| SAE International® SURFACE VEHICLE STANDARD | SAE J81 JUL2012 |
|---|---|
| | Issued 1972-07<br>Stabilized 2012-07<br><br>Superseding J81 SEP1997 |

# Thread Rolling Screws

## RATIONALE

This standard has been stabilized because it covers a mature product that is unlikely to change in the future. The same technical information is now covered in ASME B18.6.3 – 2010 and later and should be referenced for all future designs.

## STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE Fasteners Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.





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***Foreword***—This Document has also changed to comply with the new SAE Technical Standards Board format.

***1. Scope***—This SAE Standard covers requirements for thread rolling screws suitable for use in general engineering applications. (It is intended that "thread rolling" screws have performance capabilities beyond those normally expected of other standard types of tapping screws.)

NOTE—The performance requirements covered in this document apply only to the combination of laboratory conditions described in the testing procedures. If other conditions are encountered in an actual service application (such as different materials, thicknesses, hole sizes, etc.), values shown herein for drive torque, torque-to-clamp load, and proof torque may require adjustment.

***2. References***

**2.1 Applicable Publications—**The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J78—Steel Self-Drilling Tapping Screws
SAE J478—Slotted and Recessed Head Screws

2.1.2 ANSI PUBLICATIONS—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI B18.6.4—Slotted and Recessed Head Tapping Screws and Metallic Drive Screws

2.1.3 MILITARY PUBLICATIONS—Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-105D

## *3. Requirements*

### 3.1 Material and Process Requirements

3.1.1 MATERIAL AND CHEMISTRY—Screws shall be made from cold-heading quality, killed steel wire conforming to the following chemical composition requirements:

**TABLE 1—COMPOSITION LIMITS, % BY WEIGHT**

| Analysis | Carbon Min | Carbon Max | Manganese Min | Manganese Max |
|---|---|---|---|---|
| Ladle | 0.15 | 0.25 | 0.70 | 1.65 |
| Check | 0.13 | 0.27 | 0.64 | 1.71 |

3.1.2 HEAT TREATMENT—Screws shall be heat treated in a gas-carburizing system. Cyaniding systems may be approved by the purchaser when it is shown that a continuous flow (no batch) quenching process which consistently produces uniform case and core hardnesses is employed. Carbonitriding systems may also be used when approved by the purchaser.

3.1.3 TEMPERING TEMPERATURE—Minimum tempering temperature shall be 650 °F.

3.1.4 FINISH—Screws shall be cadmium or zinc plated with a coating thickness of 0.0002 to 0.0004 in, or have a phosphate and oil coating, as specified by the purchaser. At the option of the manufacturer, screws may be provided with an additional supplementary lubricant as necessary to meet the performance requirements.

Electroplated screws shall be baked within 1 h of plating at a temperature range of 375 °F to 450 °F for a minimum of 4 h at temperature.

In cases where screws are plated or coated following delivery to the purchaser (or where plating or coating of screws is otherwise under the control of the purchaser), the screw producer shall not be responsible for failures of the screw to meet mechanical or performance requirements due to plating or coating.

### 3.2 Dimensional Requirements

3.2.1 HEAD DIMENSIONS—Head dimensions shall conform to those specified in SAE J478 and ANSI B18.6.4.

3.2.2 THREAD AND POINT DIMENSIONS—Thread and point dimensions shall conform to the values shown in Table 2. Threads shall conform to a 60-degree basic thread form, but are not subject to thread gaging. Details of point configurations shall be optional with the manufacturer, provided all dimensions specified are maintained and the screws meet the performance requirements set forth in this document.

**TABLE 2—THREAD AND POINT DIMENSIONS OF THREAD ROLLING SCREWS**

| Nominal Screw Size and Threads per inch[1] | Major Diameter[2] max | Point Diameter[2] max | Dia of Circumscribing Circle[3] max | Circumscribing Circle (Point)[3] max | Point Length Max[4] | Point Length Min[5] | Min Practical Nominal Screw Lengths 90-degree Heads | Min Practical Nominal Screw Lengths Csk Heads |
|---|---|---|---|---|---|---|---|---|
| No. 2-56 | 0.086 | — | 0.088 | 0.070 | 0.062 | 0.036 | 5/32 | 3/16 |
| 3-48 | 0.099 | — | 0.101 | 0.081 | 0.073 | 0.042 | 3/16 | 7/32 |
| 4-40 | 0.112 | 0.086 | 0.115 | 0.090 | 0.088 | 0.050 | 3/16 | 1/4 |
| 5-40 | 0.125 | 0.099 | 0.128 | 0.103 | 0.088 | 0.050 | 7/32 | 1/4 |
| 6-32 | 0.138 | 0.106 | 0.141 | 0.111 | 0.109 | 0.062 | 1/4 | 5/16 |
| 8-32 | 0.164 | 0.132 | 0.167 | 0.137 | 0.109 | 0.062 | 1/4 | 11/32 |
| 10-24 | 0.190 | 0.147 | 0.194 | 0.153 | 0.146 | 0.083 | 5/16 | 13/32 |
| 1/4-20 | 0.250 | 0.198 | 0.255 | 0.206 | 0.175 | 0.100 | 13/32 | 1/2 |
| 5/16-18 | 0.313 | 0.255 | 0.318 | 0.264 | 0.194 | 0.111 | 15/32 | 5/8 |
| 3/8-16 | 0.375 | 0.310 | 0.281 | 0.320 | 0.219 | 0.125 | 9/16 | 23/32 |
| 7/16-14 | 0.438 | 0.361 | 0.445 | 0.375 | 0.250 | 0.143 | 21/32 | 13/16 |
| 1/2-13 | 0.500 | 0.416 | 0.508 | 0.433 | 0.269 | 0.154 | 23/32 | 7/9 |

1. Fine thread series screws are also available.
2. These dimensions are applicable to screw blanks prior to thread rolling and to types of screws where the periphery of the thread approximates a circle.
3. These dimensions are applicable to types of screws where some portions of the periphery of the thread are further from the screw axis than others (lobular, elliptical, tri-roundular, etc.).
4. These values are equal to 3.5 times the pitch distance rounded off to three decimal places.
5. These values are equal to 2 times the pitch distance rounded off to three decimal places.

3.2.3 THREAD LENGTH—For screws of nominal lengths equal to or shorter than the nominal lengths tabulated in Table 3, the full form threads shall extend close to the head such that the specified thread major diameter limits are maintained to within two pitches (threads), or closer if practicable, from the underside of the head. See Figure 1. Screws of nominal lengths longer than those tabulated shall, unless otherwise specified, have a minimum length of full form thread equivalent to six times the basic screw diameter or 1.50 in, whichever is shorter.



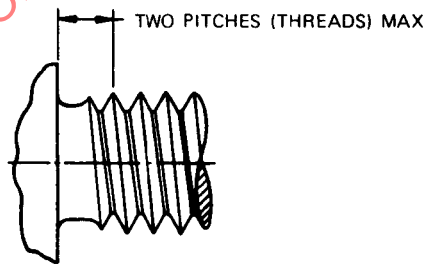


FIGURE 1—THREAD MAJOR DIAMETER LIMIT

**TABLE 3—MINIMUM FULL FORM THREAD LENGTH**

| Nominal Screw Size | Nominal Screw Length | Full Form Thread Length[1] Min | Two Pitches Length[2] Coarse Thread |
|---|---|---|---|
| 2 | 5/8 | 0.52 | 0.036 |
| 3 | 5/8 | 0.59 | 0.042 |
| 4 | 3/4 | 0.67 | 0.050 |
| 5 | 7/8 | 0.75 | 0.050 |
| 6 | 7/8 | 0.83 | 0.062 |
| 8 | 1 | 0.98 | 0.062 |
| 10 | 1-1/4 | 1.14 | 0.083 |
| 1/4 | 1-1/2 | 1.50 | 0.100 |
| 5/16 | 1-1/2 | 1.50 | 0.111 |
| 3/8 | 1-1/2 | 1.50 | 0.125 |
| 7/16 | 1-1/2 | 1.50 | 0.143 |
| 1/2 | 1-1/2 | 1.50 | 0.154 |

1. Tabulated values through No. 10 size are 6 times the basic screw diameter, rounded off to two decimal places.
2. Values are tabulated for convenient reference.

## 3.3 Mechanical and Performance Requirements

3.3.1 HARDNESS

*3.3.1.1* *Core Hardness*—Screws shall have a core hardness of Rockwell C28–38, when tested as specified in 4.1.

*3.3.1.2* *Case Hardness*—Screws shall have a case hardness equivalent to Rockwell C45 minimum, when tested as specified in 4.2.

*3.3.1.3* *Total Case Depth*—Screws shall have a total case depth conforming to the tabulation as shown in Table 4.

**TABLE 4—TOTAL CASE DEPTH**

| Nominal Screw Size | Total Case Depth (Inches) Max | Total Case Depth (Inches) Min |
|---|---|---|
| 4 and 6 | 0.007 | 0.002 |
| 8 through 12 | 0.009 | 0.004 |
| 1/4 and larger | 0.011 | 0.005 |

Total case depth shall be measured at a midpoint between crest and root on the thread flank. The recommended technique for measuring case depth is given in Appendix A of SAE J78. Total case depth is the distance measured perpendicularly from the surface of a hardened case to a point where differences in chemical or physical properties of the case and core no longer can be distinguished (see SAE J423) or when the microhardness converted to HRC is 42.

3.3.2 TENSILE STRENGTH—Hex and hex washer head screws which have nominal lengths equal to or longer than 1/2 in or three times the nominal screw diameter, whichever is longer, shall have tensile strengths not less than those specified in Tables 5A and 5B, when tested in accordance with 4.4. Screws with shorter lengths or screws with other head styles are not subject to tensile testing.

## TABLE 5A—MECHANICAL AND PERFORMANCE REQUIREMENTS FOR THREAD ROLLING SCREWS[1] (TENSILE STRENGTH, MIN LB)

| Nominal Screw Size and Threads per Inch | Tensile Strength, Min lb | Torsional Strength Min In-Lb | Torsional Strength Min ft-lb | Drive Torque For PC and CP Screws Max In-Lb | Drive Torque For PC and CP Screws Max ft-Lb | Drive Torque For ZP Screws Max In-lb | Drive Torque For ZP Screws Max ft-lb |
|---|---|---|---|---|---|---|---|
| No. 2-56 | 500 | 6 | — | 4.5 | — | 6 | — |
| 3-48 | 660 | 10 | — | 7.5 | — | 9.5 | — |
| 4-40 | 810 | 14 | — | 9 | — | 13 | — |
| 5-40 | 1 100 | 22 | — | 12 | — | 16 | — |
| 6-32 | 1 250 | 24 | — | 14 | — | 20 | — |
| 8-32 | 1 900 | 48 | — | 25 | — | 32 | — |
| 10-24 | 2 350 | 65 | — | 35 | — | 52 | — |
| 1/4-20 | 4 300 | 156 | 13 | 90 | 7.5 | 120 | 10 |
| 5/16-18 | 7 100 | 330 | 27.5 | 180 | 15 | 240 | 20 |
| 3/8-16 | 10 500 | 600 | 50 | 240 | 20 | 300 | 25 |
| 7/16-14 | 14 400 | 840 | 70 | 360 | 30 | 480 | 40 |
| 1/2-13 | 19 100 | 1080 | 90 | 540 | 45 | 660 | 55 |

Legend: CP—cadmium plated
ZP—zinc plated
PC—phosphate coated

1. Values shown in Tables 5A and 5B are intended for specification purposes and for acceptability of screws to the requirements of the specification. These values are not valid for use in design or assembly unless all conditions of the application are identical with those specified for the inspection tests.

## TABLE 5B—MECHANICAL AND PERFORMANCE REQUIREMENTS FOR THREAD ROLLING SCREWS[1] (CLAMP LOAD, LB)

| Nominal Screw Size and Threads per Inch | Clamp Load, lb | Clamp Load Torque For PC and CP Screws Max in-lb | Clamp Load Torque For PC and CP Screws Max ft-lb | Clamp Load Torque For ZP Screws Max in-lb | Clamp Load Torque For ZP Screws Max ft-lb | Proof Torque For PC and CP Screws in-lb | Proof Torque For PC and CP Screws ft-lb | Proof Torque For ZP Screws in-lb | Proof Torque For ZP Screws ft-lb | Hydrogen Embrittlement Torque For CP Screws in-lb | Hydrogen Embrittlement Torque For CP Screws ft-lb | Hydrogen Embrittlement Torque For ZP Screws in-lb | Hydrogen Embrittlement Torque For CP Screws ft-lb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. 2-56 | — | — | — | — | — | 7 | — | 8 | — | 4.5 | — | 5 | — |
| 3-48 | — | — | — | — | — | 12 | — | 13.5 | — | 7.5 | — | 8.5 | — |
| 4-40 | — | — | — | — | — | 17 | — | 19 | — | 10.5 | — | 12 | — |
| 5-40 | — | — | — | — | — | 25 | — | 28 | — | 17 | — | 19 | — |
| 6-32 | 460 | 19 | — | 25 | — | 28 | — | 33 | — | 18 | — | 20 | — |
| 8-32 | 700 | 37 | — | 48 | — | 50 | — | 57 | — | 36 | — | 41 | — |
| 10-24 | 900 | 55 | — | 68 | — | 68 | — | 77 | — | 49 | — | 55 | — |
| 1/4-20 | 1600 | 120 | 10 | 144 | 12 | 162 | 13.5 | 186 | 15.5 | 114 | 9.5 | 132 | 11 |
| 5/16-18 | 2600 | 252 | 21 | 312 | 26 | 342 | 28.5 | 372 | 31 | 252 | 21 | 276 | 23 |
| 3/8-16 | 4000 | 480 | 40 | 612 | 51 | 636 | 53 | 690 | 57.5 | 456 | 38 | 510 | 42.5 |
| 7/16-14 | 5400 | 744 | 62 | 900 | 75 | 888 | 74 | 960 | 80 | 630 | 52.5 | 720 | 60 |
| 1/2-13 | 7200 | 996 | 83 | 1140 | 95 | 1170 | 97.5 | 1260 | 105 | 816 | 68 | 930 | 77.5 |

Legend: CP—cadmium plated
ZP—zinc plated
PC—phosphate coated

1. Values shown in Table 5 are intended for specification purposes and for acceptability of screws to the requirements of the specification. These values are not valid for use in design or assembly unless all conditions of the application are identical with those specified for the inspection tests.

3.3.3 TORSIONAL STRENGTH—Screws shall not fail with the application of a torque less than the torsional strength torque specified in Tables 5A and 5B, when tested in accordance with 4.5.

3.3.4 DRIVE TORQUE—Screws shall, without deforming their own thread, form a mating internal thread in a test plate with the application of a torque not exceeding the drive torque specified in Tables 5A and 5B for the applicable screw size and finish, when tested in accordance with 4.6.

3.3.5 TORQUE-TO-CLAMP LOAD—Hex and hex washer head screws, in sizes No. 6 and larger, shall develop the clamp load specified in Tables 5A and 5B with the application of a torque not exceeding the clamp load torque specified in Tables 5A and 5B for the applicable screw size and finish, when tested in accordance with 4.7. Smaller sizes of screws and screws with other head styles are not subject to torque-to-clamp load requirements.

3.3.6 PROOF TORQUE—Hex and hex washer head screws shall withstand without failure the proof torque and shall be capable of being removed from the test plate following application of the proof torque specified in for the applicable screw size and finish, when tested in accordance with 4.7. Screws with other head styles are not subject to proof torque requirements.

3.3.7 DUCTILITY—Heads of screws shall not separate from the shank when a permanent deformation of 7 degrees is induced between the plane of the under head bearing surface and a plane normal to the axis of the screw, when tested in accordance with 4.8.

3.3.8 HYDROGEN EMBRITTLEMENT—Cadmium- and zinc-electroplated screws shall withstand without failure the hydrogen embrittlement torque specified in Tables 5A and 5B for the applicable screw size and finish, when tested in accordance with 4.9.

## *4. Test Methods*

**4.1 Core Hardness—**Core hardness shall be determined at mid-radius of a transverse section through the screw taken at a distance sufficiently behind the point of the screw to be through the full minor diameter.

**4.2 Surface Hardness—**Screws shall have a surface hardness equivalent to 45 HRC minimum. For the purpose of routine testing or a quick check, the surface hardness may be checked by the use of H515N, knoop or pyramid identor. The method selected shall be dependent on the size of the product and testable area. The readings may be taken on the surface with light surface preparation. In the event that a hardness lower than specification is obtained, the Reference Method described below will prevail.

The hardness readings shall be taken 0.002 in below the surface of the screw using a microhardness instrument with a knoop or pyramid identor and a 500-g load. Where the total depth of case is 0.004 in or less, the reading may be taken 0.001 in below the surface of the screw using a 100-g load.

For the purposes of measuring surface hardness and case depth, the readings will be taken on specimens which have been sectioned in a tolerance zone from true center to above center in order to ensure adequate support in the mounting media. When measuring the apparent major diameter on the sectioned metalographic specimen, the apparent major diameter shall be no less than 95% of the minimum major diameter permitted for the size of fastener being tested.

**4.3 Case Depth—**Case depth shall be measured at the midpoint between crest and root on the thread flank. A recommended technique for measuring case depth is given in the Appendix of SAE J78.

4.3.1 REFEREE PROCEDURE—All screws shall meet performance requirements and tests as defined by Section 4. Hardness at the maximum case depth as defined by 3.3.1.3 shall not exceed 42 HRC when read with a microhardness tester using a 500-g load and converting to HRC. This is required to ensure that the total case does not exceed the maximum specified depth.

**4.4 Tensile Strength Test—**Screws shall be assembled in a tensile testing machine with a minimum of six threads exposed, and an axial load applied against the under head bearing surface until screw failure occurs. The speed of testing as determined with a free-running cross head shall not exceed 1 in/min. The grips of the testing machine shall be self-aligning to avoid side thrust on the specimen. The tensile strength of the screw shall be the maximum load in pounds occurring coincident with or prior to screw fracture (that is, screw breakage into two or more parts).

**4.5 Torsional Strength Test—**The sample screw shall be securely clamped by suitable means (Figure 2) such that the threads in the clamped length are not damaged, and that at least two full threads project above the clamping device, and that at least two full threads exclusive of point (2 to 3 1/2 thread pitches) are held within the clamping device. A blind hole may be used in place of a threaded clamping device, provided the hole depths is such as to insure that breakage will occur beyond the point (2 to 3 1/2 thread pitches). By means of a suitably calibrated torque-measuring device, torque shall be applied to the screw until failure of the screw occurs. The torque required to cause failure shall be recorded as the torsional strength torque.

**4.6 Drive Test—**The sample screw shall be driven into the hole in a test plate (see 4.11) until an internal thread of full major diameter is formed completely through the full thickness of the plate or until the screw head comes into contact with the plate, whichever occurs first. Speed of driving shall not exceed 500 rpm. For referee purposes, speed of driving shall not exceed 30 rpm. The maximum torque occurring during the test shall be recorded as the drive torque.



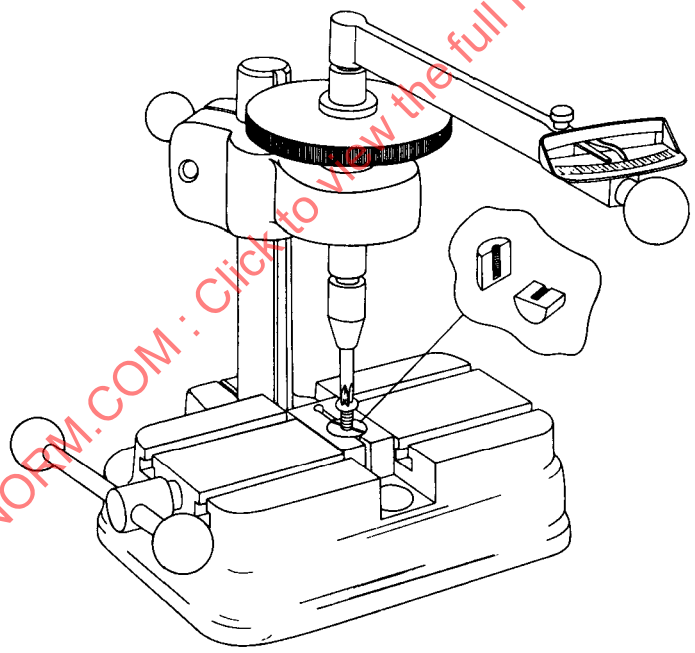

FIGURE 2—TYPICAL TORSIONAL STRENGTH TEST FIXTURE