Metric Thread Rolling Screws—SAE J1237

SAE Standard
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LAND SEA AIR SPACE

PREPRINT

METRIC THREAD ROLLING SCREWS—SAE J1237

SAE Standard

Report of Iron and Steel Technical Committee approved June 1978. Editorial change May 1979.
Note: SAE Standard J81 is available for Thread Rolling Screws dimensioned in the inch system.

1. Scope—This standard covers requirements for metric 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.)

1.1 Requirements for three material-process options are stated:

(a) Screws (in sizes M2 x 0.4 thru M12 x 1.75) manufactured from low carbon steel, carburized, and tempered. These screws are designated SAE J1237 Type 2 •.

(b) Screws (in sizes M2 x 0.4 thru M12 x 1.75) manufactured from medium carbon alloy steel, heat treated to achieve properties comparable to SAE J1199 class 9.8 screws, and additionally, with the point selectively hardened. These screws are designated SAE J1237 Type 9 •.

(c) Screws (in sizes M5 x 0.8 thru M12 x 1.75) manufactured from medium carbon alloy steel, heat treated to achieve properties comparable to SAE J1199 class 10.9 screws, and additionally, with the point selectively hardened. These screws are designated SAE J1237 Type 10 •.

1.2 When SAE J1237 is specified without Type designation, either Type 2 • or Type 9 • may be supplied.

NOTE: The performance requirements covered in this standard apply only to the combination of laboratory conditions decribed 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—Type 2 •

2.1.1 MATERIAL AND CHEMISTRY—Type 2 • screws shall be made from cold heading quality, killed steel wire conforming to the following chemical composition requirements:

Analysis	Composition Limits[a], % by Mass			
	Carbon		Manganese	
	Min	Max	Min	Max
Cast or Heat	0.15	0.25	0.70	1.65
Product	0.13	0.27	0.64	1.71

[a]Boron permitted in the range of 0.0005–0.003

2.1.2 HEAT TREATMENT—Type 2 • screws shall be heat treated in a continuous carbonitriding or 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.

2.1.3 TEMPERING TEMPERATURES—Minimum tempering temperatures shall be 340°C.

2.2 Material and Process Requirements—Types 9 • and 10 •

2.2.1 MATERIAL AND CHEMISTRY—Unless otherwise specified by purchaser, Type 9 • and 10 • screws shall be made from cold heading quality, killed alloy steel wire conforming to the following chemical composition requirements (SAE 4037):

	Cast or Heat Analysis	Product Analysis
	% by Mass	
Carbon	0.35–0.40	0.33–0.42
Manganese	0.70–0.90	0.67–0.93
Phosphorus	0.035 max	0.040 max
Sulfur	0.040 max	0.045 max
Silicon	0.15–0.30	0.13–0.32
Molybdenum	0.20–0.30	0.18–0.32

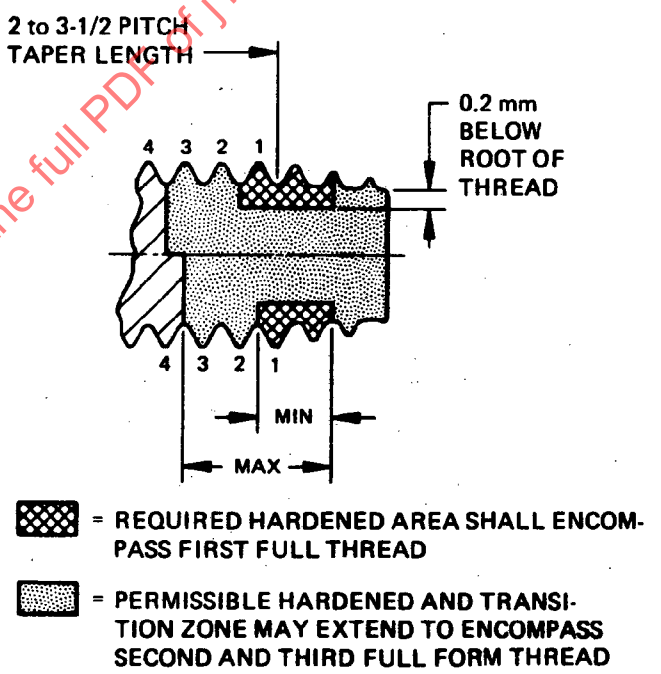
2.2.2 HEAT TREATMENT—Type 9 • and 10 • screws shall be heat treated in a continuous non-carburizing system operated under fine grain practice, oil quenched, and tempered at a minimum tempering temperature of 460°C for Type 9 • and 425°C for Type 10 •.

2.2.3 Lead threads on Types 9 • and 10 • shall be induction hardened to achieve a minimum hardness equivalent to 45 RC (Rockwell C45) on 1 to 3 full threads and one or more lead threads, as shown in Fig. 1. (File test according to SAE J864.)

2.3 Finish—Screws shall be cadmium or zinc electroplated with a coating thickness of 5–10 μm, or have a zinc phosphate and oil coating as specified by the purchaser. Unless otherwise specified, screws may be provided with an additional supplementary lubricant as necessary to meet the performance requirements. Other finishes are available, however, it is the intent of this standard that the mechanical and performance requirements shall apply only to those screws having one of the three finishes specified above. When other finishes are required, the purchaser and manufacturer may agree on performance values other than those of Section 2.7.

Electroplated screws shall be baked within the temperature range 190–230°C as soon as practicable after plating to avoid hydrogen embrittlement. In continuous type processing, a minimum of 1 h is required. In batch type processing, a minimum of 4 h is normally required to insure that all parts in the batch receive this treatment.

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.



NOTE TO USER—When selecting length of Type 9 • and 10 • screws for any application, one objective should be location of the induction hardened zone beyond the nut anchorage, or a minimum of six full form threads in the threaded hole.

FIG. 1

2.4 Dimensional Requirements

2.4.1 HEAD DIMENSIONS—Standard head styles for thread rolling screws are flat countersunk, oval countersunk, pan, hex, hex washer, and hex flange head. Flat countersunk, oval countersunk, and pan head screws are available slotted or with Type 1 or Type 1A cross recess drives. Head, slot, and cross recess dimensions shall be specified by purchaser.

2.4.2 THREAD AND POINT DIMENSIONS—Thread and point dimensions shall conform to those given in Table 2. Threads shall conform to a 60 deg basic thread form. Threads are not subject to thread gaging. Details of point configuration shall be optional with the manufacturer providing all specified dimensions are maintained and screws meet the performance requirements of this standard.

TABLE 1

Nominal Screw Size and Thread Pitch	L_T Full Form Thread Length		Y Unthreaded Length Under Head				
	For Nominal Screw Lengths >Than	Min (1)	For Nominal Screw Lengths ≤Than	Max (2)	For Nominal Screw Lengths >Than	For Nominal Screw Lengths ≤Than	Max (3)
M2 × 0.4	16	12.0	6	0.40	6	16	0.8
M2.5 × 0.45	20	15.0	8	0.45	8	20	0.9
M3 × 0.5	25	18.0	9	0.50	9	25	1.0
M3.5 × 0.6	30	21.0	10	0.60	10	30	1.2
M4 × 0.7	35	24.0	12	0.70	12	35	1.4
M5 × 0.8	40	30.0	15	0.80	15	40	1.6
M6 × 1	45	38.0	18	1.00	18	45	2.0
M8 × 1.25	45	38.0	24	1.25	24	45	2.5
M10 × 1.5	45	38.0	30	1.50	30	45	3.0
M12 × 1.75	50	38.0	36	1.75	36	50	3.5

NOTES: 1. Tabulated values thru 5 mm size are equal to 6 times basic screw diameter rounded to nearest millimetre.
2. Tabulated values are equal to 1 times thread pitch.
3. Tabulated values are equal to 2 times thread pitch.
4. All dimensions are millimetres.

TABLE 2—THREAD AND POINT DIMENSIONS OF THREAD ROLLING SCREWS

Nominal Screw and Thread Pitch		P	C	Cp		L	
	Major Dia (1)	Point Dia (1)	Dia of Circumscribing Circle (2)	Circumscribing Circle (Point) (2)	Point Length	Min Practical Nominal Screw Length	
	Max	Max	Max	Max	Max (3) / Min (4)	Pan, Hex, Hex Washer Heads	Flat and Oval Ctsk Heads
M2 × 0.4	2.00	1.6	—	—	1.4 / 0.8	4	5
M2.5 × 0.45	2.50	2.1	2.57	2.13	1.6 / 0.9	4	6
M3 × 0.5	3.00	2.5	3.07	2.58	1.8 / 1.0	5	8
M3.5 × 0.6	3.50	2.9	3.58	2.99	2.1 / 1.2	6	8
M4 × 0.7	4.00	3.4	4.08	3.40	2.4 / 1.4	8	10
M5 × 0.8	5.00	4.4	5.09	4.31	2.8 / 1.6	8	10
M6 × 1	6.00	5.3	6.10	5.12	3.5 / 2.0	10	12
M8 × 1.25	8.00	7.1	8.13	6.92	4.4 / 2.5	10	16
M10 × 1.5	10.00	9.0	10.15	8.69	5.2 / 3.0	13	16
M12 × 1.75	12.00	10.5	12.18	10.48	6.1 / 3.5	16	20

NOTES: 1. These dimensions are applicable to types of screws where periphery of the thread approximates a circle.
2. These dimensions are applicable to types of screws where some portions of the periphery of the thread are farther from the screw axis than others (lobular, triroundular, etc.).
3. These values are equal to 3.5 times the pitch distance rounded off to 1 decimal place.
4. These values are equal to 2 times the pitch distance rounded off to 1 decimal place.
5. All dimensions are millimetres.

2.4.3 THREAD LENGTH—For screws of nominal lengths within the ranges listed under column Y of Table 1, the full form threads shall extend close to the head such that the specified thread major diameter limits are maintained to within the respective Y distance from the underside of the head, or closer if practicable. See Fig. 2. Screws of longer nominal lengths, unless otherwise specified by the purchaser, shall have a minimum length of full form thread as specified in column L_T.

2.5 Mechanical Requirements—Type 2 • Screws

2.5.1 HARDNESS

2.5.1.1 *Core Hardness*—Type 2 • screws shall have a core hardness of 28–38 RC (Rockwell C) when tested as specified in Section 3.1. Core hardness shall not exceed maximum shown and preferably should be no higher than 36 RC (Rockwell C) on electroplated parts.

2.5.1.2 *Case Hardness*—Type 2 • screws shall have a case hardness of 45 RC (Rockwell C), minimum, when tested as specified in Section 3.2.

2.5.1.3 *Case Depth*—Type 2 • screws shall have a total case depth conforming to the following, when tested as specified in Section 3.3.

Nominal Size	Case Depth, mm	
	Min	Max
2 thru 3.5	0.05	0.18
4 and 5	0.10	0.23
6 thru 12	0.13	0.28

2.5.2 TENSILE STRENGTH—Type 2 • screws with hex head, hex washer head, and hex flange head, which have lengths equal to or longer than 12 mm or 3 times the nominal screw diameter, whichever is longer, shall have tensile strengths not less than those specified in Table 3, when tested in accordance with Section 3.4. Screws with shorter lengths or screws with other head styles which are weaker than the threaded section are not subject to tensile testing.

2.5.3 TORSIONAL STRENGTH—Type 2 • screws shall not fail with the application of a torque less than the torsional strength torque specified in Table 3 when tested in accordance with Section 3.5.

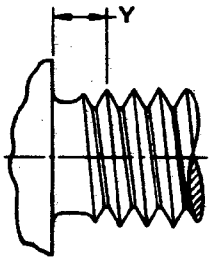


FIG. 2

2.5.4 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 Section 3.8.

2.6 Mechanical Requirements—Type 9 • and 10 • Screws

2.6.1 Type 9 • and 10 • screws shall conform to the mechanical requirements specified in Table 4 when tested according to wedge tensile and hardness procedures published in SAE J1216, Test Methods for Metric Threaded Fasteners.

2.6.2 Type 9 • and 10 • screws shall conform to Class 3/4H decarburization limits as described in SAE J121.

2.6.3 DUCTILITY—Heads of screws shall not separate from the shank when a permanent deformation of 10 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 Section 3.8.

2.7 Performance Requirements—Types 2 •, 9 •, and 10 •

2.7.1 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 6 for the applicable screw size and finish, when tested in accordance with Section 3.6.

2.7.2 TORQUE-TO-CLAMP LOAD—Screws subject to tensile test, M4 x 0.7 size and larger, shall develop the clamp load specified in Table 6 with the application of a torque not exceeding the clamp load torque specified in Table 6 for the applicable screw size and finish, when tested in accordance with Section 3.7. Smaller sizes of screws and screws not subject to tensile test are not subject to torque-to-clamp load requirements.

2.7.3 PROOF TORQUE—Screws with head styles subject to tensile test 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 6 for the applicable screw size and finish, when tested in accordance with Section 3.7. Screws not subject to tensile test are not subject to proof torque requirements.

2.7.4 HYDROGEN EMBRITTLEMENT—Cadmium and zinc electroplated screws shall withstand without failure the hydrogen embrittlement torque specified in Table 6 for the applicable screw size and finish, when tested in accordance with Section 3.9.

TABLE 3—MECHANICAL REQUIREMENTS FOR TYPE 2 • THREAD ROLLING SCREWS

Basic Dia and Thread Pitch (millimetres)	Min Tensile Strength kN	Min Torsional Strength N·m
M2 x 0.4	1.9	0.7
M2.5 x 0.45	3.15	1.2
M3 x 0.5	4.68	2.2
M3.5 x 0.6	6.3	3.5
M4 x 0.7	8.17	5.2
M5 x 0.8	13.2	10.5
M6 x 1	18.7	17.7
M8 x 1.25	34.0	43.0
M10 x 1.5	53.9	87.0
M12 x 1.75	78.4	152.0

TABLE 5—TENSILE STRENGTH VALUES—TYPE 9 • AND 10 • SCREWS

Nominal Thread Dia and Thread Pitch	Type 9 • Min Tensile Strength kN	Type 10 • Min Tensile Strength kN
M2 x 0.4	1.86	
M2.5 x 0.45	3.05	
M3 x 0.5	4.53	
M3.5 x 0.6	6.10	
M4 x 0.7	7.90	
M5 x 0.8	12.8	14.8
M6 x 1	18.1	20.9
M8 x 1.25	32.9	38.1
M10 x 1.5	52.2	60.3
M12 x 1.75	75.9	87.7

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 or DPH 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. Due to normal hardness gradients in a case structure, microhardness values shall be taken at the center of the total case.

3.3 Case Depth—Total case depth shall be measured at the midpoint between crest and root on the thread flank. A recommended technique for measuring total case by microscopic methods is given in SAE J423.

NOTE: An effective case depth of Rockwell C45 equivalent as measured by microhardness methods is normally less than the total case depth measured by microscopic methods. The purchaser and supplier may agree on effective case depth values.

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 25 mm/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 Newtons occurring coincident with or prior to screw fracture (such as, screw breakage into two or more parts).

TABLE 4—MECHANICAL REQUIREMENTS TYPE 9 • AND 10 • SCREWS

Type	Wedge Tensile Strength (Stress) MPa (1) (2)	Surface Hardness Rockwell 15N, max	Product Hardness Rockwell (3)
9•	900 min	(4)	C27–36
10•	1040 min	(4)	C33–39

NOTES:
1. Wedge tensile strength values for full size products are specified in Table 5. Wedge tensile strengths are applicable only to screws which have lengths equal to or longer than 12 mm or 3 times the nominal diameter, whichever is longer. Screws with shorter lengths or screws with head styles which are weaker than the threaded section are not subject to wedge tensile testing.
2. Tensile wedge angles: 6 deg when screws are threaded one diameter or closer to the head; 10 deg on all others.
3. Minimum product hardness values applicable to screws not subject to tensile tests, and these hardness requirements exclude induction hardened zone Section 2.2.3 (Fig. 1).
4. Surface hardness shall not exceed product hardness by more than 3 points Rockwell C equivalent, and in the case of Type 10 • shall also not exceed Rockwell 15N 80, except as noted in Section 2.2.3 (Fig. 1).

TABLE 6—PERFORMANCE REQUIREMENTS—TYPES 2 •, 9 •, AND 10 •

Basic Dia And Thread Pitch (millimetres)	Test Plate		Drive Torque			Clamp Load Torque		Proof Torque		Hydrogen Embrittlement Torque	
	Thickness	Pilot Hole Dia	For ZPC and CP Screws	For ZP Screws	Clamp Load	For ZPC and CP Screws	For ZP Screws	For ZPC and CP Screws	For ZP Screws	For CP Screws	For ZP Screws
	mm	mm	max N·m	max N·m	kN	max N·m	max N·m	N·m	N·m	N·m	N·m
M2 x 0.4	3	1.77	0.4	0.6				0.6	0.7	0.4	0.5
M2.5 x 0.45	3	2.25	0.8	1.0				1.3	1.4	0.9	1.0
M3 x 0.5	3	2.7	1.3	1.7				2.4	2.5	1.7	1.9
M3.5 x 0.6	3	3.15	1.9	2.4				3.7	4.0	2.6	3.0
M4 x 0.7	5	3.6	2.6	3.4	3.1	4.2	4.8	5.4	5.8	3.8	4.4
M5 x 0.8	5	4.55	4.8	6.0	5.0	8.0	10.0	11.0	12.0	7.8	9.0
M6 x 1	6	5.4	7.5	9.2	6.9	15.0	16.0	19.0	20.0	13.0	15.0
M8 x 1.25	8	7.3	16.0	20.0	12.6	34.0	40.0	46.0	48.0	32.0	36.0
M10 x 1.5	10	9.2	28.0	35.0	20.0	68.0	81.0	92.0	96.0	65.0	74.0
M12 x 1.75	12	11.0	46.0	55.0	29.5	110.0	130.0	160.0	170.0	110.0	130.0

Legend: CP—Cadmium Electroplated
ZP—Zinc Electroplated
ZPC—Zinc Phosphate Coated—(Commonly known as Phosphate and oil)

NOTE: Values shown in Table 6 are intended for specification purposes and for determination of acceptability of screws to the requirements of this standard. 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.

3.5 Torsional Strength Test—The sample screw shall be securely clamped by suitable means (Fig. 3) 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 (2–3.5 thread pitches), are held within the clamping device. A blind hole may be used in place of a threaded clamping device, provided the hole depth is such as to insure that breakage will occur beyond the point (2–3.5 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

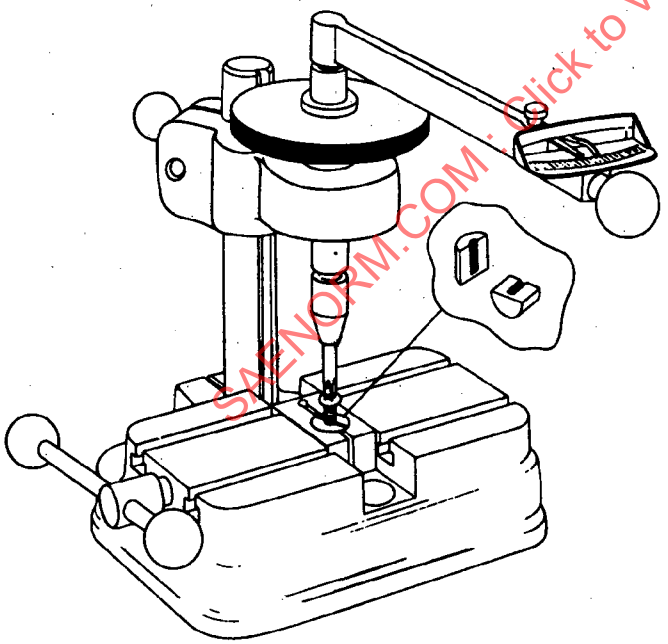


FIG. 3

plate (Section 3.6.1) 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.

3.6.1 TEST PLATE—Test plates shall be low carbon cold rolled steel having a hardness of Rockwell B75-90. Test plate thicknesses and hole sizes are given in Table 6. Test holes shall be drilled or punched and redrilled, or reamed, to ±0.025 mm of the hole sizes specified in Table 6.

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 ±5% of the test clamp load to be induced in the screw.

Assemble a plain washer, or equivalent punched or drilled steel strip as specified in Section 3.7.1, and then the load-indicating type washer on the sample screw and position this assembly for driving into the test plate (Section 3.6.1). The screw shall be driven into the test plate until the screw is seated. Tightening shall be continued until a tensile load equal to the clamp load as specified in Table 6 is developed. Care shall be taken to prevent the under head bearing surface from turning during tightening. 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 6 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.

3.7.1 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 Sections 3.6, 3.7, and 3.9. For referee purposes, the surface shall conform to 0.50–0.75 μm (AA roughness range).

3.8 Ductility Test—The sample screw shall be inserted into a drilled hole in a hardened wedge block, or other suitable device, and an axial compressive load applied against the top of the screw head. The hole shall be 0.50–1.00 mm larger than the nominal screw diameter. Loading shall be continued until the plane of the under head bearing surface is bent permanently through the angle specified for the screw type 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 having thicknesses of at least 1.5 times the nominal screw size and tightened with a torque equal to the hydrogen embrittlement torque specified in Table 6 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 ±2% of the maximum of the specified torque range of the wrench.

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