SAE INTERNATIONAL

SURFACE VEHICLE INFORMATION REPORT

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Torque-Tension Tightening for Metric Series Fasteners

RATIONALE

Enhanced description and content of Table 2.

FOREWORD

Fundamentally, threaded fasteners are required to create a clamping force or compressive load on the assembled joint to prevent joint movement or loosening. In order to accomplish this, tensile loading (axial stress) is developed in a bolt, screw, or stud by itself or by a nut tightened on the bolt, screw, or stud.

The axial stress in bolts, screws, or studs produces a clamping force equal to the product of the applied axial stress and the cross sectional area of the bolt or screw.

Although clamping force or fastener tension can be measured by load cells, strain gauges, ultrasonics, or pressure-sensitive films, these methods are often impractical for high-production assembly applications. Practical methods of achieving control of joint clamp load include load indicating washers, torque control, angle (tightening) control, or combinations of torque and angle. Therefore, it becomes very important to understand the relationship between torque and tension.

1. SCOPE

This SAE Information Report is provided as an advisory guide. Individual application discretion is recommended. The content has been presented as accurately as possible, but responsibility for its application lies with the user. The document covers a number of the variables in the torque-tension relationship: friction, materials, temperature, humidity, fastener and mating part finishes, surfaces, and the kind of tightening tools or equipment used.

Also described in this document is the torque management required to achieve satisfactory fastened joint tightening.

This guide is limited in application to clearance fit threads, such as the common 6g/6H class of fit. Other thread types including interference fit, mechanical locking, prevailing torque, or forms other than ISO-metric may apply to some aspects of this standard but are not specifically covered.

The procedures described in this document are based on general factors for the determination of the torque-tension relationship for the use of end users. This is a guide and is not intended to be made a procurement requirement. For critical joint design, the assembly torque values should be determined by experimentation using the exact assembly components.

2. REFERENCES

2.1 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J174 Torque-Tension Test Procedure for Steel Threaded Fasteners - Inch Series

SAE J1648 Protective Coatings for Fasteners

SAE J2486 Tension Indicating Washer Tightening Method for Fasteners

2.1.2 ISO Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ISO 16047 Fasteners, Torque/Clamp Force Testing

ISO 898-1 Mechanical Properties of Fasteners made of Carbon Steel and Alloy Steel

2.1.3 Military Handbook

Available from EverySpec LLC at www.everyspec.com.

MIL-HDBK-60 Threaded Fasteners - Tightening to Proper Tension.

3. EXPLANATION OF TIGHTENING TERMS

3.1 Torque

Is the product of force multiplied by lever arm, length. Is the moment resistance of the fastener and the tightened components to tighnening. Is used to attain a targeted axial load in a fastener and corresponding clamp force in the joint. Is commonly expressed in Newton-meters (Nm).

3.2 Turn of Screw or Bolt and Turn of Nut

These terms describe which mating fastener component is turned during tightening. They may also refer to the angle control method for tightening a joint.

For turn-of-screw, the head of the screw or bolt is turned against a joint surface either into a tapped hole or into a separate nut.

For turn-of-nut, the nut is turned onto a screw, bolt, or stud and is tightened against a washer or the joint surface.

3.3 Clamping Force

The compressive or reaction force within the joint which is equal and opposite to the tensile (axial) load generated in the screw, stud, or bolt when the fastener assembly is tightened. This force is normally expressed in Newtons (N).

3.4 Inertia

The tendency of a body to continue in motion after being subjected to a force in a specific direction until acted upon by an outside force. In tightening, friction between external and internal threads, and between mating parts and fastener bearing surface are major contributing outside forces and have to be overcome. Inertia of the rotating power tool is another factor that must be considered.

3.5 Target Tension

A predetermined value of axial stress with an associated acceptable level of scatter or variability, to be achieved in each tightened fastener in a joint. The predetermined value is typically expressed as a stated value with acceptable upper and lower limits. Similarly, target clamp force is the expected joint reaction to attainment of a target tension.

3.6 Angle Control

A method based upon material properties and common geometric factors which allows measurement and control of the angle of total rotation during tightening to be used as a means of develop clamp force in a joint. The method relies on first drawing the joint together into solid contact between all mating surfaces, including gaskets, if any

3.7 Torque Control

A method of controlling a joint's clamp force. It's achieved by controlling the torque applied while a threaded fastener is turned after it draws the joint together and makes solid contact to the mating part surface. This can be combined with angle control.

3.8 Proof Load

A load value that a nut or bolt must meet without permanent dimensional change or thread deformation. It is this value that's used in combination with a factor of safety for design purposes.

3.9 Snug Torque

The point where the joint components have been consolidated. Where the graph trace starts to become linear and elastic stretch of the bolt or screw begins.

3.10 Threshold Torque

When turn-of-nut (bolt) is employed, it is the point where the torque cycle is complete and the angle cycle begins.

4. VARIABLES IN THE RELATIONSHIP OF CLAMPING FORCE TO APPLIED TORQUE

4.1 Friction

The frictional resistance to torque is the most important of all of the tightening variables. Research demonstrates that ~90% of the energy expended during the fastener tightening process is lost to geometric and frictional factors (lost as heat), and that ~10% is converted to potential energy stored as fastener tension. The friction resistance between the external and internal threads accounts for ~40% of frictional losses, and the frictional resistance between the fastener element that is turned (bolt or screw head versus nut) and the mating surface, or bearing surface against which the fastener element is turned, accounts for ~50% of frictional losses. Increasing the clamping tension force on the screw or bolt increases the friction resistance to turning, and is important to note this relationship is not uniformly linear.

4.2 Fastener Materials

Characteristic properties of hardness and surface conditions (including markings on a bearing surface) can contribute to frictional variability affecting tightening torque, consequently affecting clamping force.

4.2.1 Non heat-treatable low-carbon, stainless steels, and other soft alloys exhibit increased friction resistance resulting in higher tightening torque being necessary to achieve a targeted clamp force.