



**SPECIAL PROVISIONS
FOR
F 3148 FASTENER ASSEMBLIES INSTALLED BY THE
COMBINED METHOD OF PRETENSIONING**

**Allamakee County
STP-009-9(84)--2C-03**

**Effective Date
August 1, 2023**

THE STANDARD SPECIFICATIONS, SERIES 2015, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

159008.01 DESCRIPTION.

These special provisions describe use of spline drive fastener assemblies manufactured to ASTM F 3148 - Standard Specification for High Strength Structural Bolt Assemblies, Steel and Alloy Steel, Heat Treated, 144ksi Minimum Tensile Strength, Inch Dimensions. These special provisions provide fastener pretensioning and inspection requirements for the Combined Method of pretensioning used with ASTM F 3148 fastener assemblies. Construction shall be in accordance with Section 2408 of the Standard Specifications except as modified by these Special Provisions. The provisions of IM 453.06B for manufacturing mill approval, certification procedures, acceptance, and verification sampling & testing shall also apply.

159008.02 MATERIALS.

Bolts, nuts, and washers for bolted connections of steel structures shall comply with the type and size specified in the contract documents.

A. High-Strength Fasteners.

1. Fastener Assemblies: F 3148- Type 1 galvanized. Fastener assemblies include nuts and washers as follows:
 - a. Nuts: A 563/A 563M- Grade DH galvanized.
 - b. Washers: F 436/F 436M- Type 1 galvanized.
2. For galvanized assemblies the coating shall meet the requirements of ASTM B 695, Class 55

B. Bolt Length

To determine the bolt length, add the values shown under bolt size in Table 1 to the grip length. Round to the next 1/4 inch when between sizes. Ensure the length of bolts so that when properly installed in a snug tight condition, the last thread or portion of bolt thread is visible outside the face of the nut.

Table 1: Addition to Grip for Bolt Length

Bolt Size inches	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$
Add to Grip inches	$1\frac{1}{16}$	$1\frac{3}{16}$	$1\frac{5}{16}$	$1\frac{7}{16}$	$1\frac{9}{16}$

C. Rotational-Capacity Test Requirements

Ensure the supplier's requirements are met and the following:

1. Ensure the assembly lot has passed rotational-capacity testing prior to shipment, according to ANNEX A.
2. Ensure each assembly lot has a unique rotational-capacity lot number included on the certified test report and labels.

D. Preinstallation Verification Test Requirements

Preinstallation verification test of F 3148 fastener assemblies shall be performed at the project site according to ANNEX X prior to assemblies being incorporated into the work. This shall be performed for each assembly lot number.

E. Bolts

Galvanized assemblies shall be free from significant white rust. If the Engineer suspects any change in fastener condition or level of lubrication, the Engineer may order additional pre-installation verification testing, and rotational capacity testing to determine suitability for use.

F. Nuts and Washers

Galvanized nuts shall be clean and dry, lubricated per ASTM A 563 Supplementary Requirements S1 and S2, or S3. Do not clean or re-lubricate nuts prior to installation except under the manufacturer's direction, and when approved by the Engineer. Washers shall be maintained as part of the matched assembly. The same washers as used in rotational-capacity testing and preinstallation verification testing shall be used in the work.

G. Markings

Verify bolts, nuts, and washers are marked with a symbol identifying the manufacturer and grade as required by ASTM specifications.

H. Shipping

Fastener assemblies shall be shipped in kegs or barrels. Containers shall be clearly marked with the product description, size, quantity, and rotational-capacity lot number.

I. Storage of High Strength Fasteners

Protect fasteners assemblies from the elements and site contamination. Return unused fastener assemblies to protected storage.

159008.03 CONSTRUCTION.

A. Installation of ASTM F 3148 High-Strength Fasteners.

Apply Article 2408.03, S, 5, of the Standard Specifications except where modified by the below provisions and Article X3 of ANNEX X.

1. Assemble fasteners with one hardened washer used under the nut.

B. Inspection.

Apply Article 2408.03, S, 5, c, of the Standard Specifications except where modified by Article X4 of ANNEX X.

C. Reuse of Bolts.

Apply Article 2408.03, S, 5, d, of the Standard Specifications.

159008.04 METHOD OF MEASUREMENT.

The weight of F 3148 Fastener Assemblies shall be included in the weight of structural steel. Apply Article 2408.04 of the Standard Specifications.

159008.05 BASIS OF PAYMENT.

Apply Article 2408.05 of the Standard Specifications.

ANNEX A - Rotational Capacity Field Testing.

A1.1 Prior to steel erection and in the presence of the Engineer, test at least two representative fastener assemblies from each rotational-capacity test lot (rotational-capacity lot as furnished by the supplier.)

A1.2 The Engineer may order additional rotational-capacity tests if there is reason to suspect any change in fastener condition or level of lubrication.

A1.3 Failure of rotational-capacity tests shall be cause for rejection of that fastener lot.

A1.4 Test *Method 2 – Short Bolt Test Procedure*, shall not be used when equipment is available to perform rotational capacity testing using *Method 1 - Long Bolt Test Procedure*.

A1.4 Testing:

A1.4.1 Testing Requirement:

A1.4.1.1 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 A1.3 for Test Method 1 or Table A1.6 and Table A1.7 for Test Method 2. The test shall be performed by the responsible party as noted in A1.4.2 prior to shipment, but after zinc coating, lubrication or any secondary processing of components.

A1.4.2 Testing Responsibility:

A1.4.2.1 Each lot shall be tested by the manufacturer or responsible party prior to shipment. Each lot shall be tested at the site by the Contractor prior to assemblies being placed in the work.

A1.4.2.2 When assemblies are furnished by a source other than the manufacturer, the Contractor shall assure rotational capacity tests have been performed and the bolts meet the requirements of this annex.

A1.4.2.3 Sampling shall be to F 1470 or IM 453.06B, whichever is greater, the minimum sample size in all cases shall be two (2).

A1.5 Test Method 1 – Long Bolt Procedure (bolts that fit in a tension measuring device)

A1.5.1 Equipment Required:

A1.5.1.1 Calibrated tension measuring device appropriate for the bolts to be tested.

A1.5.1.2 Calibrated torque wrench and spud wrenches.

A1.5.1.3 Appropriate bushings and spacers for the tension measuring device.

A1.5.2 Procedure:

A1.5.2.1 Install the bolt and any spacers needed in the tension measuring device so at least one thread and a maximum of three threads stick out. This will typically provide three to five threads within the grip.

A1.5.2.2 Tighten the fastener assembly to the tensions listed in Table A1.1 (-0/+2 KIPS).

TABLE A1.1 Tension Requirement by Diameter

Bolt Dia. (in.)	½ in.	⅝ in.	¾ in.	⅞ in.	1 in.	1⅛ in.	1¼ in.
Initial Tension (kips)	2	3	4	5	6	8	10

A1.5.2.3 Match-mark the bolt, nut and face of the tension measuring device.

A1.5.2.4 Tighten the fastener assembly to at least the minimum tension in Table A1.2 and record both the tension and torque. The torque shall be read with the nut in motion. The maximum torque is listed in Table A1.2.

TABLE A1.2 Maximum Permitted Torque at Minimum Design Tension

Bolt Dia. (in.)	½ in.	⅝ in.	¾ in.	⅞ in.	1 in.	1⅛ in.	1¼ in.
Tension (kips) ^A	15	24	35	49	64	80	102
Maximum Torque (ft. lbs.)	156	312	546	893	1333	1875	2656

^AMinimum A490 design tension in the RCSC Specification for Structural Joints Using High-Strength Bolts. 75% of minimum specified tensile strength.

A1.5.2.5 The torque value from A1.5.2.4 shall not exceed 0.25 PD, where:

D = Dia. (in.)/12 = bolt diameter in ft.

P = tension in pounds

A1.5.2.6 Further tighten the nut to the rotation listed in Table A1.3. The rotation is measured from the initial marking in step A1.5.2.3.

TABLE A1.3 Required Rotation

Bolt Length	Up to 4D	> 4D to 8D	> 8D to 12D
Required Rotation	240	360	420

A1.5.2.7 Record the tension at the completion of the rotation in Table A1.3. The tension shall equal or exceed 1.15 x the minimum tension in Table A1.2. The minimum required values are listed in Table A1.4.

TABLE A1.4 Minimum Tension at Full Rotation

Bolt Dia. (in.)	½ in.	⅝ in.	¾ in.	⅞ in.	1 in.	1⅛ in.	1¼ in.
Tension (kips)	17	28	40	56	74	92	117

A1.5.2.8 Loosen and remove the nut. There shall be no signs of full thread shear failure, thread 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.

A1.6 Acceptance Criteria

A1.6.1 The assembly lot passes the RC test if all samples meet the requirements of A1.5.2.5, A1.5.2.7, and A1.5.2.8 after full rotation.

A1.6.2 The lot shall be considered nonconforming if the assembly fails to pass any one of the following requirements:

A1.6.2.1 Over the maximum allowable torque in Table A1.2.

A1.6.2.2 Inability of the assembly to reach the rotation required in Table A1.3.

A1.6.2.3 Inability to remove the nut after installing to the rotation in Table A1.3.

A1.6.2.4 Failure to provide the tension required in Table A1.4 after full rotation.

A1.6.2.5 Shear failure of the threads as determined by visual examination of bolt and nut threads following removal.

A1.6.2.6 Torsional or tension failure of the bolt. Elongation of the bolt in the threads between the nut and bolt head is to be expected and not to be classified as failure.

A1.7 Test Method 2 – Short Bolt Test Procedure (Bolts too short to fit in a tension measuring device)

A1.7.1 Equipment Required:

A1.7.1.1 Steel plate.

A1.7.1.2 Calibrated torque wrench and spud wrenches.

A1.7.1.3 Bushings and Spacers.

A1.7.2 Procedure:

A1.7.2.1 Install the bolt and any spacers needed in the steel plate so that the bolt thread is flush with the nut to a maximum of three threads stick-out. This will typically provide three to five threads within the grip.

A1.7.2.2 Using a torque not to exceed 20% of that permitted in Table A1.5, tighten the assembly in the steel plate.

TABLE A1.5 Maximum Torque Values

Bolt Dia. (in.)	½ in.	5⁄8 in.	¾ in.	7⁄8 in.	1 in.	1 1⁄8 in.	1 ¼ in.
Torque (ft. lbs.)	180	370	630	1020	1540	2160	3050

A1.7.2.3 Match-mark the nut, bolt, and plate

A1.7.2.4 Tighten the bolt by rotating the nut as required in Table A1.6. Prevent the bolt from rotating. Take a torque reading at the required rotation with the nut in motion.

TABLE A1.6 Required Rotation

Bolt Length	Up to 4D	> 4D to 8D
Required Rotation	120	180

A1.7.2.5 The torque measurement taken in A1.7.2.4 should not exceed the values listed in Table A1.5. Assemblies that exceed the listed torque have failed the test. These torque values are based on the assumed tension of $1.15 \times$ minimum installation tension.

A1.7.2.6 Further tighten the bolt by rotating the nut as required in Table A1.7. Prevent the bolt from rotating. Assemblies that strip or fracture prior to this rotation fail the test.

TABLE A1.7 Required Rotation from Initial Tension

Bolt Length	Up to 4D	> 4D to 8D
Required Rotation	90	120

A1.7.2.7 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.

A1.8 Short Bolt Acceptance

A1.8.1 The assembly lot passes the RC test if all samples meet the requirements of A1.7.2.5, A1.7.2.6, and A1.7.2.7 after full rotation.

A1.8.2 The assembly lot shall be considered as nonconforming if the assembly fails to pass any one of the following specified requirements:

A1.8.2.1 Over the maximum allowable torque in Table A1.5.

A1.8.2.2 Failure to achieve the required rotation in Table A1.7.

A1.8.2.3 Inability to remove the nut after installing to the rotation in Table A1.7.

A1.8.2.4 Shear failure of the threads as determined by visual examination of bolt and nut threads following removal.

A1.8.2.5 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.

A1.9 Test Reports

A1.9.1 The responsible party shall furnish the purchaser a test report that includes the following:

A1.9.1.1 Results of rotational capacity tests. This shall include the test method used, Method 1 (Tension Measuring Device) or Method 2 (Solid Plate)

A1.9.1.2 Assembly and assembly component lot numbers.

A1.9.1.3 Mailing address of the manufacturer or responsible party.

A1.9.1.4 Title and signature of the individual assigned test report responsibility.

ANNEX X - Preinstallation Verification Testing, Installation, and Inspection

X1.1 Scope:

X1.1.1 This appendix details the testing procedure for torque-and-angle tensioning (combined method pretensioning) of fixed-spline F3148 assemblies.

X1.1.2 Test and installation tools shall be capable of tensioning fixed-spline bolts from a single side and shall be capable of installing bolts to initial tension using torque and final tension using angle.

X1.1.3 This appendix is intended for field pre-installation verification testing of assemblies and installation tools for use in pretensioned or slip-critical connections.

X2.1 Number of Tests

X2.1.1 The number of tests from each assembly lot shall be no fewer than three (3).

X2.2 Tension Measuring Device

X2.2.1 A tension measuring device shall be used to measure tension. Calibration of the device shall be at least annually by the device manufacturer or a NIST accredited agency. The calibration date shall be clearly identifiable, and a calibration certificate shall be made available if requested. The device shall have bushings that accept round bolt heads, and plates and solid spacers specific to the bolt diameter and length being tested.

X2.3 Required Testing

X2.3.1 Prior to steel erection and in the presence of the Engineer, each assembly lot to be used in the work shall be tested in a tension measuring device to verify the torque-and-angle installation (combined method pretensioning) can develop tensions that equal or exceed those specified in Table X2.1.

X2.4 Test Procedure

X2.4.1 Install the assembly in a tension measuring device using the appropriate plate, bushing and spacer(s) for the diameter and length of bolt. The bolt head shall not be captured during testing. The washer shall be installed against the plate or spacer(s). The nut shall be installed against the washer. Additional washers shall not be used in lieu of suitable spacers.

X2.4.2 Install the assembly using torque with a tool capable of engaging the nut and bolt spline. The assembly shall meet the minimum initial tension in Table X2.1.

TABLE X2.1 Assembly Tension Test Minimum Tension, lbf

Bolt Diameter (in.)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Initial Minimum	7000	11000	16000	22000	29000	36000	46000
Final Minimum	16000	25000	37000	51000	67000	84000	107000

X2.4.3 From the initial tension condition, install the assembly to final tension using the degree of angle specified in Table X2.2, with a tool capable of engaging the nut and bolt spline. The assembly shall meet the minimum final tension in Table X2.1.

TABLE X2.2 Angle Tightening Rotation

Bolt Length	Required Rotation ^A	Diameter in.						
		1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Up to 4D	90°	Up to 2	Up to 2 1/2	Up to 3	Up to 3 1/2	Up to 4	Up to 4 1/2	Up to 5
>4D to 8D	120°	2 1/4 to 4	2 3/4 to 5	3 1/4 to 6	3 3/4 to 7	4 1/4 to 8	4 3/4 to 9	5 1/4 to 10

^A See X3.3.

X2.4.4 Repeat the test in section X2.4.1 through X2.4.3 for each additional test assembly. Each assembly test must meet the minimum tension requirement for initial and final tension.

NOTE X2.1—Acceptable tolerance on Table X2.2 angle of rotation is -0 to +45 degrees.

NOTE X2.2—Where the surface of the bolt head or nut is not perpendicular to the bolt axis, the required final installation angle should be determined by testing.

NOTE X2.3—Rotations beyond the tightening angle tolerance may be an indication that the assembly was not properly initially tightened. If this occurs, notify the Engineer and seek additional guidance from the manufacturer before resuming tightening at the affected connection.

NOTE X2.4—Lengths over 8D may require additional rotation. For lengths over 8D the manufacturer's guidance shall be followed.

X3. INSTALLATION PROCEDURE

X3.1 Torque and Angle Installation Procedure

X3.1.1 Align bolt holes to permit insertion of the bolts without damage to the threads.

X3.1.2 Install a bolt in each hole. Install a washer against the steel over the threaded end of the bolt. Install the nut against the washer to a finger tight condition.

X3.2 Initial Torque Tightening

X3.2.1 Start with the most rigid point of the connection. Perform initial tightening using torque with a tool capable of engaging the nut and bolt spline. The tool shall rotate the nut and hold the bolt spline from a single side. The tool shall shut off when a torque value is reached that is sufficient to achieve the minimum initial tension in Table X2.1. Initial torque tightening shall progress systematically from the most rigid part of the joint in a manner that will minimize relaxation of previously tightened bolts.

X3.2.2 If gaps in the steel remain after the initial pass of torque tightening, repeat the initial tightening process as described in X3.2.1. Systematically progress in the same pattern until the plies are in firm contact. Initial torque tightening shall be controlled by the installation tool so that over-tightening does not occur.

X3.2.3 At the conclusion of initial torque tightening, match mark the fastener assembly bolt tip, nut, and plate to verify the angle used in final tightening.

X3.3 Final Angle Tightening

X3.3.1 With bolts in the initial tight condition from X3.2, install the assembly to final tension using angle with a tool capable of engaging the nut and bolt spline. The tool shall rotate the nut and hold the bolt spline from a single side. The tool shall shut off when the minimum degree of nut rotation in Table X2.2 is achieved, within a tolerance of -0 to + 45 degrees.

X3.3.2 Repeat the angle tightening process for each bolt in the connection, using the same systematic tightening pattern used for the initial tightening process.

X4 INSPECTION

X4.1 Inspection after initial tightening

X4.1.1 Perform routine observation of the initial tightening process to verify proper techniques are followed as described in X3.2.

X4.1.2 Verify that the plies in the connection have been pulled into firm contact.

X4.1.3 Verify that the proper length of bolt was used. The face of the nut shall be at least flush with the first thread of the bolt and the stick-out should be checked to ensure the nut does not hit the thread run-out. Verify presence of match marks.

X4.2 Inspection after angle tightening.

X4.2.1 Perform routine observation of the final angle tightening process to verify proper techniques are followed as described in X3.3. Match marking for final installation is required during the angle tightening process.

X4.2.2 Check bolted connections in the presence of the Engineer for proper installation, applicable rotation, and general joint condition. The inspection of fasteners, with a torque wrench, at connections of steel diaphragms to concrete beams will not be required.

X4.2.2 Furnish and use an inspecting wrench which is calibrated and capable of measuring torque.

X4.2.3 To calibrate the inspecting wrench:

- a) Select a representative sample of no less than three bolts and nuts of each diameter, length, grade, and turned element, to be tensioned that day.
- b) Check the samples prior to inspection in a device capable of indicating bolt tension. Turn the same element during testing that will be turned during actual work.
- c) Use the inspecting wrench to tension the bolt and determine the torque necessary to achieve a bolt tension 5% greater than the specified minimum bolt tension specified in *Table 2408.03-2 Minimum Bolt Tension*.
- d) Use the average of the three torque values for the job inspecting torque value(s).

X4.2.4 Establish the job inspecting torque value(s) at least once prior to each day's inspection. Have an approved testing agency verify calibration of the tension measuring device at least every 12 months and if found to be out of tolerance, have it calibrated.

X4.2.5 Inspect installed and tightened fasteners, represented by the above tests, for acceptance by attempting to tighten the fastener using the inspection torque wrench and the predetermined inspection torque value(s). Acceptance will be based on the random checking of at least 10% of the fasteners in each connection. A minimum of two fasteners per connection will be checked. The connection will be accepted as properly tightened if:

- a) The faying surfaces are in full and continuous contact, and
- b) No bolt or nut is turned at a torque value less than or equal to the inspection torque value(s).

X4.2.6 If any bolt or nut is turned at torque values below the inspection torque value(s), check all fasteners in that connection. Tighten and reinspect all bolts or nuts which turn below inspection torque values.

X4.2.7 Bolts tightened by the combined method may reach tensions substantially above the values specified, but this is not cause for rejection.