Pre-Installation Verification for High-Strength Bolts

by Lee Pielaet

This presentation covers the essential steps and methods for pre-installation verification of high-strength bolts in structural joints. We'll explore the required testing procedures and various installation methods to ensure proper bolt pretension and structural integrity.

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Required Testing Overview

1 On-Site Testing

Perform verification at the installation site.

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Required Testing Overview

1 On-Site Testing

Perform verification at the installation site.

2 Timing

Complete before placing bolting assemblies in the work

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Required Testing Overview

1 On-Site Testing

Perform verification at the installation site.

2 Timing

Complete before placing bolting assemblies in the work

3 Sample Size

Test at least three complete assemblies of each combination.

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Required Testing Overview

1 On-Site Testing

Perform verification at the installation site.

2 Timing

Complete before placing bolting assemblies in the work

3 Sample Size

Test at least three complete assemblies of each combination.

4 Representative Conditions

Use assemblies that reflect actual work conditions.

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Table 7.1 Minimum Bolt Pretension for Pre-Installation Verification		
Nominal Bolt Diameter, db, in.	Minimum Bolt Pretension for Pre-Installation Verification, kips	
	Group 120 = old A325	Group 144 and Group 150 = old A490
1/2	13	16
5/8	20	25
3/4	29	37
7/8	41	51
1	54	67
1 1/8	67	84
1 1/4	85	107
1 3/8	102	127
1 1/2	124	155

Test Procedure and Equipment

Bolt Tension Measurement Device

Use a calibrated device to verify that the pretensioning method develops a pretension equal to or greater than specified in Table 7.1. Ensure annual calibration of the measurement device for accuracy.

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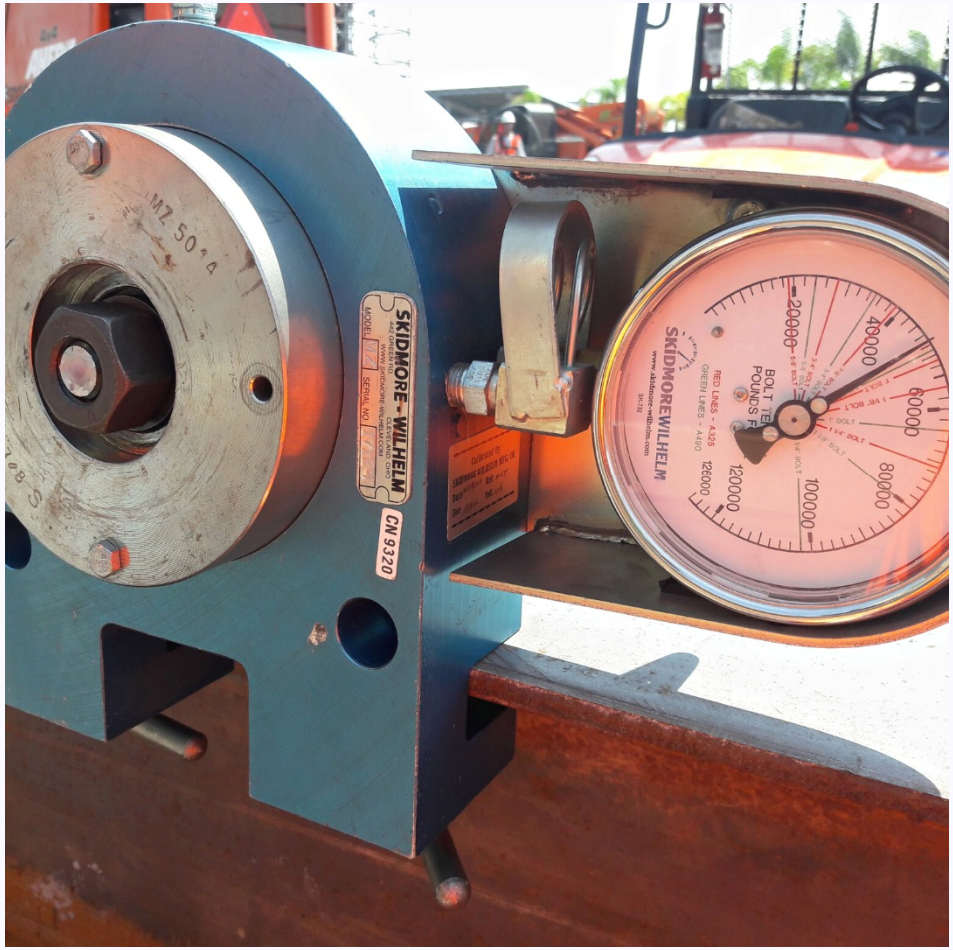

Test Procedure and Equipment

Bolt Tension Measurement Device

Use a calibrated device to verify that the pretensioning method develops a pretension equal to or greater than specified in Table 7.1. Ensure annual calibration of the measurement device for accuracy.

ASTM F436 Washers

Position washers according to current RCSC Specification Section 6.2. This ensures proper load distribution and prevents damage to the joint surface.

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Turn-of-Nut Method

1

Step 1: Snug-Tightening

Install the bolting assembly to snug-tight condition using work tools and methods.

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Turn-of-Nut Method

1

Step 1: Snug-Tightening

Install the bolting assembly to snug-tight condition using work tools and methods.

2

Step 2: Matchmarking

If used in work, matchmark the bolting assembly.

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Table 8.1 Nut Rotation from Snug-Tight Condition
For Turn-of-Nut Pre-Tensioning [a,b]

Bolt Length[c]	Disposition of Outer Faces of Bolted Parts		
	Both faces normal to the bolt axis	One face normal to bot axis, other sloped not more than 1:20[d]	Both faces sloped not more than 1:20 from normal to the bolt axis
Not more than $4d_b$	1/3 turn	1/2 turn	2/3 turn
More than $4d_b$ but not more than $8d_b$	1/2 turn	2/3 turn	5/6 turn
More than $8d_b$ but not more than $12d_b$	2/3 turn	5/6 turn	One turn

Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. For all required nut rotations, the tolerance is plus 60 degrees (1/6 turn) and minus 0 degrees.

[b] Applicable only to *joints* in which all material within the *grip* is steel.

[c] When the bolt length exceeds $12d_b$, the required nut rotation shall be determined by actual testing in a suitable *tension calibrator* that simulates the conditions of solidly fitting steel.

[d] Beveled washer not used

Both surfaces are perpendicular to the axis of the bolt.

One surface is perpendicular to the bolt's axis, while the other is inclined at a slope not exceeding 1:20d. It's also known as a 5% slope

Both surfaces are inclined at no greater than a ratio of 1:20 It's also known as a 5% slope from the perpendicular to the bolt axis.

Turn-of-Nut Method

1

Step 1: Snug-Tightening

Install the bolting assembly to snug-tight condition using work tools and methods.

2

Step 2: Matchmarking

If used in work, matchmark the bolting assembly.

3

Step 3: Pretensioning

Apply rotation specified in Table 8.1

Table 7.1 Minimum Bolt Pretension for Pre-Installation Verification		
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Turn-of-Nut Method

1

Step 1: Snug-Tightening

Install the bolting assembly to snug-tight condition using work tools and methods.

2

Step 2: Matchmarking

If used in work, matchmark the bolting assembly.

3

Step 3: Pretensioning

Apply rotation specified in Table 8.1.

4

Step 4: Final Verification

Verify pretension meets Table 7.1 specifications. Resolve issues if below specification.

Calibrated Wrench Method

1

Snug-Tightening

Install assembly to snug-tight condition using work tools and methods.

2

Pretensioning

Determine torque required to develop pretension equal to or greater than Table 7.1 specifications.

3

Torque Application

Apply installation torque to the nut.

4

Establish Minimum Torque

Use highest torque from three tested assemblies as minimum for work.

Twist-Off Tension Control Bolt Method

Snug-Tightening

Install to snug-tight condition using work tools and methods.

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Twist-Off Tension Control Bolt Method

Snug-Tightening

Install to snug-tight condition using work tools and methods.

Pretensioning

Use twist-off tension control bolt installation wrench to sever splined end.

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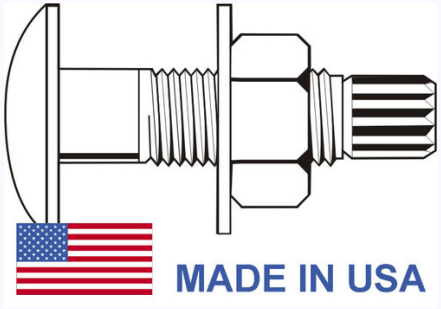
Twist-Off Tension Control Bolt Method

Snug-Tightening

Install to snug-tight condition using work tools and methods.



Pretensioning

Use twist-off tension control bolt installation wrench to sever splined end.

Final Verification

Confirm splined end is severed and pretension meets Table 7.1 specifications.

Table 7.1
Minimum Bolt Pretension for Pre-Installation Verification

Nominal Bolt Diameter, db, in.	Minimum Bolt Pretension for Pre-Installation Verification, kips	
	Group 120 = old A325	Group 144 and Group 150 = old A490
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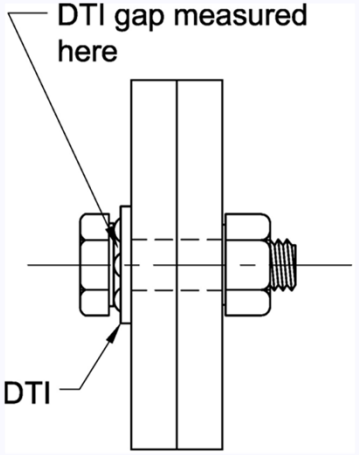
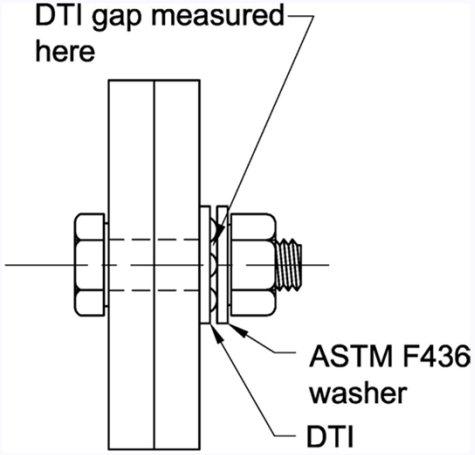
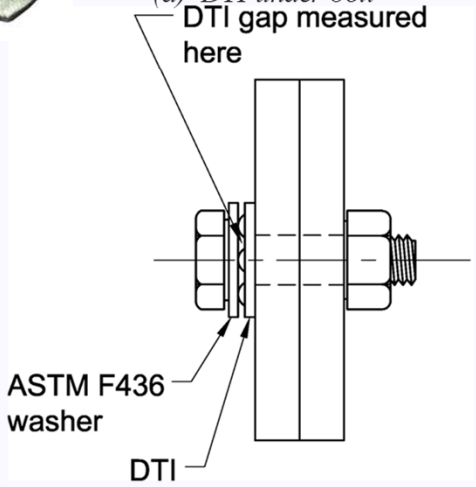
Direct Tension Indicator Method



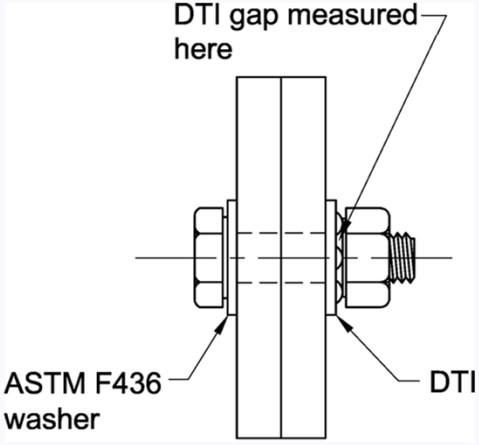
(a) DTI under bolt



(b) DTI under nut, head, nut turned



(c) DTI under bolt head,

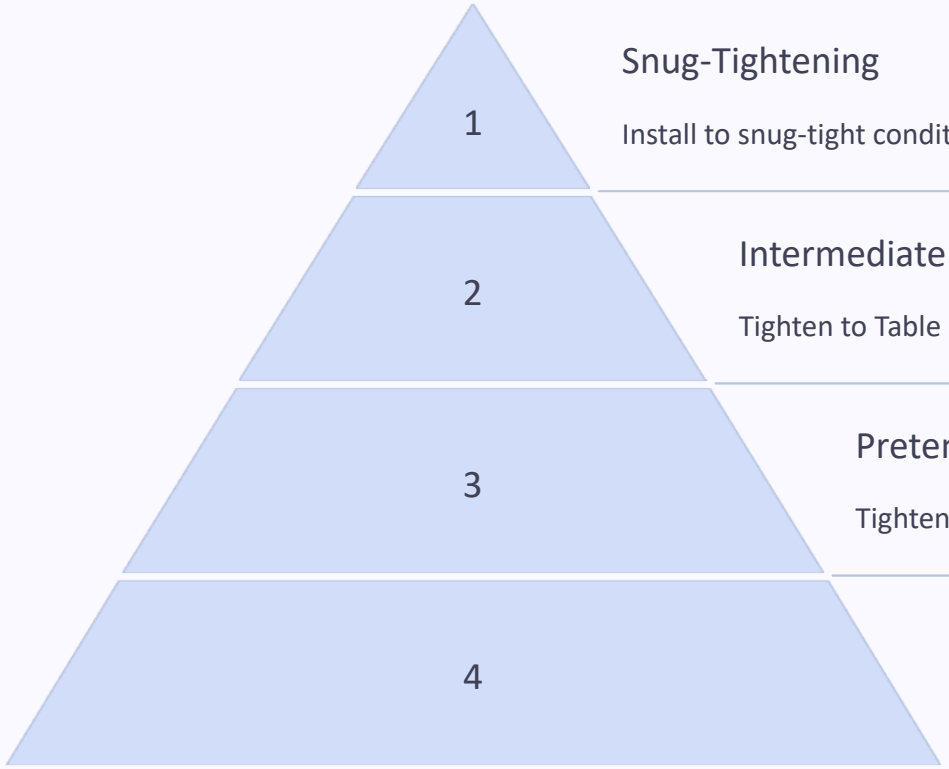


(d) DTI under nut, bolt head turned

Note: See Section 6 for general requirements for the use of washers.

Figure C-8.1. Proper use and orientation of ASTM F959 direct tension indicators

Direct Tension Indicator Method



Snug-Tightening

Install to snug-tight condition

Intermediate Verification

Tighten to Table 7.1 pretension, verify job inspection gap.

Pretensioning

Tighten until the feeler gauge is refused in most spaces.

Final Verification

Confirm pretension meets Table 7.1 specifications.

Use a feeler gauge to verify gaps between protrusions of the direct tension indicator at each step.

Bolting Assembly Tensioning: Combined Method

This presentation outlines the steps involved in the Combined Method of bolting assembly tensioning, a critical process for ensuring structural integrity in construction projects.

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Step 1: Initial Tensioning

Initial Tension or Torque Application

The initial tension or torque is applied to the nut; if using a torque wrench, it must be calibrated within +/-10 percent accuracy. The torque value is specified in Tables 7.2 or 7.3. of the RCSC Specification.

Table 7.2
Minimum Initial Tension for Pre-Installation Verification of Installation in Accordance with Section 8.2.5 (Combined Method)

Nominal Bolt Diameter, d_b, in.	Minimum Initial Tension for Pre-Installation Verification, kips	
	Group 120	Group 144 and Group 150
½	5	7
⅝	9	11
¾	13	16
⅞	17	22
1	23	29
1⅛	29	36
1¼	37	46
1⅜	44	55
1½	53	66

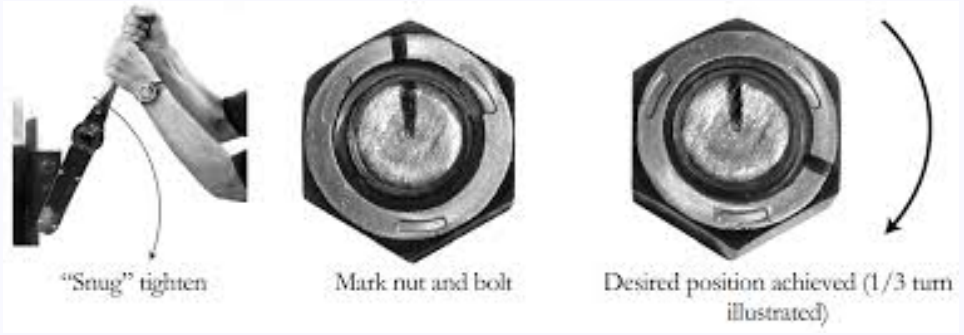
Table 7.3
Default Initial Torque Range for Pre-installation Verification of Initial Tension in Accordance with Section 8.2.5 (Combined Method)

Nominal Bolt Diameter, d_b, in.	Torque Range for Pre-Installation Verification, lb-ft[a]			
	Group 120		Group 144[b] and Group 150	
	Min	Max	Min	Max
½	45	50	60	75
⅝	100	120	120	145
¾	170	205	210	250
⅞	260	310	335	400
1	405	480	510	605
1⅛	570	680	710	845
1¼	810	965	1010	1200
1⅜	1060	1260	1325	1575
1½	1390	1655	1735	2065

Step 2: Pretensioning

Matchmarking

If required by the project, matchmarking is applied to the bolting assembly. This is a visual indication of the initial rotation applied to the nut.



Rotation Application

The specific rotation, as outlined in Table 8.2, is applied to the bolting assembly. This rotation is critical for achieving the desired pretension.

Table 8.2
Nut Rotation from Initial Torque for Combined Method Pretensioning[a,b]

Bolt Length[c]	Rotation
Not more than $4d_b$	90° (1/4 turn)
More than $4d_b$ but not more than $8d_b$	120° (1/3 turn)

[a] Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. For all required nut rotations, the tolerance is plus 45 degrees (1/6 turn) and minus 0 degrees.
[b] Applicable only to *joints* in which all material within the *grip* is steel.
[c] When the bolt length exceeds $8d_b$, the required nut rotation shall be determined by actual testing in a suitable *bolt tension measurement device*; see *combined method* Commentary.

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Step 4: Final Verification

1

Pretension Measurement

The tension developed in the bolting assembly after pretensioning is measured using the tension measurement device.

2

Verification

The measured pretension is compared to the target value specified in Table 7.1.

3

Corrective Action

If the measured pretension is below the target, the cause is identified and resolved before the assembly is used in the work.

Table 7.1
Minimum Bolt Pretension for Pre-Installation Verification

Nominal Bolt Diameter, d_b, in.	Minimum Bolt Pretension for Pre-Installation Verification, kips	
	Group 120	Group 144 and Group 150
½	13	16
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⅞	41	51
1	54	67
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1¼	85	107
1⅜	102	127
1½	124	155

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Combined Method Benefits

Accuracy

The Combined Method combines torque and tension measurements, providing a more precise and reliable method of achieving the desired tension in bolting assemblies.

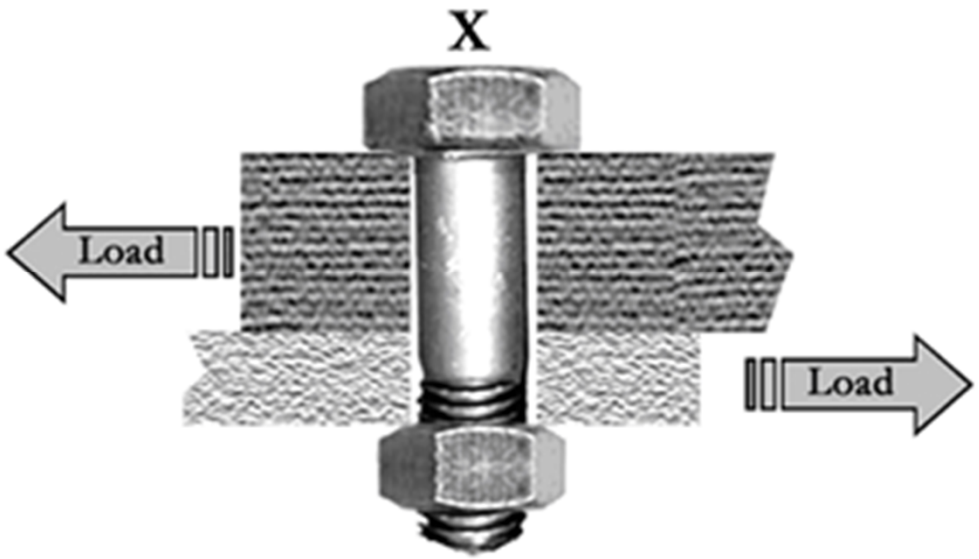
Consistency

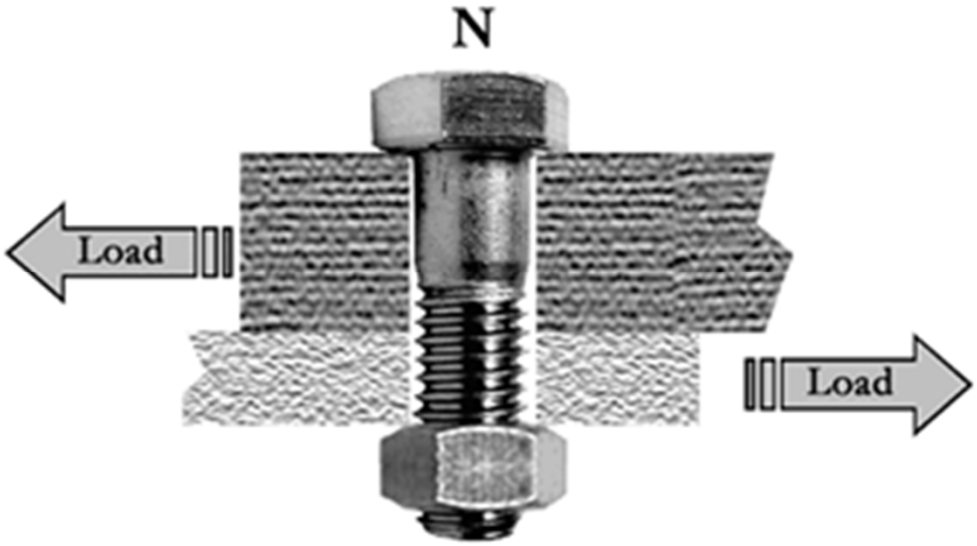
The multi-step verification process ensures consistent tensioning across multiple assemblies, minimizing the risk of under- or over-tensioning.

Structural Integrity

Properly tensioned bolts are crucial for the long-term structural integrity of the project, preventing loosening, failure, and potential safety hazards.

Defining "X" and "N" Designations





Threads Excluded: "X"

This designation signifies that the threads of the bolt are not considered to contribute to the shear strength of the connection. The shear plane is assumed to be outside the threaded portion of the bolt.

Threads Included: "N"

This designation indicates that the threads of the bolt are taken into account for the shear strength calculation. The shear plane is assumed to pass through the threaded portion of the bolt.

Storage and Lubrication Guidelines for Bolting Components

1.Protected Storage:

1. Bolting components and assemblies must be stored in a protected environment upon arrival at the installation site.
2. Only the quantity needed for a single work shift may be removed from storage.
3. Unused components must be returned to protected storage after the shift.

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Field Lubrication:

•Field lubrication is allowed for easier installation, except for the following, which only the manufacturer may relubricate:

- Spline-end twist-off matched assemblies.
- Matched assemblies used with the combined method or ASTM F3148 Grade 144 spline-end assemblies.
- Alternative-design bolting components (per Section 2.12).

Rust and Dirt Handling:

- For **snug-tightened joints**, rusty or dirty heavy hex head bolts must be cleaned and lubricated (if necessary) before use.
- For **pretensioned or slip-critical joints**, components must be cleaned, lubricated (if necessary), and retested as per Section 7. Relubrication restrictions in Section 2.10.4 apply.

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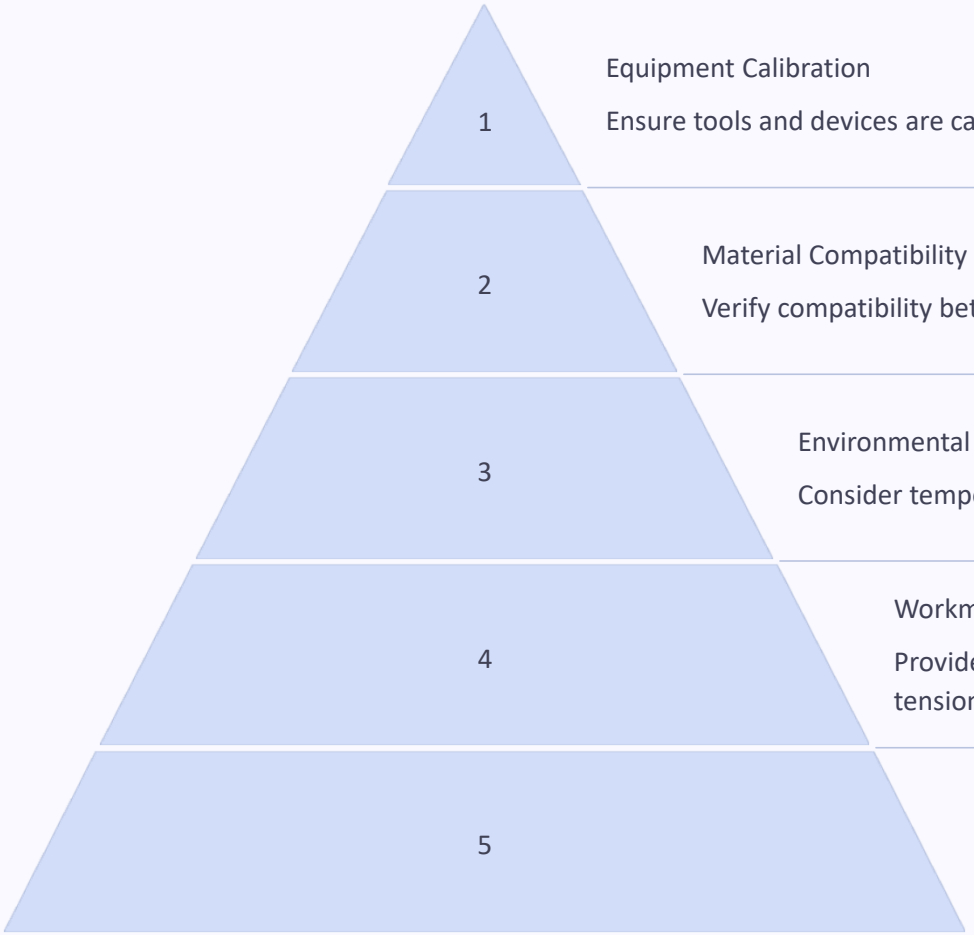
Challenges & Inspection Strategies



Equipment Calibration

Ensure tools and devices are calibrated to ensure accurate measurements.

Material Compatibility

Verify compatibility between bolt materials, nuts, and the structure for proper tensioning.

Environmental Factors

Consider temperature, humidity, and other environmental factors that may affect tensioning.

Workmanship

Provide adequate training and supervision to ensure proper execution of the tensioning process.

Documentation

Maintain detailed records of each assembly's tensioning steps for accountability and future reference.

As a minimum, bolting inspection tasks shall be in accordance with Tables N5.6-1. N5.6-2, and NS.6-3. In these tables, the inspection tasks are as follows:

- Observe (O): The inspector shall observe these items on a random basis. Operations need not be delayed pending these inspections.
- Perform (P): These tasks shall be performed for each bolted connection.

Table N5.6-1: Inspection Tasks Prior to Bolting

Inspection Tasks Prior to Bolting	QCI	QA-3RD PARTY
Manufacturer's certifications available for fastener materials	O	P
Fasteners marked in accordance with ASTM requirements	O	O
Correct fasteners selected for the joint detail (grade, type, bolt length if threads excluded)	O	O
Correct bolting procedure selected for joint detail	O	O
Connecting elements, including appropriate faying surface condition and hole preparation, as specified	O	O
Pre-installation verification testing by installation personnel observed and documented	P	O
Protected storage provided for bolts, nuts, washers, and other fastener components	O	O

Table N5.6-2: Inspection Tasks During Bolting

Inspection Tasks During Bolting	QCI	QA-3RD PARTY
Fastener assemblies placed in all holes, and washers and nuts are positioned as required	O	O
Joint brought to the snug-tight condition prior to the pretensioning operation	O	O
Fastener component not turned by the wrench prevented from rotating	O	O
Fasteners are pretensioned in accordance with the RCSC Specification, progressing systematically from the most rigid point toward the free edges	O	O

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Table N5.6-3: Inspection Tasks After Bolting

Inspection Tasks After Bolting	QA-3RD PARTY
Document acceptance or rejection of bolted connections	P

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Key Takeaways

Follow Procedures

Adhere strictly to the specified steps for each method to ensure proper bolt pretension.

Use Proper Tools

Employ calibrated and appropriate tools for each method to achieve accurate results.

Verify Results

Always perform final verification to ensure pretension meets or exceeds specifications.

Proper pre-installation verification is crucial for structural integrity and safety in high-strength bolting applications.

Link to the RCSC Specification

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End of Presentation

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