Designation: F3125/F3125M – 18

Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength[1]

This standard is issued under the fixed designation F3125/F3125M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers chemical, physical and mechanical requirements for quenched and tempered bolts manufactured from steel and alloy steel, in inch and metric dimensions, in two strength grades, two types and two styles.

1.1.1 This specification is a consolidation and replacement of six ASTM standards, including; A325, A325M, A490, A490M, F1852 and F2280.

1.1.2 This consolidated standard is to ensure alignment between standards with the same intended end use and to simplify the use and maintenance of structural bolt specifications.

1.2 *Intended Use:*

1.2.1 Bolts manufactured under this specification are intended for use in structural connections covered in the Specification for Structural Joints Using High-Strength Bolts, as approved by the Research Council on Structural Connections.

1.2.2 Bolts in this specification are furnished in sizes from ½ to 1-½ in. inclusive and from M12 to M36 inclusive.

1.3 *Classification,* Table 1*:*

1.3.1 Bolts are designated by grade, which indicates inch or metric strength and style.

1.3.2 Bolts are designated by type denoting raw material chemical composition.

1.3.3 Bolts are designated by style denoting Heavy Hex bolts or "Twist-Off" Style assemblies.

1.4 Terms used in this specification are defined in F1789.

1.5 *Units*—The values stated in either SI units or inch pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.6 Table footnotes are requirements. Notes are advisory.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A194/A194M Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both

A354 Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners

A449 Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use

A563 Specification for Carbon and Alloy Steel Nuts

A563M Specification for Carbon and Alloy Steel Nuts (Metric)

A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

B695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel

E709 Guide for Magnetic Particle Testing

E1444/E1444M Practice for Magnetic Particle Testing

[1] This specification is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.02 on Steel Bolts, Nuts, Rivets and Washers.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

TABLE 1 Classification

Grade	Min. Strength	Type[A]		Style
A325	120 ksi	1	3	Heavy Hex Head
A490	150 ksi	1	3	Heavy Hex Head
F1852	120 ksi	1	3	Twist-Off
F2280	150 ksi	1	3	Twist-Off
A325M	830 MPa	1	3	Heavy Hex Head
A490M	1040 MPa	1	3	Heavy Hex Head

[A] Type 1 - 120 ksi (830 MPa) - carbon steel, carbon boron steel, alloy steel or alloy steel with boron addition
Type 3 - 120 ksi (830 MPa) or 150 ksi (1040 MPa) - weathering steel
Type 1 - 150 ksi (1040 MPa) - alloy steel or alloy steel with boron addition

F436/F436M Specification for Hardened Steel Washers Inch and Metric Dimensions
F606/F606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
F788 Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series
F1136/F1136M Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners
F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection
F1789 Terminology for F16 Mechanical Fasteners
F1940 Test Method for Process Control Verification to Prevent Hydrogen Embrittlement in Plated or Coated Fasteners
F2328 Test Method for Determining Decarburization and Carburization in Hardened and Tempered Threaded Steel Bolts, Screws, Studs, and Nuts
F2328M Test Method for Determining Decarburization and Carburization in Hardened and Tempered Threaded Steel Bolts, Screws, Studs, and Nuts (Metric)
F2329 Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners
F2660 Test Method for Qualifying Coatings for Use on A490 Structural Bolts Relative to Environmental Hydrogen Embrittlement
F2833 Specification for Corrosion Protective Fastener Coatings with Zinc Rich Base Coat and Aluminum Organic/Inorganic Type
F3019/F3019M Specification for Chromium Free Zinc-Flake Composite, with or without Integral Lubricant, Corrosion Protective Coatings for Fasteners
G101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

2.2 *ASME Standards:*[3]
B1.1 Unified Screw Threads
B1.13M Metric Screw Threads
B18.18 Quality Assurance for Fasteners
B18.2.6 Fasteners for Use in Structural Applications
B18.2.6M Metric Fasteners for Use in Structural Applications

2.3 *IFI Standard:*[4]
IFI 144 Test Evaluation Procedures for Coating Qualification

2.4 *RCSC Standard:*[5]
Specification for Structural Joints Using High-Strength Bolts

3. Ordering Information

3.1 Orders for bolts under this specification shall include:

3.1.1 *ASTM designation.*

3.1.2 *Quantity:* Number of bolts or assemblies, including washers, if required.

3.1.3 *Size:* Including nominal bolt diameter and bolt length, and thread pitch if other than standard.

3.1.4 *Grade:* A325, A490, F1852, F2280 or A325M, A490M.

3.1.5 *Type:* Type 1 or Type 3. When Type is not specified either Type 1 or Type 3 may be furnished at the supplier's option.

3.1.6 *Style:* Heavy Hex or Twist-Off Style.

3.1.7 *Coatings or finishes:* If other than plain finish, specify the coating process or finish required, see Annex A1.

3.2 *Test reports,* see Section 14.

3.3 Additional details of other assembly components such as nuts and washers, if required.

3.4 Rotational capacity testing of matched sets or assemblies in accordance with Annex A2, as required in 8.1.5 and when requested by the purchaser.

3.5 Heavy Hex bolts may be ordered individually, packaged with nuts, packaged with nuts and washers, or as assemblies.

3.6 Any special observation or inspection requirements shall be specified at the time of inquiry and at the time of order. See Section 13.2.

3.7 Any supplementary requirements.

3.8 Country of origin requirements, if any.

NOTE 1—A typical description follows: 1000 pieces ¾ in.× 3 in. ASTM F3125–15, Grade A325 Heavy Hex Bolt, Type 1, each with one ASTM F436/F436M Type 1 Hardened Washer, and one A563 Grade DH Heavy Hex Nut.

NOTE 2—Bolts are sometimes detailed with names such as A325 HS, A325 SC, A325 X or A490 N. These names relate to connection design and bolt installation, but do not change the manufacturing requirements and are preferably not shown on bolt orders.

4. Dimensions

4.1 *Head and Body:*

4.1.1 Bolts shall conform to the dimensions specified in Table 2 for Heavy Hex or Twist-Off bolts.

4.1.2 The thread length shall not be changed except as provided in Supplementary Requirement S1 or S2. Other dimensions shall not be changed except in accordance with Supplementary Requirement S2.

4.1.3 Bolts with thread lengths or dimensional requirements which differ from this specification may also be ordered under

[3] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

[4] Industrial Fasteners Institute (IFI), 6363 Oak Tree Blvd. Independence, OH 44131. http://www.indfast.org

[5] Research Council on Structural Connections (RCSC), http://boltcouncil.org

TABLE 2 Dimensions, Threads, Marking, Matching Components

	Inch				Metric			
	120 ksi Min Tensile		150 ksi Min Tensile		830 MPa Min Tensile		1040 MPa Min Tensile	
	Type 1	Type 3	Type 1	Type 3	Type 1	Type 3	Type 1	Type 3
Style - Heavy Hex Bolts								
Dimensions, ASME[B]	B18.2.6	B18.2.6	B18.2.6	B18.2.6	B18.2.6M	B18.2.6M	B18.2.6M	B18.2.6M
Thread Fit, ASME[B]	B1.1 UNC 2A	B1.1 UNC 2A	B1.1 UNC 2A	B1.1 UNC 2A	B1.13M MC 6g	B1.13M MC 6g	B1.13M MC 6g	B1.13M MC 6g
Grade Marking[A,D]	A325	A325	A490	A490	A325M	A325M	A490M	A490M
Style - Twist-Off Bolts								
Dimensions, ASME[B]	B18.2.6	B18.2.6	B18.2.6	B18.2.6	[F]	[F]	[F]	[F]
Thread Fit, ASME[B]	B1.1 UNC 2A	B1.1 UNC 2A	B1.1 UNC 2A	B1.1 UNC 2A	[F]	[F]	[F]	[F]
Grade Marking[A,D]	A325TC	A325TC	A490TC	A490TC	[F]	[F]	[F]	[F]
Alt. Marking[A,C]	A325	A325	A490	A490	[F]	[F]	[F]	[F]
Recommended Nut and Washer								
Plain Nut	A563 DH	A563 DH3	A563 DH	A563 DH3	A563M 10S	A563M 10S3	A563M 10S	A563M 10S3
Suitable Alternative[E]	DH3, D, C, C3	C3			8S, 8S3, 10S3	8S3	10S3	
Coated Nut	A563 DH	A563 DH3	A563 DH	A563 DH3	A563M 10S	A563M 10S3	A563M 10S	A563M 10S3
Flat, Bevel or Thick Washer if used	F436/F436M - 1	F436/F436M - 3	F436/F436M - 1	F436/F436M - 3	F436/F436M - 1	F436/F436M - 3	F436/F436M - 1	F436/F436M - 3

[A] A325 and A325M bolts lengths up to 4D which are fully threaded but which are not required to be fully threaded by the relevant ASME standard shall be marked with a "T", see Supplementary Requirement S1. Bolts with any other non-standard dimensions, including non-standard thread length (except for bolts up to 4D threaded fully and marked with "T" per S1 requirement), shall be marked with an "S", see Supplementary Requirement S2.
[B] Manufactured to the latest revision at the time of manufacture, UNC for inch series and Metric Coarse (MC) for Metric Series.
[C] Previously used markings may be sold and used indefinitely, bolts must be manufactured to current marking requirements upon initial publication of this standard.
[D] Other distinguishing markings for type 3 are permitted at the manufacturers option.
[E] ASTM A194/A194M 2H Heavy Hex inch Nuts may be used in place of A563 DH nuts on type 1 A325, A490, F1852 and F2280 bolts. 2H Heavy Hex metric Nuts may be used in place of A563M 10S nuts on type 1 A325M and A490M bolts. When coated 2H nuts are used in place of DH or 10S nuts, the same requirements of A563, A563M, and this specification, including Annex A1, shall apply. These requirements include, but are not limited to, thread dimensions and overtapping allowances, coating grade, lubrication requirements, and proof load testing.
[F] Metric dimensions and requirements for this style have not been established.

TABLE 3 Chemical Requirements[A]

Heat Analysis	120 ksi/830 MPa Minimum				150 ksi/1040 MPa Minimum	
	Grade A325, A325M, F1852				Grade A490, A490M, F2280	
	Type 1	Type 3			Type 1	Type 3
	Carbon or Alloy Steel with or without Boron	Composition A	Composition B	Based on Corrosion Index[B]	Alloy Steel with or without Boron	Based on Corrosion Index[B]
Carbon	0.30 - 0.52	0.33 - 0.40	0.38 -0.48	0.30 - 0.52 max	0.30 - 0.48[C]	0.30 - 0.53
Manganese	0.60 min	0.90 - 1.20	0.70 - 0.90	0.60 min	0.60 min	0.60 min
Phosphorus, max	0.035	0.035	0.035	0.035	0.035	0.035
Sulfur, max	0.040	0.040	0.040	0.040	0.040	0.040
Silicon	0.15 - 0.30	0.15 - .30	0.30 - 0.50	[D]	[D]	[D]
Boron	0.003 max	[D]	[D]	[D]	0.003 max	[D]
Copper	[D]	0.25 - 0.45	0.20 - 0.40	0.20 - 0.60	[D]	0.20 - 0.60
Nickel	[D]	0.25 - 0.45	0.50 - 0.80	0.20[E] min	[D]	0.20[E] min
Chromium	[D]	0.45 - 0.65	0.50 - 0.75	0.45 min	[D]	0.45 min
Vanadium	[D]	[D]	[D]	[D]	[D]	[D]
Molybdenum	[D]	[D]	0.06 max	0.10[E] min	[D]	0.10[E] min
Titanium	[D]	[D]	[D]	[D]	[D]	[D]

[A] Based on heat analysis.
[B] See 6.3.
[C] Carbon requirement is 0.35-0.53 for 1-½ in. and M36 diameter bolts.
[D] Not Specified.
[E] Material that satisfies the criteria for either Nickel or Molybdenum shall be considered as satisfying the requirements for both elements.

Specification A449 or A354. Users should note that A449 and A354 are not exact equivalents to the structural grades in this specification.

4.2 *Threads:*

4.2.1 Uncoated bolt threads shall be as specified in Table 2.

4.2.2 Coated bolts shall have threads meeting Table 2 requirements before coating.

4.3 The gauging limit for coated bolts shall be verified during manufacture. In case of dispute, a calibrated thread ring gauge of the same size as the oversize limit in Annex A1 (Class X tolerance, gauge tolerance plus) shall be used to verify compliance. The gauge shall assemble with hand effort following application of light machine oil to prevent galling and damage to the gauge. These inspections, when performed to

resolve controversy, shall be conducted at the frequency specified in the quality provisions of ASME B18.18.

NOTE 3—It is the intent of this specification that coated nuts and bolts assemble freely when ordered together. It is recognized that the batch nature of coating process and the cumulative effect of coating thickness may create intermittent assembly problems. Staying within the material limits is important for assembly strength. Users are encouraged to use the smallest nut overtap which permits consistent free assembly.

5. Product Marking

5.1 At a minimum, all bolts shall be marked as required in Table 2. Marking shall be on the bolt head and may be raised or depressed at the manufacturer's option. The marking shall be visible after coating.

5.2 Grade and Type marking, and the manufacturer's mark shall be in separate and distinct locations on the head. Other markings, if used, such as private label distributor's mark shall also be separate and distinct.

6. Chemical Composition

6.1 120ksi/830MPA Type 1 bolts shall be carbon steel, carbon boron steel, alloy steel or alloy steel with boron addition at the manufacturer's option, conforming to the chemical composition specified in Table 3.

6.2 150ksi/1040MPa bolts Type 1 shall be alloy steel or alloy steel with boron addition at the manufacturer's option, conforming to the chemical composition specified in Table 3.

6.3 Type 3 bolts shall be weathering steel and shall conform to the chemical compositions A or B specified in Table 3 or be produced from a material with chemical composition "Based on Corrosion Index" that has a corrosion index of 6 or greater, as calculated from the heat analysis, and as described in G101. Calculation of the corrosion index shall be done using the predictive method based on the data of Larabee and Coburn or the predictive method based on the data of Townsend. (see Guide G101 for methods of estimating the atmospheric corrosion resistance of low alloy steels).

6.4 If performed, product analysis made on finished bolts representing each lot shall be within 10% of the value required of the heat analysis. For example; heat analysis C 0.30–0.52 = product analysis C 0.27– 0.57.

6.5 Heats to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted.

6.6 Chemical analysis shall be performed in accordance with A751.

7. Materials and Manufacture

7.1 *Production Method:*

7.1.1 Bolts shall be cold formed, warm formed, hot formed, hot forged, machined, or any combination thereof.

7.2 *Heat Treatment:*

7.2.1 All bolts shall be quenched in oil from the austenitizing temperature.

7.2.2 All bolts shall be tempered by reheating to not less than 800°F/427°C.

7.3 Threads may be rolled or cut.

7.4 *Coatings and Other Finishes:*

7.4.1 Permitted coatings, including supplementary lubrication and nut oversize requirements, are provided in Annex A1.

7.4.2 When coated fasteners are required, the purchaser shall specify the process and any additional special requirements.

7.4.3 Threaded components (bolts and nuts) shall be coated by the same process, limited to one process per item with no mixed processes in a lot.

7.5 *Secondary Processing:*

7.5.1 Lot control and full traceability shall be maintained throughout all outside or secondary processes.

7.5.2 Lots to which secondary processing has been performed by any party after sale from the manufacturer must be traceable using a lot number which differs from the manufacturer's original lot number.

7.5.3 If processing that can affect mechanical properties is performed after initial testing, the bolts shall be retested for all specified mechanical properties and performance requirements affected by the processing. This processing includes heat treatment, hot-dip zinc coating and other processing that could affect mechanical properties.

7.5.4 Secondary processing, including lubrication, by any party other than that which certified the assembly lot shall not be permitted on a Twist-Off style bolt assembly lot unless under the direction of the manufacturer.

NOTE 4—Twist-Off Style bolt performance is dependent on the torque/tension relationship and alteration of this relationship may have an adverse effect on performance.

8. Test Methods

8.1 Tensile strength, proof load, surface discontinuities, hardness, micro-hardness, carburization/decarburization, coating thickness, magnetic particle, rotational capacity, assembly tension testing and coating thickness tests, as applicable, shall be in accordance with Table 4.

8.1.1 Tensile strength shall be determined using the F606/F606M Wedge or Axial Tension Testing of Full Size Product Method or the Machined Test Specimens Method depending on size and nominal length as specified in 10.1.

8.1.2 Proof load shall be determined using F606/F606M Method 1, Length Measurement, or Method 2, Yield Strength, at the option of the manufacturer.

8.1.3 Magnetic Particle Inspection shall be conducted on 150 ksi (1040 MPa) bolts, in accordance with Table 4 and 12.1.

8.1.4 Carburization/Decarburization Inspection shall be conducted on 150 ksi (1040 MPa) bolts, in accordance with 12.2.

8.1.5 Rotational Capacity Testing shall be performed on galvanized assemblies by the responsible party. Plain finish and other coated assemblies shall be rotationally capacity tested by the responsible party when specified on the inquiry and purchase order, see Supplementary Requirement S4. Test method is as described in Annex A2.

9. Testing and Lot Control

9.1 *Testing Responsibility:*

TABLE 4 Number of Tests and Test Method or Criteria

	Sample Size (Per Lot)	Test Method Inch	Test Method Metric	Notes
All grades, types, styles				
Tensile Strength	F1470	F606/F606M	F606/F606M	Wedge or axial Full size. Machined. See 8.1.1 and 10.1
Proof Load	F1470	F606/F606M	F606/F606M	Method 1 or 2 optional. See 8.1.2
Hardness	F1470	F606/F606M	F606/F606M	
Dimensions and Thread Fit	ASME B18.18	ASME B18.2.6 B1.1 2A	ASME B18.2.6M B1.13M 6g	
Surface Discontinuities	F1470	F788	F788	
Coating Weight/Thickness	F1470[A]	Product Specification	Product Specification	
150 ksi grades all types and styles				
Magnetic Particle	F1470	F788	F788	Guide E709 or Practice E1444/E1444M
Carburization/Decarburization	At least 1	F2328	F2328M	
All Twist Off assemblies				
Assembly Tension Test (Fastener Tension)	F1470	This standard		
Rotational Capacity	F1470	Annex A2	Annex A2	

[A] Use F1470 for sampling if sample requirements are not in the coating specification.

9.1.1 Each lot shall be tested by the manufacturer prior to shipment in accordance with the lot control and identification quality assurance plan in Sections 9.2 through 9.5.

9.1.2 When supplied by a source other than the manufacturer, the responsible party shall assure all tests have been performed and the bolts conform to this specification.

9.2 Bolts shall be processed in accordance with a lot control and identification quality assurance plan. The manufacturer, secondary processors, and distributors shall identify and maintain the integrity of each production lot from raw material through all processing operations to final packing and shipment. Each lot shall be assigned a unique lot identification number, each lot shall be tested, and the lot inspection test reports retained.

9.3 Secondary processing shall be processed in accordance with a lot control and identification quality assurance plan.

9.4 A lot shall be a quantity of uniquely identified structural bolts of the same nominal size and length produced consecutively at the initial operation from a single mill heat of material and processed at one time, by the same process, in the same manner so that statistical sampling is valid.

9.5 Additional testing for fastener assemblies, such as assembly tension testing and rotational capacity testing also require that the manufacturer or responsible party maintain assembly lot traceability. A unique assembly or rotational capacity lot number shall be created for each change in assembly component lot number, such as nuts or washers.

NOTE 5—The purpose of a lot inspection and control program is to ensure that each lot conforms to this specification and that lot integrity is maintained to the point of use. It is essential that secondary processors, distributors, and users maintain lot identification and integrity until installation.

9.6 *Number of Tests:*

9.6.1 The minimum number of tests required from each lot or each assembly lot shall be according to F1470 and ASME B18.18. These tests and sample numbers are for final inspection only and shall be in addition to the manufacturer's established internal quality control system and in-process inspection procedures.

9.6.2 Disposition of non-conforming product shall be in accordance with F1470 Section 8.

NOTE 6—Section 9.6.1 is intended to identify a statistically large number of non-conformances but does not assure 100% freedom from non-conforming product.

10. Mechanical Properties

10.1 *Tensile Properties:*

10.1.1 Except as permitted in 10.1.2 and 10.1.3, diameters 1 in./M24 and smaller having a nominal length of 2¼ D and longer, and sizes over 1 in./M24 having a nominal length of 3D and longer, shall be wedge tested full size to F606/F606M and shall conform to the wedge tensile load and proof load or alternative proof load specified in Table 5.

10.1.2 Sizes 1 in./M24 and smaller having a nominal length shorter than 2¼ D down to 2D, inclusive, that cannot be wedge tensile tested, shall be axially tension tested full size to F606/F606M and shall conform to the minimum tensile load and proof load or alternate proof load specified in Table 5.

10.1.3 Sizes 1 in./M24 and smaller having a nominal length shorter than 2D and sizes larger than 1 in./M24 with nominal lengths shorter than 3D that cannot be axially tensile tested shall be qualified on the basis of hardness.

10.1.4 Fracture on full-size tests shall be in the threads of the bolt without fracture at the junction of the head and body.

10.1.5 When the length of the bolt makes full-size testing impractical, machined specimens shall be tested and shall conform to the requirements specified in Table 6. When bolts are tested by both full-size and machined specimen methods, the full-size test shall take precedence.

10.2 *Hardness:*

10.2.1 Bolts shall conform to the hardness in Table 7. For lots on which both hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence in the event of low hardness readings.

TABLE 5 Mechanical Property Requirements for Bolts Tested Full Size

		120 ksi - A325, F1852			150 ksi - A490, F2280			
	Stress Area[A]	Tensile min	Proof Load Length Measurement min	Alternative Proof Load Yield Strength Method min	Tensile min	Tensile max.	Proof Load Length Measurement min	Alternative Proof Load Yield Strength Method min
in.	in^2	lbf	lbf	lbf	lbf	lbf	lbf	lbf
½-13 UNC	0.142	17050	12050	13050	21300	24600	17050	18500
⅝-11 UNC	0.226	27100	19200	20800	33900	39100	27100	29400
¾-10 UNC	0.334	40100	28400	30700	50100	57800	40100	43400
⅞-9 UNC	0.462	55450	39250	42500	69300	79950	55450	60100
1-8 UNC	0.606	72700	51500	55750	90900	104850	72700	78800
1⅛-7 UNC	0.763	91600[B]	64900[B]	70250[B]	114450	132000	91550	99200
1¼-7 UNC	0.969	116300[B]	82400[B]	89200[B]	145350	167650	116300	126000
1⅜-6 UNC	1.155	138600[B]	98200[B]	106300[B]	173250	199850	138600	150200
1½-6 UNC	1.405	168600[B]	119500[B]	129300[B]	210750	243100	168600	182600
Above values based on		120 ksi	85 ksi	92 ksi	150 ksi	173 ksi	120 ksi	130 ksi
		830 MPa - A325M			1040 MPa - A490M			
	Stress Area[A]	Tensile min.	Proof Load Length Measurement min	Alternative Proof Load Yield Strength Method min	Tensile min.	Tensile max.	Proof Load Length Measurement min	Alternative Proof Load Yield Strength Method min
mm	mm^2	kN	kN	kN	kN	kN	kN	kN
M12 x 1.75 MC	84.3	70	50.6	55.6	87.7	103	70	79.2
M16 x 2.0 MC	157	130	94.2	104	163	190	130	148
M20 x 2.5 MC	245	203	147	162	255	296	203	230
M22 x 2.5 MC	303	251	182	200	315	366	251	285
M24 x 3.0 MC	353	293	212	233	367	427	293	332
M27 x 3.0 MC	459	381	275	303	477	555	381	431
M30 x 3.5 MC	561	466	337	370	583	679	466	527
M36 x 4.0 MC	817	678	490	539	850	989	678	768
Above values based on		830 MPa	600 MPa	660 MPa	1040 MPa	1210 MPa	830 MPa	940 MPa

[A] The stress area is calculated as follows for inch: $A_S = 0.7854\ [D - (0.9743/n)]^2$; for Metric: $A_S = 0.7854\ (D - 0.9382P)^2$; where A_S = Stress Area, D = Nominal Bolt Size, and P = thread pitch.

[B] Previous versions of ASTM A325 and F1852 required tensile testing based on 105 ksi min. tensile strength for larger diameters, and proof load testing of 74 ksi (length measurement method) and 81 ksi (yield strength method). This specification was changed to align with AISC/RCSC design and installation values and metric equivalent strength levels.

TABLE 6 Mechanical Property Requirements for Specimens Machined from Bolts

	Tensile min.	Tensile max.	Yield min.	Elongation in 4D, min. %	Reduction of Area, min. %
Inch 120 ksi, Grade A325, F1852	120 ksi	...	92 ksi	14	35
Inch 150 ksi, Grade A490, F2280	150 ksi	173 ksi	130 ksi	14	40
Metric 830 MPa, Grade A325M	830 MPa	...	660 MPa	14	35
Metric 1040 MPa, Grade A490M	1040 MPa	1210 MPa	940 MPa	14	40

TABLE 7 Hardness Requirements for Bolts

120 ksi/830 MPa Tensile, Grade A325, A325M, F1852				150 ksi/1040 MPa Tensile, Grade A490, A490M, F2280			
Brinell HB		Rockwell HRC		Brinell HB		Rockwell HRC	
Min	Max	Min	Max	Min	Max	Min	Max
253	319	25	34	311	352	33	38

11. Requirements Specific to Twist-Off style bolts

11.1 *Assembly Tension Test (Fastener Tension):*

11.1.1 The assembly lot tension test shall be performed on twist-off style fastener assemblies to determine the ability of the assembly to provide the required minimum tension.

11.1.2 Twist-Off style bolt assembly lots shall be tested by the manufacturer or responsible party to verify conformance to installation tension requirements.

11.1.3 The test assemblies shall consist of one tension control bolt, one nut and at least one washer.

11.1.4 Test assemblies shall develop a bolt tension to the minimum requirements in Table 8 when th spline end is seperated from the bolt.

NOTE 7—Assembly installation tension test values are based on 70% of minimum tensile strength, plus 5%, to meet RCSC minimum pre-installation test values. Previous assembly installation test values were

TABLE 8 Twist-Off Style Assembly Installation Tension Test (Minimum Tension, lbf)

Bolt Diameter, in.	F1852	F2280
½-13 UNC	12550	15650
⅝-11 UNC	19900	24900
¾-10 UNC	29450	36800
⅞-9 UNC	40750	50950
1-8 UNC	53450	66800
1⅛-7 UNC	67350	84100
1¼-7 UNC	85500	106850

calculated indirectly and rounded to the nearest 1000 lbs from RCSC pre-installation verification test requirements. 1-⅛ in. F1852 is now based on 120 ksi, up from 105 ksi. 1-¼ in. for both grades (F1852 and F2280) is new with the publication of this specification.

11.2 *Lubrication:*

11.2.1 Assemblies shall have at least one component lubricated by the manufacturer or responsible party to meet the assembly lot tension requirements.

11.3 Secondary processing of Twist-Off style bolts, including coatings and lubrication, shall not be permitted to an assembly lot after final assembly lot installation tension testing. See 7.5.4.

11.4 *Test Requirements:*

11.4.1 Tests shall be conducted at an ambient temperature between 50° and 90°F (10 and 32°C).

11.4.2 The tension measuring device shall be calibrated per the manufacturer's recommendation not less than once per year.

11.4.3 Lot sample size shall be in accordance with F1470.

11.5 *Installation and Tension Test:*

11.5.1 Install the bolt, nut, washer and appropriate spacer(s) in the tension measuring device.

11.5.2 Install spacers so that three to five bolt threads are located between the bearing face of the nut and the underside of the bolt head, using the washer furnished with the assembly in contact with the nut.

11.5.3 Initially tension the assembly to approximately 10% of the minimum average tension specified in Table 8.

11.5.4 Complete tensioning using a spline drive installation tool capable of engaging the nut and spline end simultaneously, tightening the assembly continuously until the spline shears off.

11.5.5 The bolt head shall not be restrained during the test.

11.5.6 Shearing of the spline shall occur in the shear groove.

11.5.7 Record the tension after shearing the spline end as the assembly installation tension. The average of the tension readings for the assembly lot shall meet or exceed the minimum tension in Table 8.

12. Testing Specific to 150 ksi and 1040 MPa Bolts

12.1 *Magnetic Particle Inspection:*

12.1.1 Magnetic particle testing shall be performed in accordance with Guide E709 or Practice E1444/E1444M. Guide E709 shall be used for referee purposes.

12.1.2 The lot, as represented by the samples, shall be free from nonconforming bolts, as defined in F788. See Note 8.

12.1.3 If any nonconforming bolt is found during the manufacturer's sample examination the lot shall be 100% magnetic particle inspected and all nonconforming bolts shall be removed and scrapped or destroyed.

12.1.4 Eddy current or liquid penetrant inspection shall be an acceptable substitute for 100% magnetic particle inspection. On completion of the eddy current or liquid penetrant inspection the lot shall be reexamined by the magnetic particle method in the original sample quantity. In case of controversy, the magnetic particle test shall take precedence.

NOTE 8—Magnetic particle indications themselves shall not be cause for rejection. If in the opinion of the quality assurance representative the indications may be cause for rejection the samples shall be examined by microscopic examination or removal by surface grinding to determine if the indicated discontinuities are within the specified limits.

12.2 *Carburization/Decarburization:*

12.2.1 This test is intended to evaluate the presence or absence of carburization and decarburization as determined by the difference in micro-hardness near the surface and core.

12.2.2 *Carburization*—Bolts shall show no evidence of a carburized surface when evaluated to Test Methods F2328 and F2328M.

12.2.3 *Decarburization*—Hardness value differences shall not exceed the requirements set forth for decarburization in Test Methods F2328 and F2328M.

13. Other Quality Assurance Requirements

13.1 *Workmanship:*

13.1.1 The allowable limits, inspection, and evaluation of surface discontinuities shall be in accordance with Specification F788.

13.2 *Special Inspection:*

13.2.1 If observation or inspection is required by the purchaser, it shall be specified in the inquiry and order. Such observation or inspection requirements shall be specific and agreed upon by all parties.

13.2.2 The purchaser's representative shall have free entry to all parts of the manufacturer's or subcontractor's works, or supplier's place of business that concern the manufacture or supply of the material ordered.

13.2.3 The manufacturer or supplier shall afford the purchaser's representative all reasonable facilities to satisfy them that the material is being furnished in accordance with this specification.

13.2.4 All tests and inspections required by the purchaser's representative shall be made before shipment, and conducted so as not to interfere unnecessarily with the operation.

13.3 *Rejection and Rehearing:*

13.3.1 Disposition of nonconforming bolts shall be in accordance with the Practice F1470 section titled "Disposition of Nonconforming Lots."

14. Test Reports

14.1 When specified on the inquiry and purchase order, the manufacturer or supplier, whichever is the responsible party as defined in Section 15, shall furnish the purchaser a test report that includes the following, as applicable.

14.2 *Information:*

14.2.1 Lot number.

14.2.2 Purchase order number, job number, sequence number or other special identifiers if specified.

14.2.3 Mailing address of responsible party.

14.2.4 Title and signature of the individual assigned test report responsibility.

14.2.5 Date and ASTM standard, including revision number.

14.3 *Results*—Report results of all required tests.

14.3.1 Heat analysis, heat number, and calculated Corrosion Index for Type 3 material if not from composition A or B.

14.3.2 Results of hardness, tensile, and proof load tests or alternative testing in accordance with 10.1.1.

14.3.3 Results of magnetic particle inspection; if required.

14.3.4 Results of carburization and decarburization tests; if required.

14.3.5 Results of rotational capacity tests; as required in 8.1.5, or when requested by the purchaser.

14.3.6 Results of fastener assembly testing; if required.

14.3.7 Results of coating thickness for coated bolts; if required.

14.3.8 Results of inspection for surface discontinuities and visual inspection for head bursts.

14.4 *Statements:*

14.4.1 Statement of conformance with dimensional and thread fit requirements.

14.4.2 Statement certifying that steel heats having the elements listed in Section 6.5 intentionally added were not used.

15. Responsibility

15.1 The party responsible for the fastener shall be the organization that supplies the fastener or fastener assemblies to the purchaser.

16. Packaging and Package Marking

16.1 *Packaging:*

16.1.1 Packaging shall be to the manufacturer's standard packaging practice or as agreed between the purchaser and supplier.

16.1.2 Matched assembly lot components subjected to rotational capacity testing shall be shipped together when practicable. The party providing such lots shall clearly identify component packages with assembly lot numbers, when used, to facilitate proper component matching and assembly in the field.

16.1.3 A Heavy Hex Bolt assembly shall consist of at least one Heavy Hex Bolt and a suitable Heavy Hex Nut, or a Heavy Hex Bolt, Heavy Hex Nut and at least one Hardened Washer, all covered by reference herein. Heavy Hex Nuts and Hardened Washers shall be in accordance with Table 2.

16.1.4 A Twist-Off Bolt assembly shall consist of a bolt with a spline end, a suitable Heavy Hex Nut and at least one Hardened Washer covered by reference herein. Hevy Hex Nuts and Hardened Washers shall be in accordance with Table 2.

16.1.5 Twist-Off style bolts shall be packaged, certified and installed as matched assemblies.

16.1.6 When special packaging or labeling is required, the requirements shall be defined at the time of the inquiry and again at the time of order.

16.2 *Package Marking:*

16.2.1 Each shipping unit shall include and be plainly marked with the following information:

16.2.1.1 ASTM designation, Grade, Type and Style,

16.2.1.2 Size,

16.2.1.3 Name of the manufacturer or responsible party,

16.2.1.4 Number of pieces,

16.2.1.5 *Lot number*—Shipping units shall be marked with the lot number of the bolt, bolt set, or components and any additional number required by the purchaser or supplier.

16.2.1.6 Purchase order number or other distinguishing information, when required by the customer, and

16.2.1.7 Country of origin, when required by the customer.

17. Keywords

17.1 alloy steel; alternate design fasteners; bolts; carbon steel; fasteners; Heavy Hex Bolt; inch; metric; spline end; steel; structural; structural bolts; tension control bolt; twist-off bolt; weathering steel

SUPPLEMENTARY REQUIREMENTS

The following requirements shall be applied when specified by the purchaser on the inquiry and order. Details of these requirements shall be agreed upon in writing between the manufacturer and purchaser.

S1. Bolts Threaded Full Length

S1.1 A325 and A325M Bolts with nominal lengths equal to or shorter than 4D may be threaded full length. These bolts need not have a shoulder.

S1.2 Bolts shall be marked in accordance with Table 2, except that the symbol shall include a "T", for example "A325T".

S1.3 The distance from the under-head bearing surface to the first complete (full form) thread, as measured with a GO thread ring gauge, assembled by hand as far as the thread will permit, shall not exceed the length of 2½ threads for bolt sizes 1 in. and smaller, and 3½ threads for bolt sizes larger than 1 in.

S2. Alternate Dimensions

S2.1 Dimensions which differ from the requirements of this specification, such as modified head geometry or special thread lengths that do not meet the requirements of section S1, are permitted when requested by the customer.

S2.2 Bolts manufactured to S2 shall have a marking indicating "S" for "special", in addition to the marking required in Table 2, for example, "A325S" or "A490S".

NOTE S1—Many structural connection designs require the shear strength of a full body fastener. Increased thread lengths may place reduced diameters in shear planes reducing connection strength. Increased thread lengths may also affect installed pretensions when using the turn of the nut installation method.

S3. Lubricant

S3.1 User-specified lubrication requirements may include lubricated sealers used with coating systems, colored lubricants, or specified K factors. These may work in combination with or in replacement of lubrication requirements in the A563 and A563M specifications.

S3.2 Lubrication requirements shall be as agreed in writing between the user and supplier.

S3.3 Supplemental lubricants are not permitted on Twist-Off style assemblies except when applied by the manufacturer, see 7.5.4.

S3.4 Lubricant applied to a lot's components shall be the same as that specified by the purchaser or used by the manufacturer during testing to meet the lot's tension or rotational capacity requirements.

S4. Rotational Capacity Testing for Plain and Other Coated Assemblies.

S4.1 When specified on the inquiry and order, rotational capacity testing in accordance with Annex A2 shall be performed by the responsible party.

S4.1.1 Rotational capacity tests shall include sets of one bolt, one nut, and at least one washer. Sampling shall be to F1470, except the minimum sample size in all cases shall be two assemblies.

S4.1.2 Rotational capacity tests may be specified for plain or coated fastener assemblies.

S4.1.3 Rotational capacity testing shall result in an assembly lot number, which must be unique for each combination of bolt, nut and washer lot used.

S4.1.4 Assembly lot rotational capacity test reports and product labeling to maintain assembly lot traceability is required.

S4.1.5 Components shall be packed together when practicable to prevent comingling with other lots.

ANNEXES

(Mandatory Information)

A1. PERMITTED COATINGS

A1.1 This annex provides information and requirements necessary for the selection of protective coatings on structural fasteners. Coatings listed in this Annex for 150 ksi/1040 MPa bolts have been qualified and approved where indicated for use with 150 ksi/1040 MPa strength bolts. For use on 150 ksi/1040 MPa bolts, other coatings must be qualified in accordance with IFI 144. Hydrogen embrittlement testing required by IFI 144 shall be performed in accordance with Test Method F1940 for internal hydrogen embrittlement and F2660 for environmental hydrogen embrittlement. Permitted coatings have been reviewed in limited tests using IFI 144, Test Method F1940 and Test Method F2660 to evaluate susceptibility to hydrogen embrittlement. The purchaser should evaluate any other desired performance characteristics of these coatings.

A1.1.1 Many of the referenced coating specifications have only minimum thickness requirements. The nut overtap allowances in Table A1.2 are listed for strength consideration, but may not provide assembly clearance with considerably thicker coating deposits.

A1.1.2 For 120 ksi and 830 MPa Bolt Assemblies, this annex is not all-inclusive, other coatings may be approved if the purchaser is confident the performance of the fastener will not be compromised. Coatings for 150 ksi and 1040 MPa Bolt Assemblies must be qualified in accordance with IFI 144. See Note A1.1 Performance requirements shall be specified by the purchaser and agreed to in writing, and the coatings shall be applied by the manufacturer.

TABLE A1.1 Permitted Coatings

120 ksi & 830 MPa Bolt Assemblies[A]		150 ksi & 1040 MPa Bolt Assemblies[A]	
Commonly Applied Coatings	Grade or Class	Qualified Coatings	Grade or Class
F2329	Hot Dip Galvanized / 50 µm	F1136/F1136M	Bolt & Washer Grade 3, Nut Grade 5
B695	Class 55	F2833	Grade 1
Other Coatings	Grade or Class	F3019/F3019M	Grade 4
F1136/F1136M	Bolt & Washer Grade 3, Nut Grade 5	...	...
F2833	Grade 1	...	...
F3019/F3019M	Grade 4	...	...

[A] Coatings for Twist-off style bolt assemblies shall be agreed upon between the producer, supplier and user, and are not permitted except when applied under the direction of the manufacturer.

TABLE A1.2 Nut Overlap Allowances

Dimensional Limits	Galvanized B695/F2329[A]			Zn/Al Coatings F1136/F1136M/F2833/F3019/F3019M[B,C,D]	
	Nut Pitch Dia. Overtap[E,F]	Bolt Pitch Dia. OS After B695 Coating[G]	Bolt Pitch Dia. OS After F2329 Coating[G]	Nut Pitch Dia. Overlap[E]	Bolt Pitch Dia. OS after Coating[F]
UNC Thread	in.	in.	in.	in.	in.
½-13	0.018	0.012	0.018	0.009	0.006
⅝-11	0.020	0.013	0.020	0.010	0.007
¾-10	0.020	0.013	0.020	0.010	0.007
⅞-9	0.022	0.015	0.022	0.011	0.008
1-8	0.024	0.016	0.024	0.012	0.008
1⅛-7	0.024	0.016	0.024	0.012	0.008
1¼-7	0.024	0.016	0.024	0.012	0.008
1⅜-6	0.027	0.018	0.027	0.014	0.010
1½-6	0.027	0.018	0.027	0.014	0.010
MC Thread	mm	mm	mm	mm	mm
M12 × 1.75 MC	0.45	0.30	0.45	0.23	0.16
M16 × 2.0 MC	0.50	0.33	0.50	0.25	0.17
M20 × 2.5 MC	0.50	0.33	0.50	0.25	0.17
M22 × 2.5 MC	0.55	0.36	0.55	0.28	0.19
M24 × 3.0 MC	0.60	0.40	0.60	0.30	0.20
M27 × 3.0 MC	0.60	0.40	0.60	0.30	0.20
M30 × 3.4 MC	0.70	0.46	0.70	0.35	0.24
M36 × 4.0 MC	0.70	0.46	0.70	0.35	0.24

[A] Supplementary nut lubrication to A563 S1 is required for hot dip and mechanically deposited zinc coatings.
[B] Grade 5 of F1136/F1136M coating meets the supplementary lubrication requirements of A563 S1.
[C] Grade 1 of F2833 coating meets the supplementary lubrication requirements of A563 S1.
[D] Nuts overtapped for coating for use with 150 ksi/1040 MPa minimum tensile strength fasteners shall be proof load tested to a minimum of 175,000 psi after overtapping.
[E] Nut overtap shall not exceed this amount unless agreed upon between the purchaser and user. If a larger overtap is used or required, coated bolts and overtapped and coated nuts shall pass the RC test requirements per Annex A2 as proof of assembly, ductility and thread strength.
[F] Bolt pitch oversize limit in case of dispute. Material within the plain gauge limits, which meets the coating thickness requirements and assembles freely need not be measured to this tolerance.
[G] Hot-Dip galvanized is typically tapped after coating. Others coatings are typically applied after nut tapping.

NOTE A1.1—Coatings in this table have been tested to indicate they will not degrade the performance of the bolt due to selected conditions. Inclusion in this table does not imply any particular corrosion protection performance.

A2. ROTATIONAL CAPACITY TEST

A2.1. Scope

A2.1.1 This annex details rotational capacity (RC) tests intended to evaluate the presence of lubricant, the efficiency of lubricant and the compatibility of assemblies. The test serves as a further quality control measure against excessively overtapped nuts, material with insufficient ductility, and generally assures the assembly of elements (bolt, nut, and washer) will function together as a unit to achieve required preloads. When tested to meet the requirements of this Annex, assemblies shall be purchased and installed as matched sets Heavy Hex or Twist-off Bolt, Heavy Hex Nut and at least one Hardened Washer.

A2.1.2 This test is intended primarily for galvanized fastener assemblies, and fastener assemblies that must be fully tensioned in structural applications. This test may also be requested by the purchaser for other coated or plain assemblies that must be fully pretensioned.

A2.1.3 Test Methods 1 and 2 are replacements for previous ASTM rotational capacity test requirements.

A2.1.4 When specified in contract documents this test may also be used for field-testing.

NOTE A2.1—The RC test shall only apply to matched assembly lots that contain one bolt, one nut and one or more washers. It is the intent of this test that sets be packaged together in the same shipping container when practicable to maintain lot integrity. These test methods are intended for use with A325, A325M, F1852, A490, A490M and F2280 bolts mated to recommended nuts. Other specifications, such as A354 and A449, may refer to this Annex as a guide. Research has not been done on all grades, diameters and coatings available, therefore some of the requirements in this test are extrapolated from existing requirements. The purchaser and supplier should consider any additional investigation necessary to establish appropriate RC testing guidelines.

A2.1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

A2.2. Referenced Documents

A2.2.1 *ASTM Standards:*[2]

A354 Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners

A449 Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile

Strength, General Use
A563 Specification for Carbon and Alloy Steel Nuts
A563M Specification for Carbon and Alloy Steel Nuts (Metric)
F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection
F1789 Terminology for F16 Mechanical Fasteners

A2.3. Terminology

A2.3.1 Terms used in this specification are defined in Terminology F1789, unless otherwise defined herein.

A2.3.2 KIPS = Thousands of pounds

A2.4 Testing

A2.4.1 *Requirement:*

A2.4.1.1 Assemblies shall be tested in an assembled joint or tension-measuring device in accordance with Test Method 1 or Test Method 2, and shall not show signs of failure when subjected to the nut rotation in Table A2.3 for Test Method 1 or Table A2.5 and Table A2.7 for Test Method 2. The test shall be performed by the responsible party as noted in A2.4.2 prior to shipment, but after zinc coating, lubrication or any secondary processing of components.

A2.4.2 *Testing Responsibility:*

A2.4.2.1 Each lot shall be tested by the manufacturer or responsible party prior to shipment.

A2.4.2.2 When bolts are furnished by a source other than the manufacturer, the responsible party shall assure all tests have been performed and the bolts comply with the requirements of this specification.

A2.4.2.3 Sampling shall be to F1470, except that a minimum of two assemblies shall be tested regardless of lot quantity. Alternate sampling may be agreed upon between the supplier and purchaser.

A2.5. Method 1—Long Bolt Test Procedure

A2.5.1 *Equipment Required:*

A2.5.1.1 Calibrated bolt tension -measuring device appropriate for the bolts to be tested.

A2.5.1.2 Calibrated torque wrench and spud wrenches.

A2.5.1.3 Appropriate bushings and spacers.

A2.5.2 *Procedure—Bolts that fit in a tension measuring device:*

A2.5.2.1 Install the bolt and any required spacers in the tension measuring device so that the bolt stick-out is flush with the nut to a maximum of three threads stick-out. This will typically provide three to five threads within the grip.

A2.5.2.2 Tighten the fastener assembly to the tensions listed in Table A2.1 (-0/+2 kips or -0/+8 kN).

A2.5.2.3 Match-mark the bolt, nut and faceplate of the calibrator.

A2.5.2.4 Tighten the fastener assembly to at least the minimum installation tension in Table A2.2 and record both the tension and torque. The torque shall be read with the nut in motion. Maximum torque values at minimum tension are provided for convenience in Table A2.2. For tensions exceeding minimum tension, the torque shall not exceed 0.25 PD, where P = tension in pounds, and D = Dia. (in.)/12 = bolt diameter in feet.

A2.5.2.5 Further tighten the nut to the rotation listed in Table A2.3. The rotation is measured from the initial marking in step A2.5.2.3. Assemblies that strip or fracture prior to this rotation fail the test.

A2.5.2.6 Record the tension at the completion of the rotation in Table A2.3. The tension shall equal or exceed 1.15 × the minimum installation tension. The minimum required values are listed in Table A2.4.

A2.5.2.7 Loosen and remove the nut. There shall be no signs of thread shear failure, stripping or torsional failure. The nut shall turn on the bolt threads to the position it was in during the test. The nut does not need to run the full length of the threads. Inability to turn the nut by hand is considered thread failure. Broken bolts fail the test.

A2.6 Long Bolt Acceptance Criteria

A2.6.1 The assembly lot passes the RC test if all samples meet the requirements of A2.5.2.4, A2.5.2.6 and A2.5.2.7 after full rotation.

A2.6.2 The lot shall be considered nonconforming if the assembly fails to pass any one of the following requirements:

A2.6.2.1 Exceeding the maximum allowable torque in Table A2.2.

A2.6.2.2 Inability of the assembly to reach the rotation required in Table A2.3.

A2.6.2.3 Inability to remove the nut after installing to the rotation specified in Table A2.3.

A2.6.2.4 Failure to provide the tension required in Table A2.4 after full rotation.

A2.6.2.5 Shear failure of the threads as determined by visual examination of bolt and nut threads following removal.

A2.6.2.6 Torsional or torsional/tension failure of the bolt.

NOTE A2.2—Elongation of the bolt, in the threads between the nut and bolt head, is to be expected and is not to be classified as a failure.

A2.7. Method 2—Short Bolt Test Procedure

A2.7.1 *Equipment Required:*

A2.7.1.1 Steel plate.

A2.7.1.2 Calibrated torque wrench and spud wrenches.

A2.7.1.3 Appropriate bushings and spacers.

TABLE A2.1 Pre-tension Requirements by Strength and Diameter

Strength	Bolt Dia. (in.)	½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½
120 ksi min.	Initial Tension (kips)	1	2	3	4	5	6	8	10	12
150 ksi min.	Initial Tension (kips)	1	2	4	5	6	8	10	12	15
	Bolt Dia. (mm)	12	16	20	22	24	27	30		36
830 MPa min.	Initial Tension (kN)	4	9	13	18	22	27	31		44
1040 MPa min.	Initial Tension (kN)	9	13	18	22	27	36	40		58

TABLE A2.2 Maximum Permitted Torque at Minimum Design Tension[A]

Strength	Bolt Dia. (in.)	½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½
120 ksi min.	Tension (kips)[A]	12	19	28	39	51	64	81	97	118
	Maximum Torque (ft. lbs.)	125	247	437	710	1062	1502	2120	2779	3688
150 ksi min.	Tension (kips)[A]	15	24	35	49	64	80	102	121	148
	Maximum Torque (ft. lbs.)	156	312	546	893	1333	1875	2656	3466	4625
	Bolt Dia. (mm)	12	16	20	22	24	27	30		36
830 MPa min.	Tension (kN)[A]	49	93	142	178	205	267	325		476
	Maximum Torque (Nm)	150	380	719	976	1234	1803	2440		4284
1040 MPa min.	Tension (kN)[A]	61	114	178	221	257	334	408		595
	Maximum Torque (Nm)	190	461	895	1220	1546	2251	3064		5369

[A] Minimum design in the RCSC Specification for Structural Joints Using High-Strength Bolts. It represents 70% of minimum specified tensile strength.

TABLE A2.3 Minimum Required Degrees of Rotation

Bolt Length Required Rotation	Up to 4D	>4D to 8D	>8D to 12D
120 ksi (830 MPa) min	240	360	420
150 ksi (1040 MPa) min	240	300	360

A2.7.2 *Procedure—Bolts too short to fit in a tension measuring device:*

A2.7.2.1 Install the bolt and any required spacers in the steel plate with the so that the bolt stick-out is flush with the nut to a maximum of three threads stick-out. This will typically provide three to five threads within the grip.

A2.7.2.2 Pre-tension the assembly in the steel plate. The torque used shall not exceed 20% of the torque permitted Table A2.6.

A2.7.2.3 Match-mark the nut, bolt and plate.

A2.7.2.4 Tension the bolt by rotating the nut as required in Table A2.5. Prevent the bolt head from rotation. Take a torque reading at the required rotation with the nut in motion.

A2.7.2.5 The torque measurement taken in A2.7.2.4 should not exceed the values listed in Table A2.6. Assemblies that exceed the listed torque fail the test. These torque values are based on the assumed tension of 1.15 × minimum installation tension.

A2.7.2.6 Further tighten the bolt the additional rotation in Table A2.7. Assemblies that strip or fracture prior to this rotation fail the test.

A2.7.2.7 Loosen and remove the nut. There shall be no signs of thread shear failure, stripping, or torsional failure. The nut shall turn on the bolt threads to the position it was in during the test. The nut does not need to run the full length of the threads. Inability to turn the nut by hand is considered thread failure. Broken bolts fail the test.

A2.8 Short Bolt Acceptance Criteria

A2.8.1 The assembly lot passes the RC test if all samples meet the requirements of A2.7.2.5, A2.7.2.6 and A2.7.2.7 after full rotation.

A2.8.2 The lot assembly shall be considered as nonconforming if the assembly fails to pass any one of the following specified requirements:

A2.8.2.1 Exceeding the maximum allowable torque in Table A2.6.

A2.8.2.2 Failure to achieve the required rotation in Table A2.7.

A2.8.2.3 Inability to remove the nut after installing to the rotation in Table A2.7.

A2.8.2.4 Shear failure of the threads as determined by visual examination of bolt and nut threads following removal.

A2.8.2.5 Torsional or torsional/tension failure of the bolt.

Elongation of the bolt, in the threads between the nut and bolt head, is to be expected at the required rotation and is not to be classified as a failure.

A2.9. Test Reports

A2.9.1 When specified on the purchase order, the manufacturer or supplier, whichever is the responsible party, shall furnish the purchaser a test report that includes the following:

A2.9.1.1 Results of rotational capacity tests. This shall include the test method used (solid plate or tension measuring device).

A2.9.1.2 Assembly and component lot numbers.

A2.9.1.3 Mailing address of responsible party.

A2.9.1.4 Title and signature of the individual assigned test report responsibility.

TABLE A2.4 Minimum Tension at Full Rotation

Strength	Bolt Dia. (in.)	½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½
120 ksi min.	Tension (kips)	14	22	32	45	59	74	94	112	136
150 ksi min.	Tension (kips)	17	28	40	56	74	92	117	139	170
	Bolt Dia. (mm)	12	16	20	22	24	27	30		36
830 MPa min.	Tension (kN)	57	108	164	205	235	307	373		547
1040 MPa min.	Tension (kN)	72	133	205	256	297	384	471		685

TABLE A2.5 Minimum Required Degrees of Rotation

Bolt Length	Up to and including 4D	Greater than 4D up to and including 8D
Required Rotation All Grades	120	180

TABLE A2.6 Maximum Torque Values

Strength	Bolt Dia. (in.)	½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½
120 ksi min.	Torque (ft. lbs.)	150	290	500	820	1230	1730	2450	3210	4250
150 ksi min.	Torque (ft. lbs.)	180	370	630	1020	1540	2160	3050	3980	5310
	Bolt Dia. (mm)	12	16	20	22	24	27	30		36
830 MPa min.	Torque (Nm)	176	427	827	1125	1416	2074	2807		4922
1040 MPa min.	Torque (Nm)	217	536	1024	1417	1790	2583	3539		6162

TABLE A2.7 Minimum Required Degrees of Rotation

Bolt Length	Up to and including 4D	Greater than 4D up to and including 8D
Required Rotation		
120 ksi (830 MPa) min	120	180
150 ksi (1040 MPa) min.	90	120