Process Specification for Installation of Threaded and Collared Fasteners

Engineering Directorate

Structural Engineering Division

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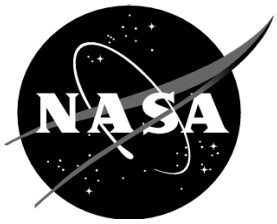

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REVISIONS		
VERSION	CHANGES	DATE
--	Original version	7/13/00
A	Changed Division name. Revised Section 3.1 (Work Instructions) and moved to Section 6.1, renumbered Section 6, and revised Section 9.0 (Training).	10/2004
B	Updated document number for JPR 8500.4 in Section 4.0 (References)	2/2007
C	Sections 1.0, 3.0, 5.0, 6.0, 8.0, 9.0, & 10.0 were extensively re-written. Shop options for substitution were reduced. Joint fit process made more rigorous. Requirements for collared fasteners were separated out.	9/2020

1.0 SCOPE

This process specification establishes the engineering requirements for the installation of threaded fasteners, including conventional threaded fasteners and collared (Hi-Lok) fasteners.

For the purpose of this document, the term “bolt” refers to any standard externally threaded fastener, including both bolts and screws.

2.0 APPLICABILITY

This specification shall be applicable whenever the installation of threaded or collared fasteners is invoked per section 3.0, “Usage”.

3.0 USAGE

Manufactured heads are on the forward or near side relative to the engineering drawing, unless otherwise noted. Standard design practice typically utilizes one washer under the head, and another under the nut. The quantity of washers and their location (under head or nut) shall be specified.

Countersunk washers should be used under protruding head bolts to prevent interference between the fillet under the head of the bolt and the corner of the hole or washer. The countersunk washer should be selected to provide enough clearance for the bolt head fillet without excess reduction of the bearing surface area.

Fastener size and hole size shall be specified on the engineering drawing. When countersunk washers are not used under fastener heads, an appropriate radius or chamfer shall be specified on the hole to accommodate the fastener head fillet. Allowing washer additions in these instances is not recommended unless a countersunk washer is specified. A clearance hole may not need a radius or chamfer if there is no interference between the under head fillet of the bolt and the hole diameter.

When flush head fasteners are used, the angle of a countersink shall correspond to that of the fastener being installed. The diameter and depth of the countersink shall be specified on the engineering drawing so that the fasteners will meet the standard maximum flushness tolerance of 0.010 inch above the surface. Alternate flushness tolerances may be specified on the drawing.

This process specification shall be called out on the engineering drawing via a drawing note. For example:

INSTALL FASTENERS PER NASA/JSC PRC-9007. TORQUE TO 190-210 IN-LBS ABOVE RUNNING TORQUE. RUNNING TORQUE SHALL BE 6.5-60 IN-LBS.

For threaded fasteners, the effective torque and running torque shall be specified or referenced by the engineering drawing. These torques may be included in the process specification callout note (as above), or they may be located in the field of the drawing in a table or near the appropriate joint, or an assembly specification referenced by the engineering drawing. The running torque can be obtained from the procurement specification for the locking element, such as MIL-DTL-25027, MIL-DTL-18240, MIL-I-45914, MIL-I-45932, and NASM8846.

When wet installation of fasteners with corrosion preventative primer is required, it shall be called out in the engineering drawing. An example callout is:

SEAL FASTENER PER NASA/JSC PRC-4004 USING XXXXX SEALANT.

The “XXXXX” must be replaced with the name of the sealant.

Design is responsible for selecting parts and performing the dimensional analysis to attain a proper fit. Min/Max tolerances should be utilized in the fit analysis. Proper fit is defined in section 6. The technician will verify proper fit during the assembly process. If design has any specific fit requirements that require checking during assembly, instructions should be placed on the engineering drawing.

The thread engagement requirements for nuts and inserts in section 6 assume complete engagement in the internal thread, and 1D engagement in tapped holes. If different thread engagement is required, such as longer thread engagement to prevent thread stripping, it should be specified on the engineering drawing.

To achieve proper fit, there may be some threads in bearing. Without washers, there can be as much as 2P + 1/16” (two incomplete threads + up to 1 grip length) of threads in bearing. JSC stress analysis may require that threads in bearing not exceed 25% of a clamped member. Specifying an appropriate bolt grip or adding washers can reduce the number of threads in bearing.

This specification does not allow grip substitutions or washer changes unless specifically allowed by the engineering drawing. An example callout is:

GRIP SUBSTITUTIONS AND WASHER CHANGES ARE ALLOWED.

This approach depends on having additional grip fasteners in stock, as well as extra washers. The alternate grip fastener does not need to be called out on the drawing, but the substitute bolt must have the same part number as the original bolt, except for the grip. Extra washers must be the same part number as called out in the engineering for that joint. If there are no washers in the as-designed joint, or a different washer part number is desired, the washer must be called out on the drawing on an as-required basis.

When multiple fasteners are used and an evenly distributed clamp load is needed, an appropriate torque sequence along with incremental torqueing should be specified on the engineering drawing or hardware-specific installation procedure. Examples of torque sequences are star (for circular bolt patterns) or spiral (for rectangular bolt patterns). Unless otherwise specified by the engineering drawing, the process for incremental tightening and torque sequencing will be per section 6.

For Hi-Loks, the perpendicularity of the hole axis to the surface should be specified to be 90 +/- ½ degrees. When joining a sloped surface, self-aligning Hi-Loks can be used. Hi-Loks are generally used without washers due to a built-in washer in the collar. The design of the collar eliminates shanking and threads in bearing as long as the appropriate grip length pin is chosen. When selecting hi-lok pins and collars, either the pin or the collar (but not both) shall be procured with lubricant.

4.0 REFERENCES

All documents listed are assumed to be the current revision unless a specific revision is listed.

SOP-007.1	*Preparation and Revision of Process Specifications*
JPR 8500.4	*Engineering Drawing System Manual*
NASA/JSC PRC-4004	*Sealing of Joints and Faying Surfaces, PRC for the*
MIL-DTL-25027	*Nut, Self-Locking, 250□F, 450□F. and 800□F*
MIL-DTL-18240	*Fastener Element, Self-Locking, Threaded Fastener, 250□F Maximum*
MIL-I-45914	*Insert, Screw Thread - Locked In, Key Locked*
MIL-I-45932	*Insert, Screw Thread, Thin Wall, Locked In*
NASM8846	*Inserts, Screw Thread, Helical Coil*

5.0 MATERIAL REQUIREMENTS

None identified.

5.1 TORQUE WRENCH

All torque wrenches shall be verified to be in calibration before they are used.

Torque wrenches shall only be used between 20 and 80 percent of their torqueing capability (middle 60 percent of full scale). Extensions do not apply.

6.0 PROCESS REQUIREMENTS

6.1 WORK INSTRUCTIONS

All work shall be performed to written procedures. The work instructions shall contain sufficient detail to ensure that the manufacturing process produces consistent, repeatable products that comply with this specification.

For work performed at JSC facilities, these work procedures consist of Detailed Process Instructions (DPI's).

For contracted work, the contractor shall be responsible for preparing and maintaining, and certifying written work procedures that meet the requirements of this specification.

6.2 REQUIREMENTS FOR CONVENTIONAL THREADED FASTENERS

Holes shall be verified to be chamfered or radiused before fasteners are installed.

Lubricant or sealant shall not be applied to fasteners or threads unless it is specifically called out on the engineering drawing.

Running torque shall be measured during installation of self-locking fasteners and verified to be within the specified range.

Removed fasteners may be reinstalled on the same hardware and shall follow the same installation procedure. Fasteners shall be examined for wear or deformation before being reinstalled. Removed fasteners shall not be returned to stock.

Changes to bolt grip length or washer quantity during installation are not allowed unless specifically called out on the engineering drawing.

6.2.1 FIT REQUIREMENTS

The proper fit is achieved when the following requirements are met:

- Shanking: Incomplete runout threads near the shank shall not engage the internal threads of the mating part.

- Thread Engagement: The following engagement requirements are applicable based on the internally threaded part type, unless otherwise stated on the engineering drawing:

    - Nuts and nut plates: the bolt shall protrude beyond the end of the nut by a length equal to or greater than two thread pitches.
    - Inserts: the bolt shall fully engage the length of the insert.
    - Tapped holes: The length of engagement shall be at least 1 times the nominal diameter of the bolt.

- Bottoming Out: The bolt shall not bottom out when installing a bolt in a blind hole.

- Engagement of Locking Feature: The following engagement requirements are applicable to prevailing torque type self-locking fasteners:

    - Locking feature located on bolt: The locking feature shall be fully engaged.
    - Locking feature located on internally threaded part: the bolt shall protrude beyond the end of the locking feature by a length equal to or greater than two thread pitches.

- Threads in Bearing: Threads in bearing shall be minimized while still meeting the other fit requirements.

6.2.2 Fit Verification Methods

Although the fasteners identified in the engineering drawing are anticipated to provide proper fit, a stack up of tolerances can lead to improper fit during installation. The technician shall verify proper fit. Any requirement that cannot be verified by visual inspection shall be measured directly or indirectly.

Direct and indirect verification is accomplished using grip gages, calipers, and other measurement tools. Detailed measurement and verification techniques shall be defined in DPI or written shop instructions.

Shanking

In some cases, direct visual inspection can provide verification that the incomplete threads will not extend into the mating internal threads. Often a washer can be removed to visually verify incomplete threads are inside the joint. However, when there is no washer, or when installing into an insert or nut plate, indirect measurement must be used.

Engagement

Nuts: Direct measurement will be used to verify required protrusion.

Inserts, nut plates, and tapped holes: Indirect measurement will be used to verify required engagement.

Bottoming out

Indirect measurement will be used to verify bolt does not bottom out in hole.

Locking Feature

Locking feature located on bolt: The locking feature engagement will be verified by indirect measurement.

Locking feature located on internally threaded part: Locking feature engagement will typically be met by verifying the thread engagement requirements. However, if reduced thread engagement is allowed by the drawing, verification of locking feature engagement will need to be performed separately, by indirect measurement.

Threads in Bearing

Threads in bearing are acceptable unless otherwise specified on the engineering drawing or hardware-specific installation procedure.

6.2.3 Grip Substitution

Grip substitution is allowed only when stated on the engineering drawing, and may be utilized to meet the fit requirements of section 6.3. Grip substitution requirements are as follows:

- Bolts up to one grip length increment (1/16”) longer or shorter may be substituted for the bolt called out in the engineering drawing.
- Substituted bolts shall be the same part number as those called out in the engineering except for the grip length.

- Grip length should be chosen to use the longest grip length that would not result in shanking in order to minimize the threads in bearing and maximize thread protrusion.

6.2.4 Washer Addition/Removal

Washers can be added or removed only when allowed by the engineering drawing, in order to meet the fit requirements of section 6.3. Requirements for adding washers are as follows:

- Added washers shall be the same part number as those specified on the engineering drawing or specified as an if-needed basis on the engineering drawing.
- When a plain washer is added to the head side along with a countersunk washer, the plain washer shall be located under the countersunk washer (the countersunk washer remains directly underneath the bolt head).
- Unless otherwise specified, the total number of installed washers on a single bolt shall not exceed three.
- Only one countersunk washer may be installed on a single bolt and it shall be located directly underneath the bolt head.

Requirements for removing washers are as follows:

- Only one plain washer can be removed from a single bolt.
- Countersunk washers cannot be removed.

6.2.5 TORQUE APPLICATION

Fasteners shall be tightened to within the torque range specified by the engineering drawing. When the engineering drawing specifies the torque range as “above running torque”, the specified torque must be added to the measured running torque to calculate the final installation torque range for each individual fastener. Fasteners should be tightened from the nut side whenever possible. Fasteners tightened from the head side should be torqued to the high side of the specified torque range.

6.2.6 TORQUE SEQUENCING

When assembling joints with more than two fasteners in a pattern, torque shall be applied to the fasteners in an appropriate sequence. Unless otherwise specified on the drawing, the fasteners should be installed in a star sequence for circular bolt patterns, and a spiral sequence for rectangular bolt patterns.

6.2.7 INCREMENTAL TIGHTENING

Unless otherwise specified, torque shall be applied in three increments:

- Snug (approximately 0% of final torque)
- Between 50% and 75% of final torque
- 100% of final torque

When installed in a sequence, the entire sequence is completed for each increment before tightening to the next increment.

Note: The torque wrench only needs to be in the torque range specified in section 5.1 for the final torque increment (100%).

6.3 REQUIREMENTS FOR COLLARED FASTENERS

Holes shall be deburred before fasteners are installed.

Lubricant shall not be applied to fasteners or threads.

The joint and pin shall be measured before installation with a Hi-Lok grip gage to check proper grip.

The minimum and maximum protrusion after Hi-Lok installation shall meet the requirements in Table 1.

Table 1: Hi-Lok Pin Protrusion

Fastener		Protrusion	
Dash No.	Size	Minimum	Maximum
-05	(0.164)	0.302	0.384
-06	(0.190)	0.315	0.397
-08	(0.250)	0.385	0.467
-10	(0.312)	0.490	0.572
-12	(0.375)	0.535	0.617
-14	(0.437)	0.625	0.707
-16	(0.500)	0.675	0.757

Changes to pin grip length or washer quantity during installation are not allowed.

Proper hand or pneumatic equipment shall be used to install Hi-Lok fasteners.

Hi-Loks shall be tightened until clamped up using hand tools, and unless otherwise specified on the drawing, torqued in a star sequence for circular bolt patterns, and a spiral sequence for rectangular bolt patterns.

Running torque and installation torque are not measured during installation of Hi-Loks.

Collars shall not be removed and reinstalled.

7.0 PROCESS QUALIFICATION

None required.

8.0 PROCESS VERIFICATION

8.1 Conventional Threaded Fasteners

Joints requiring secondary verification or quality assurance (MIP) inspection of installation torque and the recording of torque values shall have this indicated on the engineering drawing or in the assembly procedure referenced by the engineering drawing.

Assembled joints shall be visually inspected to verify the requirements of Section 6.0 can be determined visually.

There shall be no gap underneath the fastener head or nut.
Torque audits made at a later time to verify torque shall only be conducted under the appropriate materials review board (MRB) activity. When they are conducted, torque audits shall be measured in the tightening direction.

8.2 Collared Fasteners

After installation, the joint shall be inspected for the following:

- Maximum gap under collars or protruding or flush head pins shall be 0.002 inch.
- Collars shall not be loose, cracked or split nor exhibit abnormal shear fracture.
- Manufactured heads shall not have cracks or a dimple.
- The pin protrusion length, in inches, shall be meet the limits in Table 1.

9.0 TRAINING AND CERTIFICATION OF PERSONNEL

This process shall be performed by personnel qualified through training or experience and certified by their supervision to conduct the process. The training shall include techniques for determination of proper joint fit.

10.0 DEFINITIONS

Running Torque	The torque required to overcome kinetic friction of the mating threads plus the torque required to overcome the locking feature when 100 percent of the locking feature is engaged and the fastener is unseated. This torque can be measured in either a loosening or a tightening direction while the mating threads are in relative motion. Also known as “locking” or “prevailing torque”.
Effective Torque	A torque in excess of any running torque. Also known as “preload torque”.
Installation Torque	The Installation torque, as measured by the torque wrench, includes both the running torque and the effective torque.