Designation: ~~F3148 – 17~~ F3148 – 17a

Standard Specification for High Strength Structural Bolt Assemblies, Steel and Alloy Steel, Heat Treated, 144ksi Minimum Tensile Strength, Inch Dimensions[1]

This standard is issued under the fixed designation F3148; 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, dimensional, physical and mechanical requirements for quenched and tempered bolts manufactured from steel and alloy steel, in inch dimensions. The bolts are available as structural bolting assemblies which include a fixed spline bolt, a suitable nut and at least one washer covered by reference herein.

1.2 *Intended Use:*

1.2.1 Bolts manufactured under this specification, and structural bolting assemblies supplied under this specification, are intended for use in structural connections covered in the Specification for Structural Joints Using High-Strength Bolts and installed using the torque-and-angle or part turn/combined installation method.

1.2.2 Structural bolting assemblies in this specification are furnished in nominal diameters from ½ to 1-¼ in. inclusive.

1.3 *Classification:*

1.3.1 Structural bolting assemblies are designated as Grade 144.

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

Type 1 - 144ksi - carbon steel, carbon boron steel, alloy steel or alloy steel with boron addition
Type 3 - 144ksi - weathering steel

1.4 Terms used in the specification are defined in Terminology F1789.

1.4.1 *Torque-and-Angle Fixed-Spline Structural Bolt*—bolt that includes an integral fixed-spline end which extends beyond the threaded portion of the bolt and is used as a component of a torque-and-angle fixed-spline structural bolting assembly.

1.4.2 *Torque-and-Angle Fixed-Spline Structural Bolting Assembly*[2]— a fastener assembly comprised of a torque-and-angle fixed-spline bolt with a suitable nut and at least one washer, installed and tightened using a special electric wrench and socket system which has an inner socket that engages the fixed-spline end of the bolt and with an outer socket that engages and turns the nut, in two separate and distinct operations, the first is a controlled torque application and the second is a specified angle.

1.4.3 *Combined Method*—A tightening method comprised of two steps, the first tightening step using a torque regulating tool and the second tightening step in which a specified turn is applied to the turned part of the assembly. Also known as the 'part turn method'.

1.5 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

1.7 *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.*

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[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] The torque-and-angle fixed-spline structural bolting system has a patent application pending. Interested parties are invited to submit information regarding the identification of an alternative(s) to this patent-pending item to the ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

A563 Specification for Carbon and Alloy Steel Nuts
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
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
F2328 Test Method for Determining Decarburization and Carburization in Hardened and Tempered Threaded Steel Bolts, Screws, Studs, and Nuts
F2833 Specification for Corrosion Protective Fastener Coatings with Zinc Rich Base Coat and Aluminum Organic/Inorganic Type
G101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

2.2 *ASME Standards:*[4]

B 1.1 Unified Screw Threads
B 18.2.6 Fasteners for Use in Structural Applications
B 18.18 Quality Assurance for Fasteners

2.3 *RCSC:*[5]

Specification for Structural Joints Using High-Strength Bolts

3. Ordering Information

3.1 Orders for structural bolting assemblies under this specification shall include:

3.2 *Mandatory ordering information:*

3.2.1 ASTM F3148 designation and revision,
3.2.2 *Quantity*—Number of assemblies,
3.2.3 Grade 144,
3.2.4 *Size*—Including nominal diameter and bolt length,
3.2.5 *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.
3.2.6 *Coatings or finishes*—If other than plain finish, specify the coating process or finish required, see Table 1.

3.3 Additional ordering information when specified by purchaser;

3.3.1 Test reports, see Section 15.
3.3.2 Additional details of other assembly components.
3.3.3 Rotational capacity testing of assemblies per Annex A1.
3.3.4 Observation or inspection requirements. See 14.2.
3.3.5 Country of origin.
3.3.6 Supplementary requirements.

NOTE 1—A typical description follows: 1000 pieces ¾-10 × 3 in. ASTM F3148-15, Grade 144, Type 1, each with one hardened ASTM F436/F436M Type 1 washer, and one A563 Grade DH heavy hex nut.

4. Dimensions

4.1 *Head and Body:*

4.1.1 Bolts shall be round head conforming to the dimensions specified in Table 2.

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

4.2 *Threads:*

[3] 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.

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

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

TABLE 1 Permitted Coatings^{G}

	B695^{A,F}		F1136/F1136M^{D,F}		F2833^{E,F}	
Bolt	Class 55		Grade 3		Grade 1	
Nut	Class 55		Grade 5		Grade 1	
Washer	Class 55		Grade 3		Grade 1	
	Nut Pitch Dia. Overtap in.	Bolt Pitch OS After Coating^{C} in.	Nut Pitch Dia. Overtap^{B} in.	Bolt Pitch OS After Coating^{C} in.	Nut Pitch Dia. Overtap^{B} in.	Bolt Pitch OS After Coating^{C} in.
½-13 UNC	0.018	0.012	0.009	0.006	0.009	0.006
⅝-11 UNC	0.020	0.013	0.010	0.007	0.010	0.007
¾-10 UNC	0.020	0.013	0.010	0.007	0.010	0.007
⅞-9 UNC	0.022	0.015	0.011	0.008	0.011	0.008
1-8 UNC	0.024	0.016	0.012	0.008	0.012	0.008
1 ⅛-7 UNC	0.024	0.016	0.012	0.008	0.012	0.008
1 ¼-7 UNC	0.024	0.016	0.012	0.008	0.012	0.008

^{A} Supplementary nut lubrication to A563 S1, S2 or S3 is required for mechanically deposited zinc coatings.
^{B} Nut overtap shall not exceed this amount unless agreed upon between the purchaser and user. If a larger overtap is used or required, coated structural bolt assembles shall pass the RC test requirements per F3148, Annex A1 as proof of assembly, ductility and thread strength.
^{C} Bolt pitch oversize limit in case of dispute. Material within the plain gage limits which meets the coating thickness requirements and assembles freely need not be measured to this tolerance.
^{D} Grade 5 of this coating meets the supplementary lubrication requirements of A563 S1.
^{E} Grade 1 of this coating meets the supplementary lubrication requirements of A563 S1.
^{F} Nuts overtapped for coating shall be proof load tested to a minimum of 175 000 psi.
^{G} Other finishes – specify other protective finish, if required.
OS= Oversize

TABLE 2 Dimensions, Threads, Marking, and Matching Components

	Type 1	Type 3
Round Head Dimensions, ASME^{A}	B18.2.6	B18.2.6
Thread Fit, ASME	B1.1 UNC 2A	B1.1 UNC 2A
Grade Marking	144	144
Nut	A563 DH	A563 DH3
Flat Washer	F436/F436M – 1	F436/F436M – 3

^{A} All dimensions except spline geometry

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

4.2.2 Coated bolt threads shall be as specified in Table 2 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 Table 1 (Class X tolerance, gauge tolerance plus) shall be used to verify conformance. 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 assurance provisions of ASME B 18.18.

NOTE 2—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 processes and the cumulative effect of coating thickness may create intermittent assembly problems.

5. Product Marking

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

5.2 Grade/Type marking, the manufacturer's mark, and the private label distributor's mark (if used), shall be in separate and distinct locations.

6. Chemical Composition

6.1 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 Type 3 bolts shall be weathering steel and shall conform to the chemical compositions A or B specified in Table 3. Optionally, the chemical composition may have a Corrosion Index of 6 or greater, as calculated from the Heat Analysis, and as described in Guide G101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels.

6.3 Product analysis made on finished bolts representing each lot shall conform to the product analysis requirements specified in Table 3, Footnote A.

TABLE 3 Chemical Requirements[A]

Heat Analysis	Type 1		Type 3		
	Carbon Steel with or without Boron	Alloy Steel with or without Boron	Composition A	Composition B	Based on Corrosion Index[B]
Carbon	0.30 – 0.52	0.30 – 0.48	0.33 – 0.40	0.38 – 0.48	0.30 – 0.52
Manganese	0.60 min	0.60 min	0.90 – 1.20	0.70 – 0.90	0.60 min
Phosphorus, max	0.035	0.035	0.035	0.035	0.035
Sulfur, max	0.040	0.040	0.040	0.040	0.040
Silicon	0.15 – 0.30	...	0.15 – 0.30	0.30 – 0.50	...
Boron, max	0.003	0.003	...	...	...
Copper	...	...	0.25 – 0.45	0.20 – 0.40	0.20 – 0.60[B]
Nickel	...	...	0.25 – 0.45	0.50 – 0.80	0.20[B,C] min
Chromium	...	...	0.45 – 0.65	0.50 – 0.75	0.45[B] min
Molybdenum	...	...	...	0.06 max	0.15[B,C] min

[A] Individual product analysis that is outside the specified range is permitted provided it is within 10% of the value required of the heat analysis.
[B] Type 3 bolts conforming to composition A or B, or type 3 bolts which have a copper minimum Heat Analysis of 0.20% and a Corrosion Index of 6 or higher as calculated from the Heat Analysis as described in Guide G101 Predictive method shall be accepted
[C] Either Nickel or Molybdenum must be present in the amount specified.

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

6.5 Chemical analysis shall be performed in accordance with Test Methods, Practices, and TerminologyA751.

7. Materials and Manufacture

7.1 Structural bolting assemblies shall be certified, supplied and installed as matched sets. These assemblies shall be capable of developing a minimum predetermined initial and final tension when installed using an appropriate fixed spline-drive installation tool. See Appendix X1.

7.2 *Production Method:*

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

7.3 *Heat Treatment:*

7.3.1 All Bolts shall be quenched in oil from the austenitizing temperature.

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

7.4 Threads shall be rolled or cut.

7.5 *Coatings and Other Finishes:*

7.5.1 Coatings, including supplementary lubrication and nut oversize requirements are provided in Table 1.

7.5.2 When coated assemblies are required, the purchaser shall specify the coating process and any additional special requirements.

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

7.5.4 Nut and washer components of the assemblies shall be in accordance with Table 2.

7.6 *Secondary Processing:*

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

7.6.2 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.

7.6.3 If processing that can affect mechanical or performance properties is performed after initial testing, the bolts or assemblies, or both, shall be retested for all specified mechanical properties and performance requirements affected by the processing.

7.6.4 When the secondary process is heat treatment, the bolts shall be tested for all specified mechanical properties.

7.6.5 Secondary processing, including lubrication, by any party other than that which certified the assembly lot shall not be permitted unless under the direction of the manufacturer or responsible party.

7.7 *Lubrication:*

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

8. Testing and Lot Control

8.1 *Testing Responsibility:*

8.1.1 Each lot shall be tested by the responsible party prior to shipment in accordance with the lot control and identification quality assurance plan in 8.2 through 8.5.

8.2 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.

8.3 Secondary processing shall be in accordance with a lot control and identification plan.

8.4 A lot shall be a quantity of uniquely identified 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.

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

8.6 *Number of Tests:*

8.6.1 The minimum number of tests required from each lot or each assembly lot shall be in accordance with 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.

NOTE 3—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.

NOTE 4—8.6.1 is intended to identify a statistically large number of non-conformances but does not assure 100% freedom from non-conforming product.

9. Test Methods

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

9.2 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.

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

9.4 Magnetic Particle Inspection shall be conducted in accordance with Table 4 and Section 11.

9.5 Carburization/Decarburization Inspection shall be conducted in accordance with Table 4 and Section 12.

9.6 Assembly torque and angle tension tests shall be performed in accordance with Table 5 and Section 13.

10. Mechanical Properties

10.1 *Tensile Properties:*

10.1.1 Except as permitted in 10.1.2 and 10.1.3, diameters 1 in. and smaller having a nominal length of 2¼ D and longer, and sizes over 1 in. having a nominal length of 3D and longer, shall be wedge tested full size to F606/F606M and shall conform to the minimum wedge tensile load and proof load or alternative proof load specified in Table 6.

TABLE 4 Number of Tests and Test Method or Criteria

	Sample Size	Test Method	Notes
Tensile Strength	F1470	F606/F606M	Wedge or axial full size. Machined. See 8.1.1.
Proof Load	F1470	F606/F606M	Method 1 or 2 optional. See 8.2.
Hardness	F1470	F606/F606M	
Dimensions and Thread Fit	ASME B18.18	ASME B18.2.6 and B1.1 2A	
Surface Discontinuities	F1470	F788	
Coating Weight/Thickness	F1470[B]	Product Specification	
Magnetic Particle	F1470	F788	Guide E709 or Practice E1444/E1444M. Sample based on quantity per heat number, per heat treatment process. At least one sampling per heat number, per heat treatment process
Carburization/Decarburization	At least 1	F2328	
Fastener Tension	F1470	Section 11	
Rotational Capacity[A]	F1470	Annex A1	Minimum of 2 sample size

[A] Fasteners assemblies shall be rotational capacity tested when specified on the inquiry and order.
[B] Use F1470 for sampling if sample requirements are not in the coating specification.

TABLE 5 Assembly ~~Installation~~ Tension Test Minimum Tension, ~~lbf.~~

~~Bolt Diameter, in.~~	~~Intial Minimum~~	~~Final[A] Minimum~~
~~½ in.-13~~	~~6000~~	~~16000~~
~~⅝ in.-11~~	~~9500~~	~~25000~~
~~¾ in.-10~~	~~14050~~	~~37000~~
~~⅞ in.-9~~	~~19400~~	~~51000~~
~~1 in.-8~~	~~25450~~	~~67000~~
~~1 ⅛ in.-7~~	~~32050~~	~~84000~~
~~1¼ in.-7~~	~~41850~~	~~107000~~

TABLE 5 Assembly Tension Test Minimum Tension, lbf

Bolt Diameter (in.)	½	⅝	¾	⅞	1	1⅛	1¼
Initial Minimum	7000	11000	16000	22000	29000	36000	46000
Final Minimum	16000	25000	37000	51000	67000	84000	107000

[A] ~~Equal to RCSC A490 minimum pre-installation verification tension~~

TABLE 6 Tensile Strength Requirements for Bolts Tested Full Size

Nominal Size, in.	Stress Area[A] $in.^2$	Tensile min lbf	Proof Load[B] min lbf	Proof Load[C] min lbf
½-13 UNC	0.142	20450	15350	16350
⅝-11 UNC	0.226	32550	24400	26000
¾-10 UNC	0.334	48100	36100	38400
⅞-9 UNC	0.462	66550	49900	53150
1-8 UNC	0.606	87250	65450	69700
1⅛-7 UNC	0.763	109900	82400	87750
1¼-7 UNC	0.969	139550	104650	111450
Above values based on		**144000psi**	**108000psi**	**115000psi**

[A] The stress area is calculated as follows:
$A_S = 0.7854\ [D-(0.9743/P)]^2$
Where A_S = Stress Area, D = Nominal Bolt Size, and P = thread pitch
[B] Proof load length measurement
[C] Alternative Proof load Yield Strength Method

10.1.2 Sizes 1 in. 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 specified in Table 6.

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

10.1.4 Fracture on full-size tests shall be in the threads of the bolt without fracture in the body or 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 7. 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 8. 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

11. Magnetic Particle Inspection

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

11.2 The lot, as represented by the samples, shall be free from nonconforming bolts, as defined in Specification F788. See Note 5.

TABLE 7 Tensile Strength Requirements for Specimens Machined from Bolts

Tensile min.	Tensile max.	Yield min.	Elongation in 4D, min. %	Reduction of Area, min. %
144000 psi	...	115000 psi	14	35