AISC, CSA, AASHTO

# RESEARCH COUNCIL ON STRUCTURAL CONNECTIONS

## SPECIFICATION COMMITTEE A.1 MEETING JUNE 7, 2012
## 8:00 AM - 12:00 PM

## AGENDA

0.1 ATTENDANCE

1.0 CHAIRMAN'S REMARKS

2.0 APPROVAL OF MINUTES OF JUNE 2011 MEETING

3.0 APPROVAL OF AGENDA

4.0 MEMBERSHIP
- 4.1 Review and Update Membership List

5.0 RESOLUTION OF BALLOT RESULTS (Affirmative/Negative/Abstain)

| | | | |
|---|---|---|---|
| 5.1 | S06-002B | Turn-of-the-Nut Rotation Tolerances | (Shaw) |
| 5.2 | S11-033 | Merge Appendix B with main spec | (Harrold) |
| 5.3 | S11-035 | Hole Definitions | (Shaw) |
| 5.4 | S11-036 | Pretension Definitions | (Shaw) |

6.0 DISCUSSION OF PROPOSED SPECIFICATION CHANGES

| | | | |
|---|---|---|---|
| 6.1 | S11-038 | Sections 8.2, 8.2.1, and 8.2.3 - Pre-installation Verification Testing Language | (Curven) |
| 6.2 | S12-039 | Table 2.1 – Delete Zn/Al coating from F1852 and F2280 assemblies | (Schlafly) |
| 6.3 | S12-041 | Section 6.2.5 Commentary – Footnote reference | (Schlafly) |
| 6.4 | S12-042 | Section 5.4 – Slip Critical Equations | (Schlafly) |
| 6.5 | S12-043 | Section 8.1 Commentary – TC bolts in Snug Tight joints | (Schlafly) |
| 6.6 | S12-044 | Section 5.1 – Fillers | (Schlafly) |
| 6.7 | S12-045 | Sections 8.2.3, 9.2.1, 9.2.2, 9.2.3 – Inspection Process | (Curven) |
| 6.8 | S12-046 | Glossary – Torque, Tension Definitions | (Curven) |

7.0 TASK GROUP REPORTS

| | | |
|---|---|---|
| 7.1 | Turn-of-the-Nut Parameters - A325T (S08-020B) | (Greenslade) |
| 7.2 | SI Specification | (Greenslade) |
| 7.3 | S12-042 Slip Critical Connections (AISC) (See 6.4 above) | (Schlafly) |
| 7.4 | S12-043 Snug-Tight TC Bolts (See 6.5 above) | (Schlafly) |
| 7.5 | Shear Allowables (from Ballot S08-024) | (Yura) |
| 7.6 | Oversize Holes - Slip Critical? (Shear Connections) | (Yura) |
| 7.7 | Calibrated Wrench Installation | (Vissat) |
| 7.8 | Thick Coatings | (Birkemoe) |
| 7.9 | Large standard hole sizes | (Carter) |
| 7.10 | S11-038 Pre-installation Verification Testing Language (See 6.1 above) | (Curven) |

8.0 OLD BUSINESS

| | | |
|---|---|---|
| 8.1 | Length Tolerance on bolts | (Lohr) |
| 8.2 | U of Cincinnati Bolt Research – Where do we go from here? | (Swanson) |
| 8.3 | Request to modify prohibition of non-steel items in grip of HS bolted joints. | (Schlafly) |

9.0 NEW BUSINESS

| | | |
|---|---|---|
| 9.1 | Failures due to tightening bolts from the head side | (Mitchell) |
| 9.2 | Appendix A creep tests at service load level | (Yura) |
| 9.3 | EOR to specify actual hole size for oversize holes | (Shaw) |
| 9.4 | Matchmarking language for turn-of-the-nut | (Kasper) |
| 9.5 | Glossary Definition of Torque (See 6.8 above) | (Shaw, Curven) |

10.0 LIAISON REPORTS

10.1 AISC (Carter)

10.2 S16 (Miazga)

10.3 ASTM F16 (Greenslade)

11.0 NEXT MEETING

12.0 ADJOURNMENT