

American Railway Engineering & Maintenance-of-Way Association Letter Ballot 15-22-04

Assignment: At the February 2022 meeting in Ft. Worth, TX, Letter Ballot 15-22-04 was proposed by the subcommittee and general committee to update many Articles pertaining to bolting, including the addition of spline-end bolts (ASTM F3148).

Rationale: The language updates in this ballot are proposed to match the updated bolting provisions to match RCSC 2020. Major changes include the addition of spline-end bolts (ASTM F3148). For further explanation of the changes, the complete markup including additional line-item rationale is included in an annotated earlier draft following the ballot.

Review of this language has been completed by SC1, SC2 and SC3 and, due to the interconnectivity of the language, it is being proposed as a single ballot.

Submitted by: Duncan Paterson, Chair SC 3 Fabrication & Erection
Due Date: April 29, 2022

Insert new Tables 15-3-3, 15-3-4, and 15-3-5, re-number existing Table 15-3-3 to 15-3-6, and edit Articles, Tables, Glossary, and References as shown (deletions in **bold red strikethrough**, new text in **red bold underline** (except in new Tables), comments in brackets [] are not to be published, existing entries shown as they will appear in the 2022 MRE):

Special Index

High-strength bolts, re-use	3.2.3(3) 3.2.3i
Reuse of high-strength bolts	3.2.3(3) 3.2.3i
Turn-of-nut method of installing high-strength bolts	3.2.3d 3.2.3c(1)

1.2.1 MATERIALS (~~2018~~**2023**)²

- a. The design requirements of these recommended practices, contained in this part are based on the use of materials conforming to the current requirements of the following ASTM specifications:

Structural Steel	A709(Grades 36, 50, 50W, HPS 50W, 50S, HPS 70W), A36, A572(Grade 42 or 50), A588, A992. See also Table 15-9-1.
Rivet steel	see Part 7 and Appendix 1
High-strength bolts without spline end	F3125, Grades A325 and A490
High-strength twist-off spline-end bolts	F3125, Grade F1852
High-strength fixed spline-end bolts	F3148
Carbon and A lloy S steel N nuts	A563
Washers, S steel, H hardened	F436
Direct T ension I ndicators	F959
High-Strength "Twist Off" Type Tension Control Bolts.	F3125, Grade F1852
Machine bolts	A307
Cast steel	A27, Grade 65-35 or A148
Forged steel, for large pins	A668
Welding electrodes	See Article 1.2.2a
Rivet steel	see Part 7 and Appendix 1

[remainder unchanged]

[continued]

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1.3.13 FATIGUE (~~2021~~2023)¹

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1.3.13.1 High-Strength Bolts Subjected to Tensile Fatigue Loading

Fully pretensioned high-strength bolts subjected to tensile fatigue loading shall be designed for the combined external load and prying force using the following allowable tensile stress ranges:

F3125 Grade A325 ~~or Grade F1852 B~~ bolts in axial tension: 31,000 psi on the tensile stress area (see Table 15-1-8, Section 8.2) at the threads

F3125 Grade A490 ~~B~~ bolts in axial tension: 38,000 psi on the tensile stress area (see Table 15-1-8, Section 8.2) at the threads

F3148 bolts in axial tension: 37,000 psi on the tensile stress area (see Table 15-1-8, Section 8.2) at the threads

In no case shall the prying force exceed 20% of the total externally applied load.

[remainder unchanged]

Table 15-1-11. Structural Steel, Fasteners and Pins

Stress Area	Pounds per square inch
Tension on fasteners, including the effect of prying action: F3125 Grade A325 or Grade F1852 bolts, gross section F3125 Grade A490 bolts, gross section <u>F3148 bolts, gross section</u>	44,000 54,000 <u>52,000</u>
Bearing on F3125 Grade A325 and , Grade A490, <u>and F3148</u> bolts where: L = Distance, inches, measured in the line of force from the center line of a bolt to the nearest edge of an adjacent bolt or to the end of the connected part toward which the force is directed. d = Diameter of bolts, inch. F _u = <u>H</u> owest specified minimum tensile strength of the connected part, psi.	$\frac{LF_u}{2d}$ or 1.2F _u (Note 1) (whichever is smaller)

[continued]

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Table 15-1-11a Allowable Stress for Slip-Critical Connections (Slip Load per Unit of Bolt Area, psi)

Contact Surface of Bolted Parts	Hole Type and Direction of Applied Load								
	Standard and Short-Slotted Perpendicular to the Direction of Load			Oversize and Short-Slotted Parallel to the Direction of Load			Long-Slotted Any Direction		
	F3125 Grade A325 or F1852	F3125 Grade A490	F3148	F3125 Grade A325 or F1852	F3125 Grade A490	F3148	F3125 Grade A325 or F1852	F3125 Grade A490	F3148
Class A (Slip Coefficient 0.30) Uncoated clean mill scale and blast-cleaned surfaces with Class A coatings (Note 1), (Note 2)	12,900	16,200	15,500	11,000	13,800	13,200	9,000	11,300	10,800
Class B (Slip Coefficient 0.50) Uncoated blast-cleaned surfaces to SSPC-SP6 or better, blast-cleaned surfaces with Class B coatings and unsealed thermal-sprayed surfaces	21,500	26,900	25,700	18,300	23,000	21,900	15,000	18,900	18,000
Class C (Slip Coefficient 0.30) Hot-dip galvanized	12,900	16,200	15,500	11,000	13,800	13,200	9,000	11,300	10,800
Class D (Slip Coefficient 0.45) Blast-cleaned surfaces with Class D coatings (Note 1)	19,300	24,200	23,200	16,500	20,700	19,700	13,500	17,000	16,900
<p>Note 1: Coatings classified as Class A, Class B or Class D include those coatings which provide a mean slip coefficient not less than 0.30, 0.50 or 0.45 respectively, as determined by Testing Method to Determine the Slip Coefficient for Coatings Used in Bolt Joints Joints, (Appendix A of RCSC (Reference 157141)).</p> <p>Note 2: For Classes A and B, uncoated, contact surfaces shall be free of oil, paint, lacquer, or other coatings and loose oxide.</p> <p>Note 3: Any other faying surface preparation not described herein can be qualified to one of the surface condition classifications in accordance with Appendix A of RCSC (Reference 141) and may be used subject to the approval of the Engineer.</p> <p>Note 4: The values in this table are for design of new construction and are based on a factor of safety of 1.5. For repair, strengthening, retrofit, or other special conditions, a lower factor of safety may be considered at the Engineer's discretion. Previous editions of this table were based on lower factors of safety.</p>									

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Table 15-1-12. Minimum Tension of Installed Bolts

Nominal Bolt Size Inches	Minimum Tension in Kips	
	F3125 Grade A325 and Grade F1852 Bolts	F3125 Grade A490 and F3148 Bolts
1/2	12	15
5/8	19	24
3/4	28	35
7/8	39	49
1	51	64
1-1/8	64	80
1-1/4	81	102
1-3/8	97	121
1-1/2	118	148

3.2.2 TESTING AND DOCUMENTATION OF HIGH-STRENGTH FASTENERS (20212023)¹

3.2.2.1 Testing

- a. Bolts: In addition to the requirements of ASTM F3125 **or F3148**, if galvanized bolts are **supplied supplied**, measurements of coating thickness shall be taken on the wrench flats or top of bolt head.
- b. Nuts: In addition to the requirements of ASTM A563, if galvanized nuts are **supplied supplied**, measurements of coating thickness shall be taken on the wrench flats.
- c. Washers: In addition to the requirements of ASTM **F436 F436**, if galvanized washers are supplied, hardness testing shall be performed after galvanizing but coating shall be removed prior to taking hardness measurements.
- d. Assemblies:
 - (1) Rotational capacity tests are required **for all high-strength fastener assemblies** and shall be performed **by the manufacturer or distributor prior to shipping. Tests** on all **assemblies of ASTM F3125 Grade A325 and Grade A490 bolt, nut and washer assemblies by the manufacturer or distributor bolts and their corresponding nuts shall be performed** in accordance with ASTM F3125 Annex A2 **prior to shipping , and tests on all assemblies of ASTM F3148 bolts and their corresponding nuts shall be performed in accordance with ASTM F3148 Annex A1. Washers are required as part of the test procedure.** Direct-tension indicators shall not be included in the test. Zinc-coated assemblies shall be tested after coating.

[remainder unchanged]

[continued]

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3.2.3 INSTALLATION OF HIGH-STRENGTH BOLTS (~~2021~~2023)¹

[move 3.2.3j to 3.2.3a]

ja. Storage:

- (1) Fasteners Fastener assemblies** shall be protected from dirt and moisture.
- (2)** Only as many **fasteners fastener assemblies** as are anticipated to be installed and tightened during a work shift shall be taken from protected storage. **Fasteners Fastener assemblies** not used shall be returned to protected storage at the end of the shift. **Fasteners shall not be cleaned of lubricant that is present in as-delivered condition. Fasteners for slip-critical connections which accumulate dirt shall be cleaned and relubricated prior to installation, except that ASTM F3125 Grade F1852 twist-off-type tension-control assemblies shall be discarded or returned to the manufacturer.**

[move 3.2.3l to 3.2.3b]

lb. Lubrication:

- (1) Galvanized nuts shall be checked to verify that a visible lubricant is on the threads.
- (2) Black bolts shall be “oily” to the touch when delivered and installed.
- (3) ~~Weathered or rusted~~ **Weathered, rusted, or dirty** bolts or nuts, except **for spline-end bolting assemblies** as noted below in (4), shall be cleaned and relubricated prior to installation. Recleaned or relubricated bolt, nut and washer assemblies shall be retested in accordance with paragraph **k e and Article 3.2.2.1d** prior to installation.
- (4) ~~ASTM F3125 Grade F1852 twist-off-type tension-control~~ **Spline-end bolting** assemblies that are not in the as-delivered condition shall not be relubricated in the field, but shall be discarded or returned to the manufacturer.

[move 3.2.3m to 3.2.3c]

mc. Rotational-Capacity Lots. Bolt, nut and washer (when required) Bolt and nut combinations as installed shall be from the same rotational-capacity lot.

[move 3.2.3c to 3.2.3d(1) – 3.2.3d(3) and 3.2.3f(1) – 3.2.3f(4) to 3.2.3d(4)]

ed. Washer use. Washers shall be used as follows:

- (1)** ASTM F436 washers are required under the turned element.
- (2)** When ASTM F3125 Grade A490 **or ASTM F3148** bolts are used with connected material having a specified yield strength of less than 40 ksi, ASTM F436 washers shall be used under both the bolt head and the nut.
- (3) Special washer requirements when using direct tension indicator tensioning are given in paragraph f.** Beveled washers shall be used where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis.

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(4) When direct-tension indicators are used, the following additional washer use requirements apply:

- ~~(1a)~~ When the nut is turned and the direct-tension indicator is located under the bolt head, an ASTM F436 washer shall be used under the nut;
- ~~(2b)~~ When the nut is turned and the direct-tension indicator is located under the nut, an ASTM F436 washer shall be used between the nut and the direct-tension indicator;
- ~~(3c)~~ When the bolt head is turned and the direct-tension indicator is located under the nut, an ASTM F436 washer shall be used under the bolt head;
- ~~(4d)~~ When the bolt head is turned and the direct-tension indicator is located under the bolt head, an ASTM F436 washer shall be used between the bolt head and the direct-tension indicator.

[move 3.2.3h to 3.2.3e, adding 3.2.3e(4)]

~~h.e.~~ Pre-installation Verification. Pre-installation verification testing shall be conducted at the site of installation prior to all tensioning methods to ensure that the installation method can deliver the necessary tension. A Skidmore-Wilhelm Calibrator or an acceptable equivalent tension-measuring device shall be available for use whenever high-strength bolts are being installed. The device shall be used to confirm the suitability of the complete fastener assembly, including lubrication, for installation and confirm the procedure and proper use by the bolting crew of the tensioning method to be used. Washer configuration during pre-installation verification shall be the same as that which will be used in the work. The required testing consists of:

- (1) Turn-of-Nut Method. When the turn-of-nut installation method will be used, A a representative sample of ~~not fewer than~~ at least three complete fastener assemblies of each combination of diameter, length, and grade, ~~and lot~~ to be used in the work shall be ~~checked at the site of installation installed~~ in a tension calibrator ~~to verify that the tensioning method develops a tension that is equal to or greater than 1.05 times that specified in Table 15-1-12. Washers shall be used in the pre-installation verification assemblies as required in the work in accordance with the requirements in paragraphs e and f, snug-tightened in accordance with paragraph g, and tensioned in accordance with paragraphs h and h(1), using the same equipment and methods for both snug-tightening and tensioning as those to be used in the work.~~ If the actual tension developed in any of the fastener assemblies is less than 1.05 times that specified in Table 15-1-12, the ~~cause(s) cause or causes~~ shall be determined and resolved before the fastener assemblies are used in the work. Cleaning, lubrication, and retesting of these fastener assemblies, ~~except for ASTM F3125 Grade F1852 twist-off type tension control assemblies,~~ are permitted, provided all assemblies to be tested or installed are treated in the same manner.
- (2) Twist-Off Method. When twist-off bolts (ASTM F3125 Grade F1852) will be used, a representative sample of at least three complete fastener assemblies of each combination of diameter, grade, and rotational-capacity lot to be used in the work shall be installed in a tension calibrator and then snug-tightened in accordance with paragraph g using the same equipment and methods as those to be used in the work. If the spline is severed during snug-tightening, the snug-tightening method shall be revised and the pre-installation verification testing shall restart with three new assemblies. After snug-tightening, the assembly shall be tensioned in accordance with paragraphs h and h(2) using the same equipment and methods as those to be used in the work. If the actual tension developed in any of the fastener assemblies is less than 1.05 times that specified in Table 15-1-12, the cause or causes shall be determined and resolved before the fastener assemblies are used in the work. Cleaning, lubrication, and retesting of these fastener assemblies is not permitted.

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- (23) **Direct-Tension Indicator Method.** When direct-tension indicators are used, **a representative sample of at least five three** fastener assemblies of each combination of diameter, grade, and lot to be used in the work shall be ~~tightened to 1.05 times the tension specified in Table 15-1-12.~~ **The job inspection gap shall be the average of the gaps attained in the test installed in a tension calibrator and then snug-tightened in accordance with paragraph g. It shall be verified that a feeler gauge of 0.015-inch thickness can be inserted in at least half of the spaces. If this is not the case, the snug-tightening method shall be revised and the pre-installation testing shall restart with three new assemblies. After snug-tightening, the assembly shall be tensioned in accordance with paragraphs h and h(3) using the same equipment and methods as those to be used in the work.** The position of the direct-tension indicator, the ASTM F436 washer, and the turned element shall match the conditions in the work. **If the actual tension developed in any of the fastener assemblies is less than 1.05 times that specified in Table 15-1-12, the cause or causes shall be determined and resolved before the fastener assemblies are used in the work, provided all assemblies to be tested or installed are treated in the same manner. Cleaning, lubrication, and retesting of the fastener assemblies is permitted, provided all assemblies to be tested or installed are treated in the same manner.**
- (34) **Calibrated Wrench Method.** When the calibrated wrench method is used, **at the beginning of each day's production, a representative sample of at least three fastener assemblies of each combination of diameter, grade, and lot to be used in the work that day shall be installed in a tension calibrator, snug-tightened in accordance with paragraph g, and tensioned in accordance with paragraphs h and h(4) to 1.05 times the tension specified in Table 15-1-12 using the same equipment and methods for both snug-tightening and tensioning as those to be used in the work.** †The installation torque **for that day and combination** shall be the **average highest** of the three **(or more)** torques attained in the test.
- (5) **Combined Method.** When the combined method is used, **a representative sample of at least three fastener assemblies of each combination of diameter, grade, and lot to be used in the work shall be installed in a tension calibrator, and the initial torque specified in paragraph h(5) shall be applied using the same equipment and methods as those to be used in the work. If the actual tension developed in the bolting assembly is less than the initial tension specified in Table 15-3-4, the cause or causes shall be determined and resolved before the bolting assemblies are used in the work. Then the rotation specified in Table 15-3-5 shall be applied using the same equipment and methods as those to be used in the work. If the actual tension developed in any of the fastener assemblies is less than 1.05 times that specified in Table 15-1-12, the cause or causes shall be determined and resolved before the fastener assemblies are used in the work. Cleaning, lubrication, and retesting of these bolting assemblies is not permitted. Pre-installation verification testing for the combined method shall be conducted at least weekly.**

[first two sentences of 3.2.3a become new 3.2.3f]

f. Initial Installation. 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 provided as required in paragraph d and the nuts installed to complete the assembly.

[continued]

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[move 3.2.3a to 3.2.3g]

ag. Snug-Tightening Snug-Tightening:

- (1) The provisions for snug-tightening shall apply to all installation methods except the combined method described in paragraph h(5).**
- (2) 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 provided as required in paragraph e and the nuts installed to complete the assembly.** Compacting the joint to the snug-tight condition shall progress systematically from the most rigid part of the joint in a manner that will minimize relaxation of previously snugged bolts. The snug-tight condition is the tightness that is attained with a few impacts of an impact wrench, **resistance to a suitable non-impacting wrench**, or the full effort of an ironworker using an ordinary spud wrench to bring the connected plies into full contact, **with the end of the bolt (not including the spline, if present) flush with or extending beyond the outer face of the nut.**

[move 3.2.3b to 3.2.3h]

bh. Tensioning. ~~After compacting the joint to the snug-tight condition, bolts shall be tensioned so as to obtain, when all the bolts in the joint are tight, at least the minimum tension per bolt shown in Table 15-1-12 for the grade and size of bolt using the turn-of-nut method, twist-off type tension-control bolts, direct tension indicators, or the calibrated wrench method as described in paragraphs d, e, f, or g.~~ **For all of the following tensioning methods, a pre-installation verification test in accordance with paragraph e shall have been performed prior to installation. Washers shall be used in accordance with paragraph d.** Tightening shall progress systematically from the most rigid part of the joint in a manner that will minimize relaxation of previously tensioned bolts. **All assemblies shall be initially installed in accordance with paragraph f.**

[move 3.2.3d to 3.2.3h(1)]

d.(1) Turn-of-Nut Tensioning: An installation verification test specified in paragraph h shall be performed prior to bolt installation. All bolts fastener assemblies shall be **installed snug-tightened** in accordance with the requirements of paragraph a **g with washers installed as required in paragraph e.** Subsequently, the nut or head rotation specified in Table 15-3-2 shall be applied to all fastener assemblies in the joint. The part not turned by the wrench shall be prevented from rotating during this operation.

[move 3.2.3e to 3.2.3h(2)]

e.(2) Twist-Off-Type Tension-Control Bolt Tensioning: If the use of twist-off type tension-control bolt assemblies is Twist-off bolting assemblies (ASTM F3125 Grade 1852) may be used when permitted by the Engineer, the following provisions shall apply.

- (1) Twist-off type tension control bolt assemblies that meet the requirements of ASTM F3125 Grade F1852 shall be used.**
- (2) An installation verification test specified in paragraph h shall be performed prior to bolt installation.**
- (3) All fastener assemblies shall be installed in accordance with the requirements of paragraph a snug-tightened in accordance with the requirements of paragraph g without severing the splined end and with washers positioned as required in paragraph e. If a splined end is severed during snugging snug-tightening, the fastener assembly shall be removed and replaced. Subsequently, all the bolts in the joint shall be tensioned with the twist-off type tension control bolt installation by turning the nut using a shear wrench designed for use with twist-off bolts.**

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[move 3.2.3f to 3.2.3h(3)]

~~f.~~**(3)** Direct-Tension Indicator Tensioning: ~~If the use of d~~Direct-tension indicators (ASTM F959) is may be used when permitted by the Engineer, ~~the direct tension indicators shall meet the requirements of ASTM F959. The pre-installation verification procedure in paragraph h shall be performed before the indicators are used in the work to establish the job inspection gap.~~ Direct-tension indicators shall be installed with protrusions bearing against a hardened washer or the unturned nut or bolt head, with washers. ~~All bolts shall be used installed~~ in accordance with paragraph ~~a with the washers positioned as follows:~~ d. The assemblies shall be snug-tightened in accordance with paragraph g.

- ~~(1) When the nut is turned and the direct tension indicator is located under the bolt head, an ASTM F436 washer shall be used under the nut;~~
- ~~(2) When the nut is turned and the direct tension indicator is located under the nut, an ASTM F436 washer shall be used between the nut and the direct tension indicator;~~
- ~~(3) When the bolt head is turned and the direct tension indicator is located under the nut, an ASTM F436 washer shall be used under the bolt head;~~
- ~~(4) When the bolt head is turned and the direct tension indicator is located under the bolt head, an ASTM F436 washer shall be used between the bolt head and the direct tension indicator.~~

After snug-tightening, ~~t~~The installer shall verify that in half of more of the locations, the direct-tension indicator protrusions have not been compressed to a gap ~~that is~~ less than the job inspection gap during the snug tightening of the connection, and 0.015 inch (i.e., at least half of the spaces accept a 0.015-inch feeler gauge). ~~if~~ This has occurred, the direct-tension indicator shall be removed and replaced. Subsequently, all bolts in the joint shall be tensioned. After tensioning, ~~t~~The installer shall verify that in half or more of the locations, the direct-tension indicator protrusions have been compressed to a gap ~~that is~~ less than the job inspection gap 0.015 inch (i.e., at least half of the spaces refuse a 0.015-inch feeler gauge).

[move 3.2.3g to 3.2.3h(4)]

~~g.~~**(4)** Calibrated Wrench Method Tensioning: The pre-installation verification procedure in paragraph ~~h~~ **e****(4)** shall be performed to establish the installation torque prior to bolt installation at least once each working day and when conditions change. Torque values from tables or equations shall not be used. All bolts fastener assemblies shall be installed snug-tightened in accordance with the requirements of paragraph ~~a with washers installed as required in paragraph e g.~~ The part not turned by the wrench shall be Subsequently, the installation torque shall be applied to the nut, while the bolt head is prevented from rotating ~~during this operation.~~

[new]

(5) Combined Method Tensioning: The combined method applies to tensioning fixed spline-end bolting assemblies (ASTM F3148), and may be used when permitted by the Engineer. The initial torque provided by the bolting assembly supplier or the default values in Table 15-3-3 to be used when no initial torque has been provided by the supplier, shall be applied to all bolting assemblies by turning the nut using a wrench designed for use with the combined method. The wrench shall demonstrate or have certified output that does not vary by more than ±10% during use. The plies shall be brought into firm contact with the end of the bolt (not including the spline) flush with or extending beyond the outer face of the nut. Subsequently, the rotation specified in Table 15-3-5 shall be applied.

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- i. ~~Fastener Reuse. ASTM F3125 A490 bolts and galvanized Grade A325 bolts shall not be reused after having once been fully tensioned. These same type bolts may be used for both fit-up and final bolting if tightened to no more than snug-tight during fit-up. Other Uncoated "black" Grade A325 bolts that have been tensioned beyond snug-tight condition only once may be reused if approved by the Engineer. Any other bolts may be used for both fit-up and final bolting if tightened to no more than snug-tight during fit-up, but shall not be reused after having once been fully tensioned.~~

[3.2.3k becomes 3.2.3j]

- kj. **Field Rotational-Capacity Test.** At the direction of the Engineer, if the condition of the fastener assembly is in question, the rotational-capacity test ~~for ASTM F3125 Grade A325 and Grade A490 high-strength bolts~~ described in Article 3.2.2 shall be performed on two fastener assemblies from the rotational-capacity lot in question. Hardened steel washers are required as part of the test although they may not be **required configured** in the **same way as in the** actual installation procedures.

Table 15-3-2. Nut Rotation from Snug-Tight Condition *for Turn-of-Nut Method*

Bolt Length (measured from underside of head to end of bolt)	Condition of Outer Faces of Bolted Parts		
	Both Faces Normal to Bolt Axis-	One face normal to bolt axis and other sloped not more than 1:20 (beveled washer not used)	Both faces sloped to bolt axis not more than 1:20 from normal (beveled washer not used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters (Note 2)	2/3 turn	5/6 turn	1 turn

Note 1: Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. The tolerance is +60° (1/6 turn), -30 0°.

Note 2: Where the bolt length exceeds 12 diameters, the required rotation shall be determined by actual tests in a suitable **bolt** tension **measuring** device **simulating actual conditions**.

Note 3: The values given are applicable only to joints in which all material within the grip is steel.

Table 15-3-3. Default Initial Torque Range for the Combined Method Using ASTM F3148 Bolts

Nominal Bolt Diameter, d _b , in.	Torque Range for Combined Method, lb-ft	
	Minimum	Maximum
1/2	60	75
5/8	120	145
3/4	210	250
7/8	335	400
1	510	605
1-1/8	710	845
1-1/4	1010	1200

Note 1: This table shall not be used in lieu of supplier-provided torque values and shall only be used when torque has not been provided for a bolting assembly by the bolt supplier.

Note 2: This table applies to ASTM F3148 bolts only.

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Table 15-3-4. Minimum Initial Tension for Pre-installation Verification of Installation by the Combined Method Using ASTM F3148 Bolts

Nominal Bolt Diameter, d _b , in.	Minimum Initial Tension for Pre-Installation Verification, kips
1/2	7
5/8	11
3/4	16
7/8	22
1	29
1-1/8	36
1-1/4	46
Note 1: This table applies to ASTM F3148 bolts only.	

Table 15-3-5. Nut Rotation from Initial Torque for Combined Method

Bolt Length	Rotation
Not more than 4 diameters	90° (1/4 turn)
More than 4 diameters but not more than 8 diameters (Note 3)	120° (1/3 turn)
<p>Note 1: Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. For all required nut rotations, the tolerance is +45°, -0°.</p> <p>Note 2: Applicable only to joints in which all material within the grip is steel.</p> <p>Note 3: When the bolt length exceeds 8 diameters, the required nut rotation shall be determined by actual testing in a suitable bolt tension measurement device.</p>	

[Re-number existing Table 15-3-3 as 15-3-6]

3.2.5 SIZE AND WORKMANSHIP OF HOLES (~~2020~~2023)¹

c. At locations approved by the Engineer, oversize **holes**, short slotted, or long slotted holes may be used with high-strength bolts 5/8 inch in diameter or larger in accordance with the following requirements.

- (1) *Oversize holes* may have nominal diameters up to 3/16 inch larger than bolts 7/8 inch and less in diameter, 1/4 inch larger than bolts 1 inch in diameter, and 5/16 inch larger than bolts 1-1/8 inch and greater in diameter. They may be used in any or all plies of connections. Hardened washers shall be installed over oversized holes in an outer ply. Where ASTM F3125 Grade A490 **or ASTM F3148** bolts over 1 inch in diameter are used in oversized holes in external plies, a single hardened washer conforming to ASTM F436, except with a 5/16 inch minimum thickness, shall be used under both the head and the nut in lieu of standard thickness hardened washers. Multiple hardened washers with combined thickness equal to or greater than 5/16 inch do not satisfy this requirement.

[continued]

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- (2) Short slotted holes are nominally 1/16 inch wider than bolt diameter and have a length which does not exceed the oversized diameter provisions for oversize holes by more than 1/16 inch. They may be used in any or all plies of connections without regard to direction of loading. Hardened washers shall be installed over short slotted holes in an outer ply. Where ASTM F3125 Grade A490 or ASTM F3148 bolts over 1 inch diameter are used in short slotted holes in external plies, a single hardened washer conforming to ASTM F436, except with a 5/16 inch minimum thickness, shall be used under both the head and the nut in lieu of standard thickness hardened washers. Multiple hardened washers with combined thickness equal to or greater than 5/16 inch do not satisfy this requirement.
- (3) Long slotted holes are nominally 1/16 inch wider than the bolt diameter and have a length more than allowed for short slotted holes, but not more than 2.5 times the bolt diameter. The slots may be used without regard to direction of loading. Long slotted holes may be used in only one of the connected parts at an individual faying surface. Where ASTM F3125 Grade A325 or Grade F1852 bolts of any diameter or ASTM F3125 Grade A490 or ASTM F3148 bolts equal to or less than 1 inch in diameter are to be installed and tightened in a long slotted hole in an outer ply, a plate washer or continuous bar of at least 5/16 inch thickness with standard holes shall be provided. These washers or bars shall have a size sufficient to completely cover the slot after installation and shall be of structural grade material, but need not be hardened except as follows. When ASTM F3125 Grade A490 or ASTM F3148 bolts over 1 inch in diameter are to be used in long slotted holes in external plies, a single hardened washer conforming to ASTM F436 but with 5/16 inch minimum thickness shall be used in lieu of washers or bars of structural grade material. Multiple hardened washers with combined thickness equal to or greater than 5/16 inch do not satisfy this requirement. If hardened washers are required to satisfy specification provisions, the hardened washers shall be placed over the outer surface of the plate washer or bar.

3.6.1 MARKING, PACKAGING, AND LOADING (1995) R(20242023)

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- .
- .
- c. Fasteners, except ASTM F3125 Grades A325 and A490 and F3148 high-strength bolts and their accompanying nuts and washers, shall be packaged separately according to length and diameter. Loose nuts and washers shall be packaged separately according to size.
- d. Pins and other small parts and packages of fasteners, except ASTM F3125 Grades A325 and A490 and F3148 high-strength bolts, nuts, and their accompanying nuts and washers washers, shall be shipped in boxes, crates, kegs, or barrels, none of which shall exceed 300 lb gross weight. A list and description of material contained therein shall be firmly secured to or marked on the outside of each container.
- e. ASTM F3125 Grades A325 and A490 and F3148 high-strength bolts, nuts, and washers (where required) bolts and their accompanying nuts from each rotational-capacity lot shall be shipped in the same container. If there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. Each container (not the lid) shall be permanently marked with the rotational-capacity lot number such that identification will be possible at any stage prior to installation.

[remainder unchanged]

[continued]

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[edit beginning of Twist-Off section and add F3148 following Twist-Off section, yellow highlight to retain bold and underline when published]

9.1.2.1 MATERIALS (**20192023**)

a. **Weathering Steel:** ASTM A588...

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Twist-Off ~~Tension-Control~~ Bolts: ASTM includes two designations for "~~twist-off~~" **twist-off type tension-control** "~~tension-control~~" **"tension-control"** bolts (F3125 Grades F1852 ...

.
. .

F3148 Bolts: **F3148 bolts were developed to be used with the combined method for tension (sometimes called the "torque and angle" method) described in Article 3.2.3.h(5). They have similar ductility to F3125 Grade A325 and A1852 bolts, but have a tensile strength of 144 ksi, approaching that of F3125 Grade A490. They have a spline end similar to that of F3125 Grade A1852 bolts, except that the spline is not designed to be severed during installation.**

9.1.4.1 STRUCTURAL STEEL, FASTENERS AND PINS (**20182023**)

In determining the ...

Yielding of the ...

The more conservative ...

Since there have ...

From 1935 to 1969, the ...

The column curve ...

The difficulty of ...

The formula to ...

Professor Thürliman ...

Thus, the critical...

If σ_v , is assumed...

For I shaped ...

Based on a ...

This formula is ...

The second compression...

[continued]

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Since tests have ...

For box type flexural ...

The allowable stress ...

The allowable shears in [ASTM F3125](#) Grade A325 and Grade A490 [and ASTM F3148](#) bolts are based on recommendations of the Research Council on Structural Connections of the Engineering Foundation. Also see [Reference References](#) 107 and 141.

The allowable shear values ...

The change in ...

A new Class D ...

Unsealed thermal-spray surfaces ...

The allowable stress in bearing ...

9.3.2.2 TESTING AND DOCUMENTATION OF HIGH-STRENGTH FASTENERS ([20172023](#))

9.3.2.2.1 Testing

d. Assemblies:

The purpose of the ~~rotational capacity~~ ~~rotational capacity~~ test is to verify that the bolt, nut, and washer assembly will effectively develop the desired clamping force when it is tightened in the structure, and has adequate lubrication, installation ductility, and resistance to stripping. With the exception of galvanized ASTM F3125 Grade A325 bolts, the ASTM standards that define manufacture and testing requirements only address mandatory testing of the individual fastener components. The only test that evaluates the ~~bolt, bolt and~~ nut ~~and washer~~ assembly is the ~~rotational capacity~~ ~~rotational capacity~~ test. This manual requires rotational capacity testing for all ~~Grade A325 and A490~~ ~~high-strength~~ bolts to assure the performance of the fastener assembly. A ~~rotational capacity~~ ~~rotational capacity~~ lot is established so that components manufactured with like characteristics that have been tested as an assembly are controlled for use as bolt, nut, and washer assemblies in the structure.

In general, the required nut rotation for the ~~rotational capacity~~ ~~rotational capacity~~ test is about twice the rotation required to pretension the bolts using the turn-of-nut method. ~~The RCSC "Specifications for Structural Joints Using High-Strength Bolts" does not have a required turn-of-nut installation rotation for bolts longer than 12 times the diameter. The required rotation for installation must be determined by actual tests using a suitable tension device simulating actual conditions (Reference 141 and Table 15-3-2 Note 2). Since the rotational capacity test rotation is a function of the turn-of-nut installation rotation, ASTM exempts bolt assemblies longer than 12 times the diameter because there is not an established standard for these bolts. The rotational capacity test is applicable only to Grade A325 and A490 bolts, and therefore is not applicable to "twist-off" (Grade F1852 and F2280) bolts.~~

[continued]

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9.3.2.3 INSTALLATION OF HIGH-STRENGTH BOLTS (~~2021~~2023)

See Article 9.3.2.1.

h. Tensioning

(5) Approval from the Engineer is required for certain installation methods since conditions may exist that are not necessarily accounted for during design, for example, galvanization of twist-off bolts leaves an unprotected surface post-installation.

Chapter 15 Glossary

[add entry under ASTM]

ASTM F3148 Standard Specification for High Strength Structural Bolt Assemblies, Steel and Alloy Steel, Heat Treated, 144ksi Minimum Tensile Strength, Inch Dimensions

References

141. Research Council on Structural Connections. *Specification for Structural Joints Using High-Strength Bolts*. Chicago, IL: American Institute of Steel Construction, ~~1 Aug. 2014~~ 11 Jun. 2020. Cited in Table 15-1-11a and Articles 3.2.1, 3.5.4b, 9.1.4.1, and 9.3.2.14.1d.
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157. Slutter, Roger C., and John W. Fisher. "Fatigue Strength of Shear Connectors." Highway Research Record No. 147. Washington, DC: National Research Council, 1966. pp. 65-88. Cited in ~~Table 15-1-11a and~~ Articles 9.1.7.9, 9.1.7.9.2, and 9.1.7.9.3.1.

[end of Letter Ballot 15-22-04]