

# SURFACE VEHICLE STANDARD

Submitted for recognition as an American National Standard

**SAE** J81

REV.  
JUN79

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Superseding J81 JUL72

## THREAD ROLLING SCREWS

- 1. Scope**—This 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 standard 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. Requirements

### 2.1 Material and Process Requirements

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

| Analysis | Composition Limits, % by weight |      |           |      |
|----------|---------------------------------|------|-----------|------|
|          | Carbon                          |      | Manganese |      |
|          | Min                             | Max  | Min       | Max  |
| Ladle    | 0.15                            | 0.25 | 0.70      | 1.65 |
| Check    | 0.13                            | 0.27 | 0.64      | 1.71 |

- 2.1.2 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.

- 2.1.4 TEMPERING TEMPERATURE**—Minimum tempering temperature shall be 650 F.

- 2.1.5 FINISH**—Screws shall be cadmium or zinc plated with a coating thickness of 0.0002-0.0004 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 for a minimum of 1 h within the temperature range 375-450 F as soon as practicable after plating to avoid hydrogen embrittlement. (In batch type processing, a minimum of 4 h is normally required to insure that all parts in the batch receive this treatment.)

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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.

### 2.2 Dimensional Requirements

**2.2.1 HEAD DIMENSIONS**—Head dimensions shall conform to those specified in SAE J478 and ANSI B18.6.4, Slotted and Recessed Head Tapping Screws and Metallic Drive Screws.

**2.2.2 THREAD AND POINT DIMENSIONS**—Thread and point dimensions shall conform to the values shown in Table 1. Threads shall conform to a 60 deg 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 standard.

**TABLE 1—THREAD AND POINT DIMENSIONS OF THREAD ROLLING SCREWS**

| Nominal Screw Size and Threads per Inch <sup>a</sup> | Major Diameter <sup>b</sup> | Point Diameter <sup>b</sup> | Dia of Circum-scribing Circle <sup>c</sup> | Circum-scribing Circle (Point) <sup>c</sup> | Point Length     |                  | Min Practical Nominal Screw Lengths |           |
|------------------------------------------------------|-----------------------------|-----------------------------|--------------------------------------------|---------------------------------------------|------------------|------------------|-------------------------------------|-----------|
|                                                      |                             |                             |                                            |                                             | Max <sup>d</sup> | Min <sup>e</sup> | 90 deg Heads                        | 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       |

<sup>a</sup> Fine thread series screws are also available.

<sup>b</sup> 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.

<sup>c</sup> 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.).

<sup>d</sup> These values are equal to 3.5 times the pitch distance rounded off to three decimal places.

<sup>e</sup> These values are equal to 2 times the pitch distance rounded off to three decimal places.

**2.2.3 THREAD LENGTH**—For screws of nominal lengths equal to or shorter than the nominal lengths tabulated below, 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 Fig. 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 of 1.50 in., whichever is shorter.

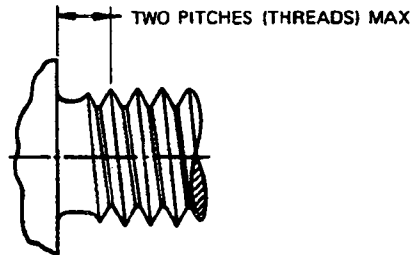


FIG. 1

| Nominal<br>Screw<br>Size | Nominal<br>Screw<br>Length | Full Form<br>Thread<br>Length <sup>a</sup> | Two Pitches<br>Length <sup>b</sup> |
|--------------------------|----------------------------|--------------------------------------------|------------------------------------|
|                          |                            | Min                                        | Coarse<br>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                              |

<sup>a</sup> Tabulated values through No. 10 size are 6 times the basic screw diameter, rounded off to two decimal places.

<sup>b</sup> Values are tabulated for convenient reference.

## 2.3 Mechanical and Performance Requirements

### 2.3.1 HARDNESS

**2.3.1.1 Core Hardness**—Screws shall have a core hardness of Rockwell C28-38, when tested as specified in paragraph 3.1.

**2.3.1.2 Case Hardness**—Screws shall have a case hardness equivalent to Rockwell C45 minimum, when tested as specified in paragraph 3.2.

**2.3.1.3 Case Depth**—Screws shall have a case depth conforming to the following, when tested as specified in paragraph 3.3.

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| Nominal Size   | Case Depth, in |       |
|----------------|----------------|-------|
|                | Min            | Max   |
| No. 2 thru 6   | 0.002          | 0.007 |
| No. 8 and 10   | 0.004          | 0.009 |
| 1/4 and larger | 0.005          | 0.011 |

2.3.2 TENSILE STRENGTH—Hex and hex washer head screws which have nominal lengths equal to or longer than ½ in. or three times the nominal screw diameter, whichever is longer, shall have tensile strengths not less than those specified in Table 2, when tested in accordance with paragraph 3.4. Screws with shorter lengths or screws with other head styles are not subject to tensile testing.

TABLE 2—MECHANICAL AND PERFORMANCE REQUIREMENTS FOR THREAD ROLLING SCREWS

| Nominal<br>Screw<br>Size and<br>Threads<br>per Inch | Tensile<br>Strength,<br>Min<br>lb | Torsional<br>Strength |      | Drive Torque               |              |                  |              | Clamp<br>Load,<br>lb | Clamp Load Torque          |              |                  |              | Proof Torque               |              |                  |       | Hydrogen<br>Embrittlement Torque |       |                  |       |       |
|-----------------------------------------------------|-----------------------------------|-----------------------|------|----------------------------|--------------|------------------|--------------|----------------------|----------------------------|--------------|------------------|--------------|----------------------------|--------------|------------------|-------|----------------------------------|-------|------------------|-------|-------|
|                                                     |                                   |                       |      | For<br>PC and CP<br>Screws |              | For<br>ZP Screws |              |                      | For<br>PC and CP<br>Screws |              | For<br>ZP Screws |              | For<br>PC and CP<br>Screws |              | For<br>ZP Screws |       | For<br>CP Screws                 |       | For<br>ZP Screws |       |       |
|                                                     |                                   |                       |      | Min<br>in-lb               | Min<br>ft-lb | Max<br>in-lb     | Max<br>ft-lb |                      | Max<br>in-lb               | Max<br>ft-lb | Max<br>in-lb     | Max<br>ft-lb | Max<br>in-lb               | Max<br>ft-lb | in-lb            | ft-lb | in-lb                            | ft-lb | in-lb            | ft-lb | in-lb |
|                                                     |                                   |                       |      |                            |              |                  |              |                      |                            |              |                  |              |                            |              |                  |       |                                  |       |                  |       |       |
| No.                                                 | 2-56                              | 500                   | 6    | —                          | 4.5          | —                | 6            | —                    | —                          | —            | —                | —            | 7                          | —            | 8                | —     | 4.5                              | —     | 5                | —     |       |
|                                                     | 3-48                              | 660                   | 10   | —                          | 7.5          | —                | 9.5          | —                    | —                          | —            | —                | —            | 12                         | —            | 13.5             | —     | 7.5                              | —     | 8.5              | —     |       |
|                                                     | 4-40                              | 810                   | 14   | —                          | 9            | —                | 13           | —                    | —                          | —            | —                | —            | 17                         | —            | 19               | —     | 10.5                             | —     | 12               | —     |       |
|                                                     | 5-40                              | 1,100                 | 22   | —                          | 12           | —                | 16           | —                    | —                          | —            | —                | —            | 25                         | —            | 28               | —     | 17                               | —     | 19               | —     |       |
|                                                     | 6-32                              | 1,250                 | 24   | —                          | 14           | —                | 20           | —                    | 460                        | 19           | —                | 25           | —                          | 28           | —                | 33    | —                                | 18    | —                | 20    | —     |
|                                                     | 8-32                              | 1,900                 | 48   | —                          | 25           | —                | 32           | —                    | 700                        | 37           | —                | 48           | —                          | 50           | —                | 57    | —                                | 36    | —                | 41    | —     |
|                                                     | 10-24                             | 2,350                 | 65   | —                          | 35           | —                | 52           | —                    | 900                        | 55           | —                | 68           | —                          | 68           | —                | 77    | —                                | 49    | —                | 55    | —     |
|                                                     | 1/4-20                            | 4,300                 | 156  | 13                         | 90           | 7.5              | 120          | 10                   | 1600                       | 120          | 10               | 144          | 12                         | 162          | 13.5             | 186   | 15.5                             | 114   | 9.5              | 132   | 11    |
|                                                     | 5/16-18                           | 7,100                 | 330  | 27.5                       | 180          | 15               | 240          | 20                   | 2600                       | 252          | 21               | 312          | 26                         | 342          | 28.5             | 372   | 31                               | 252   | 21               | 276   | 23    |
|                                                     | 3/8-16                            | 10,500                | 600  | 50                         | 240          | 20               | 300          | 25                   | 4000                       | 480          | 40               | 612          | 51                         | 636          | 53               | 690   | 57.5                             | 456   | 38               | 510   | 42.5  |
|                                                     | 7/16-14                           | 14,400                | 840  | 70                         | 360          | 30               | 480          | 40                   | 5400                       | 744          | 62               | 900          | 75                         | 888          | 74               | 960   | 80                               | 630   | 52.5             | 720   | 60    |
|                                                     | 1/2-13                            | 19,100                | 1080 | 90                         | 540          | 45               | 660          | 55                   | 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

NOTE: Values shown in Table 2 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.

2.3.3 TORSIONAL STRENGTH—Screws shall not fail with the application of a torque less than the torsional strength torque specified in Table 2, when tested in accordance with paragraph 3.5.

2.3.4 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 Table 2 for the applicable screw size and finish, when tested in accordance with paragraph 3.6.

2.3.5 TORQUE-TO-CLAMP LOAD—Hex and hex washer head screws, in sizes No. 6 and larger, shall develop the clamp load specified in Table 2 with the application of a torque not exceeding the clamp load torque specified in Table 2 for the applicable screw size and finish, when tested in accordance with paragraph 3.7. Smaller sizes of screws and screws with other head styles are not subject to torque-to-clamp load requirements.

- 2.3.6 **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 Table 2 for the applicable screw size and finish, when tested in accordance with paragraph 3.7. Screws with other head styles are not subject to proof torque requirements.
- 2.3.7 **DUCTILITY**—Heads of screws shall not separate from the shank when a permanent deformation of 7 deg 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 paragraph 3.8.
- 2.3.8 **HYDROGEN EMBRITTLEMENT**—Cadmium and zinc electroplated screws shall withstand without failure the hydrogen embrittlement torque specified in Table 2 for the applicable screw size and finish, when tested in accordance with paragraph 3.9.

### 3. Test Methods

- 3.1 **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.
- 3.2 **Case Hardness**—For routine quality control purposes (where case depth and geometry of screws permit), case hardness may be measured on end, shank, or head using Rockwell 15 N. Hardness tests shall be made on plain finish or plated screws after removal of finish. As an alternate, or where this method is not applicable, a microhardness instrument with a Knoop indenter and a 500 g load may be used. In such cases, measurements shall be made on the thread profile of a properly prepared longitudinal metallographic specimen.
- 3.3 **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.
- 3.4 **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).
- 3.5 **Torsional Strength Test**—The sample screw shall be securely clamped by suitable means (Fig. 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 3½ 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 3½ 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.
- 3.6 **Drive Test**—The sample screw shall be driven into the hole in a test plate (paragraph 3.11) 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.

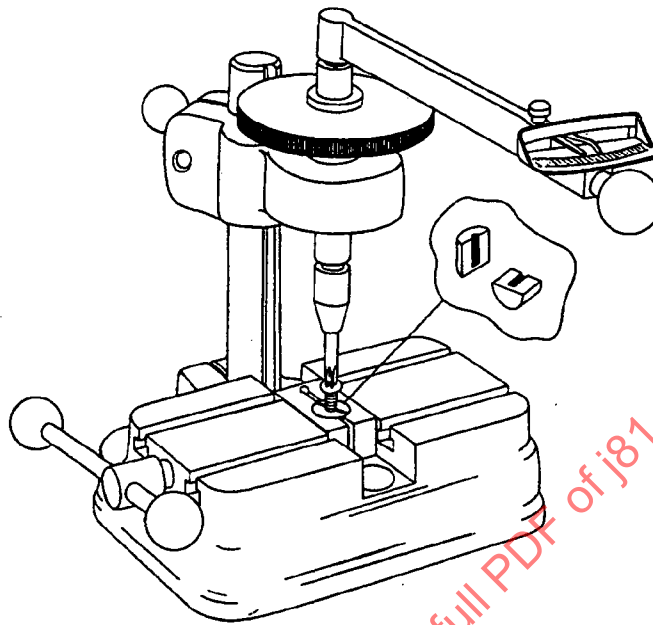


FIG. 2

**3.7 Clamp Load and Proof Torque Test**—The test shall be conducted using a load indicating type washer, or other load measuring device, capable of measuring the actual tension induced in the screw as the screw is tightened. The device shall be accurate within  $\pm 5\%$  of the test clamp load to be induced in the screw.

Place plain washer, or equivalent punched or drilled steel strip (paragraph 3.12), and then load-indicating-type washer (paragraph 3.7) on sample screw and position this assembly for driving into prescribed hole in test plate (paragraph 3.11). Drive the screw into the test plate until the screw is seated and continue tightening until a tensile load equal to the clamp load as specified in Table 2 is developed. Restrain plain washer from turning to prevent damage to load-indicating-type washer. The torque necessary to develop the clamp load shall be recorded as the clamp load torque.

Tightening shall be continued until a torque equal to the proof torque as specified in Table 2 has been applied to the screw. The assembly shall remain in this tightened state for 10 s, following which the screw shall be removed from the test plate by the application of removal torque.

If convenient, the clamp load and proof torque test may be conducted in conjunction with the drive test.

**3.8 Ductility Test**—The sample screw shall be inserted into a hole in a hardened 7 deg wedge block, or other suitable device, and an axial compressive load applied against the top of the screw head. The hole shall be 0.020-0.040 in. larger than the nominal screw diameter. Loading shall be continued until the plane of the under head bearing surface of the protruding-type heads or the plane through the largest diameter of the head of countersunk-type heads is bent permanently through 7 deg with respect to a plane normal to the axis of the screw.

**3.9 Hydrogen Embrittlement Test**—Screws shall be threaded into a tapped hole or free running nut (paragraph 3.12) having thickness of at least 1.5 times the nominal screw size and tightened with a torque equal to the hydrogen embrittlement torque specified in Table 2 for the applicable screw size and finish. Spacers should be used for screws with unthreaded shanks and may be used with other lengths providing full thread engagement is maintained within the test nut or tapped hole. The assembly shall remain in this tightened state for 24 h. The original hydrogen embrittlement torque shall then be reapplied, following which the screw shall be removed by the application of removal torque. Nuts may be hardened to permit reusability.

**3.10 Torque Wrenches**—Torque wrenches used in all tests shall be accurate within  $\pm 2\%$  of the maximum of the specified torque range of the wrench.

Alternatively, a torque sensing power device of equivalent accuracy may be used.

**3.11 Test Plate**—Test plates shall be low carbon cold rolled steel having a hardness of Rockwell B 70-85. Test plate thicknesses and hole sizes are given in Table 3. Test holes shall be drilled or punched and redrilled, or reamed, to  $\pm 0.001$  in. of the hole sizes specified in Table 3.

**TABLE 3—TEST PLATE THICKNESSES AND HOLE SIZES FOR  
DRIVE CLAMP LOAD AND PROOF TORQUE TESTS**

| Nominal Screw<br>Size and<br>Threads<br>per Inch | Thickness,<br>in. |        | Hole<br>Dia,<br>in |
|--------------------------------------------------|-------------------|--------|--------------------|
|                                                  | Max               | Min    |                    |
| No. 2-56                                         | 0.1270            | 0.1230 | 0.075              |
| 3-48                                             | 0.1270            | 0.1230 | 0.087              |
| 4-40                                             | 0.1270            | 0.1230 | 0.098              |
| 5-40                                             | 0.1270            | 0.1230 | 0.110              |
| 6-32                                             | 0.1270            | 0.1230 | 0.120              |
| 8-32                                             | 0.1905            | 0.1845 | 0.147              |
| 10-24                                            | 0.1905            | 0.1845 | 0.166              |
| 1/4-20                                           | 0.2540            | 0.2460 | 0.219              |
| 5/16-18                                          | 0.3175            | 0.3075 | 0.277              |
| 3/8-16                                           | 0.3800            | 0.3700 | 0.339              |
| 7/16-14                                          | 0.4425            | 0.4325 | 0.394              |
| 1/2-13                                           | 0.5050            | 0.4950 | 0.456              |

NOTE: Values shown in Table 3 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.

**3.12 Under Head Bearing Test Surface**—The surface condition of plain commercially available flat washers, free running nuts, and cold rolled steel is normally suitable for tests specified in paragraphs 3.6, 3.7, and 3.9. For referee purposes, however, the surface shall conform to 20-30  $\mu$ in. (AA roughness range).