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SURFACE VEHICLE STANDARD

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(R) STEEL SELF-DRILLING TAPPING SCREWS

1. Scope

1.1 General—This SAE Standard covers the dimensional and general specifications, including performance requirements, for carbon steel self-drilling tapping screws suitable for use in general applications.

It is the objective of this document to insure that carbon steel self-drilling tapping screws, by meeting the mechanical and performance requirements specified, shall drill a hole and form or cut mating threads in materials into which they are driven without deforming their own thread and without breaking during assembly.

Appendix A is included to provide a recommended technique for measuring the case depth on the screws.

1.2 Screw Types and Application—The two types of self-drilling tapping screws covered by this document are designated and described as follows:

1.2.1 TYPE BSD—Type BSD screws shall have spaced threads with drill points of varying configuration, designated Style 2 and Style 3, designed to accommodate different panel thickness conditions as delineated in Section 6.

1.2.2 TYPE CSD—Type CSD screws shall have threads of machine screw diameter-pitch combinations approximating Unified Form with drill points of varying configuration, designated Style 2 and Style 3, designed to accommodate different panel thickness conditions as delineated in Section 6. Type CSD screws are not subject to thread gaging but shall meet dimensions specified in this standard. They are intended for application where the use of a machine screw pitch thread is preferred over the spaced thread.

1.3 Head Types—The head types applicable to self-drilling tapping screws covered by this standard shall include those specified in ANSI B18.6.4, except for slotted head and hex (nonwasher) head designs which are not recommended for self-drilling screws.

2. References

2.1 Applicable Documents—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

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

SAE J423—Methods of Measuring Case Depth

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 Topping Screws and Metallic Drive Screws

ANSI B18.22.1—Plain Washers

3. Dimensional Requirements

3.1 General Dimensions—Dimensions and general specifications applicable to heads, body, and screw length for Type BSD and Type CSD screws shall conform to those specified for Type B and Type C tapping screws, respectively, as specified in SAE J478 or ANSI B18.6.4, except as specified in 3.2 to 3.4.

3.2 Heads—The underside on all noncountersunk styles of heads on milled point self-drilling screws may be chamfered at the periphery of head in accordance with the dimensions specified in Figure 1 and Table 1.

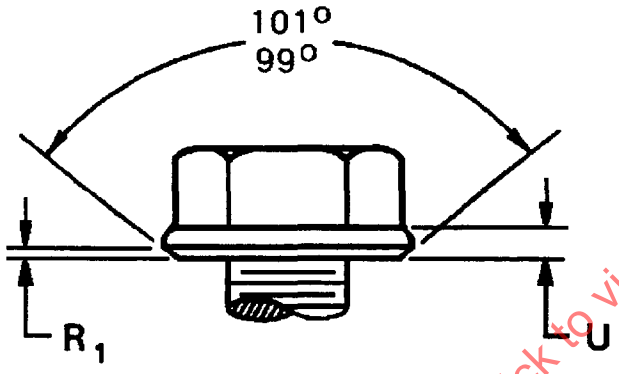

FIGURE 1A—HEX WASHER HEAD

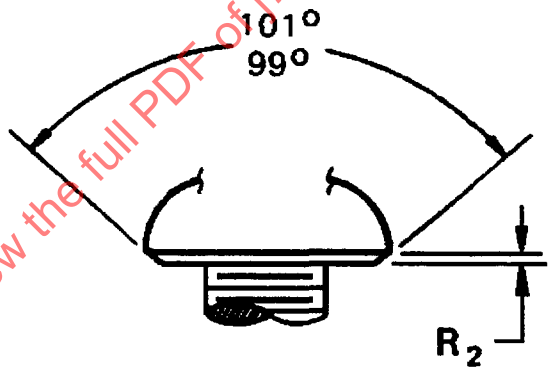

FIGURE 1B—RECESSED HEADS

FIGURE 1—HEAD CHAMFERS ON MILLED POINT SCREWS

TABLE 1—HEAD CHAMFER DIMENSIONS FOR MILLED POINT SELF-DRILLING TAPPING SCREWS, IN (FIGURE 1)

Nominal Screw Size	U Washer Thickness Max	U Washer Thickness Min	R_1 Chamfer Height Hex Washer Heads Ref	R_2 Chamfer Height Recessed Heads Ref
4	0.030	0.020	0.015	0.015
6	0.040	0.025	0.015	0.015
8	0.050	0.035	0.020	0.015
10	0.050	0.035	0.020	0.020
12	0.050	0.035	0.020	0.020
1/4	0.060	0.040	0.025	0.020

3.3 Eccentricity—Eccentricity is defined as one-half of the full or total indicator reading.

3.3.1 ECCENTRICITY OF HEX AND HEX WASHER HEADS—Hex and hex washer heads shall not be eccentric with the axis of screw by an amount equal to more than 4% of the basic screw diameter.

3.3.2 ECCENTRICITY OF RECESS—The recess in recessed head screws shall not be eccentric with the axis of screw by an amount equal to more than 4% of the basic screw diameter.

3.4 Length of Thread

3.4.1 TYPE BSD SCREWS—For screws of nominal lengths equal to or shorter than 1.50 in, the full form threads shall extend close to the head such that the specified minor diameter limits are maintained to within one pitch (thread), or closer if practicable, of the underside of the head. See Figure 2. For screws of nominal lengths longer than 1.50 in, the length of full form thread shall be as specified by the purchaser.

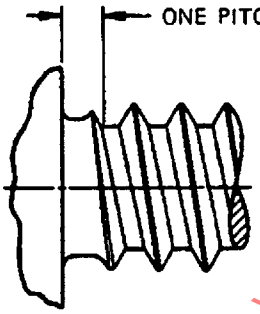

FIGURE 2—TYPE BSD THREAD FORM

3.4.2 TYPE CSD SCREWS—For screws of nominal lengths equal to or shorter than 1.50 in, the full form threads shall extend close to the head such that the specified major diameter limits are maintained to within two pitches (threads), or closer if practicable, of the underside of the head. See Figure 3. For screws of nominal lengths longer than 1.50 in, the length of full form thread shall be as specified by the purchaser.

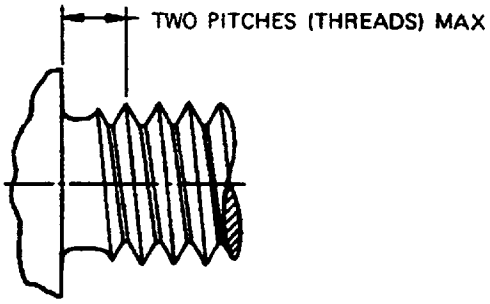

FIGURE 3—TYPE CSD THREAD FORM

3.5 Threads and Points—The threads and points applicable to screws covered by this document are generally described under 1.2. They shall conform to the dimensions specified in Table 2.

TABLE 2—DIMENSIONS OF THREADS AND POINTS FOR TYPES BSD AND CSD SELF-DRILLING TAPPING SCREWS (FIGURE 4)

Nominal Size[2] or Basic Screw Diameter	Type BSD Threads Per Inch	Type BSD D Major Diameter Max	Type BSD D Major Diameter Min	Type BSD d Minor Diameter Max	Type BSD d Minor Diameter Min	Type BSD Z[3] Protrusion Allowance (Ref) Style 2 Point	Type BSD Z[3] Protrusion Allowance (Ref) Style 3 Point	Type CSD Threads Per Inch	Type CSD D Major Diameter Max	Type CSD D Major Diameter Min	Type CSD Z[3] Protrusion Allowance (Ref) Style 2 Point	Type CSD Z[3] Protrusion Allowance (Ref) Style 3 Point
4 0.1120	24	0.114	0.110	0.086	0.082	0.163	—	40	0.1120	0.1072	0.130	—
6 0.1380	20	0.139	0.135	0.104	0.099	0.190	0.220	32	0.1380	0.1326	0.152	0.172
8 0.1640	18	0.166	0.161	0.122	0.116	0.211	0.251	32	0.1640	0.1586	0.162	0.202
10 0.1900	16	0.189	0.183	0.141	0.135	0.235	0.300	24	0.1900	0.1834	0.193	0.258
12 0.2160	14	0.215	0.209	0.164	0.157	0.283	0.353	24	0.2160	0.2094	0.223	0.293
1/4 0.2500	14	0.246	0.240	0.192	0.185	0.318	0.393	20	0.2500	0.2428	0.275	0.350

TABLE 2—DIMENSIONS OF THREADS AND POINTS FOR TYPES BSD AND CSD SELF-DRILLING TAPPING SCREWS (FIGURE 4) (CONTINUED)

Nominal Size[2] or Basic Screw Diameter	Types BSD and CSD L Minimum Practical Nominal Screw Lengths (Ref) Style 2 Points Formed 90 deg Heads	Types BSD and CSD L Minimum Practical Nominal Screw Lengths (Ref) Style 2 Points Formed Csk Heads	Types BSD and CSD L Minimum Practical Nominal Screw Lengths (Ref) Style 2 Points Milled 90 deg Heads	Types BSD and CSD L Minimum Practical Nominal Screw Lengths (Ref) Style 2 Points Milled Csk Heads	Types BSD and CSD L Minimum Practical Nominal Screw Lengths (Ref) Style 3 Points Formed 90 deg Heads	Types BSD and CSD L Minimum Practical Nominal Screw Lengths (Ref) Style 3 Points Milled Csk Heads	Types BSD and CSD L Minimum Practical Nominal Screw Lengths (Ref) Style 3 Points Formed 90 deg Heads	Types BSD and CSD L Minimum Practical Nominal Screw Lengths (Ref) Style 3 Points Milled Csk Heads
4 0.1120	5/16	3/8	3/8	7/16	—	—	—	—
6 0.1380	5/16	3/8	3/8	7/16	3/8	7/16	7/16	1/2
8 0.1640	3/8	7/16	7/16	1/2	7/16	1/2	1/2	9/16
10 0.1900	7/16	1/2	15/32	19/32	1/2	9/16	9/16	21/32
12 0.2160	1/2	5/8	17/32	21/32	1/2	5/8	21/32	25/32
1/4 0.2500	1/2	5/8	17/32	11/16	1/2	5/8	11/16	27/32

1 Drill portion of points may be milled and/or cold formed and details of point taper and flute design shall be optional with the manufacturer, provided the screws meet the performance requirements specified in this standard and are capable of drilling the maximum panel thicknesses shown in Table 5 prior to thread pickup.

2 Where specifying nominal size in decimals, zeros preceding decimal and in fourth decimal place shall be omitted.

3 Protrusion allowance Z is the distance, measured parallel to the axis of screw, from the extreme end of the point to the first full form thread beyond the point and encompasses the length of drill point and the tapered incomplete threads. It is intended for use in calculating the maximum effective design grip length Y on the screw in accordance with the following:

$$Y = L\ min - z$$

4. *Material and Process Requirements*

4.1 Material and Chemistry—Screws shall be made from cold heading quality, killed steel wire conforming to the chemical composition in Table 3:

TABLE 3—CHEMICAL COMPOSITION—COMPOSITION LIMITS, % BY WEIGHT

Analysis[1]	Carbon Max	Carbon Min	Manganese Max	Manganese Min
Ladle	0.25	0.15	1.65	0.70
Check	0.27	0.13	1.71	0.64

[1] Ladle analyses are shown for informational purposes. Check analyses are mandatory and refer to individual determinations on uncarburized or core portions of screws.

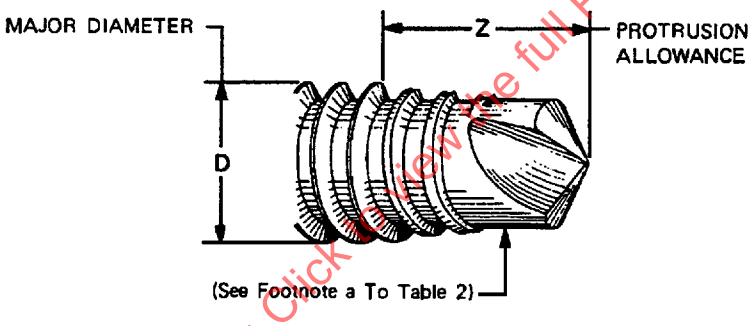

FIGURE 4—TYPICAL SELF-DRILLING TAPPING SCREW POINT

4.2 Heat Treatment—Screws shall be heat treated in a 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.

4.2.1 TEMPERING TEMPERATURE—Minimum tempering temperature shall be 330 °C (625 °F).

When cyaniding systems are approved, the minimum tempering temperature shall be 232 °C (450 °F).

4.2.2 TOTAL CASE DEPTH—Screws shall have a total case depth conforming to the tabulation in Table 4:

TABLE 4—TOTAL CASE DEPTH

Nominal Screw Size	Total Case Depth, in Max	Total Case Depth, in Min
4 and 6	0.007	0.002
8 through 12	0.009	0.004
1/4	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. 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 can no longer be distinguished (see SAE J423) or when the microhardness converted to HRC is 42.

4.2.3 SURFACE HARDNESS—Screws shall have a surface hardness equivalent to 50 to 56 HRC. For the purpose of the routine testing or a quick check, the surface hardness may be checked by the use of HR15N, 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 Referee Method described as follows will prevail.

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

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 metallographic specimen, the apparent major diameter shall be no less than 95% of the minimum major diameter permitted for the size of fastener being tested.

4.2.4 CORE HARDNESS—Screws shall have a core hardness equivalent to Rockwell C 32-40 when measured 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.

4.3 Ductility—Heads of screws shall not separate completely from the shank when a permanent deformation of 5 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 4.3.1.

4.3.1 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 (or impact) load applied against the top of the screw head. Loading shall be continued until the plane of the under head bearing surface is bent permanently through 5 degrees with respect to a plane normal to the axis of the screw.

4.4 Finish—Unless otherwise specified, screws shall be supplied with a natural (as processed) finish, unplated or uncoated. Where corrosion preventive or decorative finishes are required, screws shall be plated or coated as specified by the user. However, where steel screws are plated or coated and subject to hydrogen embrittlement, they shall be suitably treated subsequent to the plating or coating operation to obviate such embrittlement. Cadmium or zinc electroplated screws shall be subjected to the hydrogen embrittlement test in 4.4.1.

4.4.1 HYDROGEN EMBRITTLEMENT TEST—Cadmium and zinc electroplated screws shall drill their own hole and form a thread in a steel test plate with a thickness equal to the maximum specified for the applicable screw type and size in Section 6. The head of the screw shall be seated against one or more ANSI B18.22.1 Standard Type B Plain Washers, Narrow Series (size corresponding to screw size and minimum stack thickness corresponding to maximum unthreaded length under the head), or an equivalent spacer, and tightened with a torque equal to the hydrogen embrittlement torque specified in Table 5. 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. There shall be no evidence of failure of the screws.

4.4.2 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 screws to meet mechanical or performance requirements due to plating or coating. In such cases, additional screws from the same lot shall be stripped of plating or coating, baked, lubricated with machine oil, and retested in the natural finish.

5. Performance Requirements and Tests

5.1 Torsional Strength—Screws shall not fail with the application of a torque less than the torsional strength torque specified in Table 5, when tested in accordance with 5.1.1.

TABLE 5—MECHANICAL AND PERFORMANCE REQUIREMENTS FOR TYPES BSD AND CSD SELF-DRILLING TAPPING SCREWS

Nominal Screw Size	Minimum Torsional Strength, lb-in Type BSD	Minimum Torsional Strength, lb-in Type CSD	Hydrogen Embrittlement Test Torque, lb-in Cadmium Plated Screws Types BSD and CSD	Hydrogen Embrittlement Test Torque, lb-in Zinc Plated Screws Types BSD and CSD
4	14	14	10.5	12
6	24	24	18	20
8	42	48	36	41
10	61	65	49	55
12	92	100	72	85
1/4	150	156	114	132

5.1.1 TORSIONAL STRENGTH TEST—The sample screw shall be securely clamped by suitable means (Figure 5) 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, flutes, or thread cutting slot, are held within the clamping device. 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.

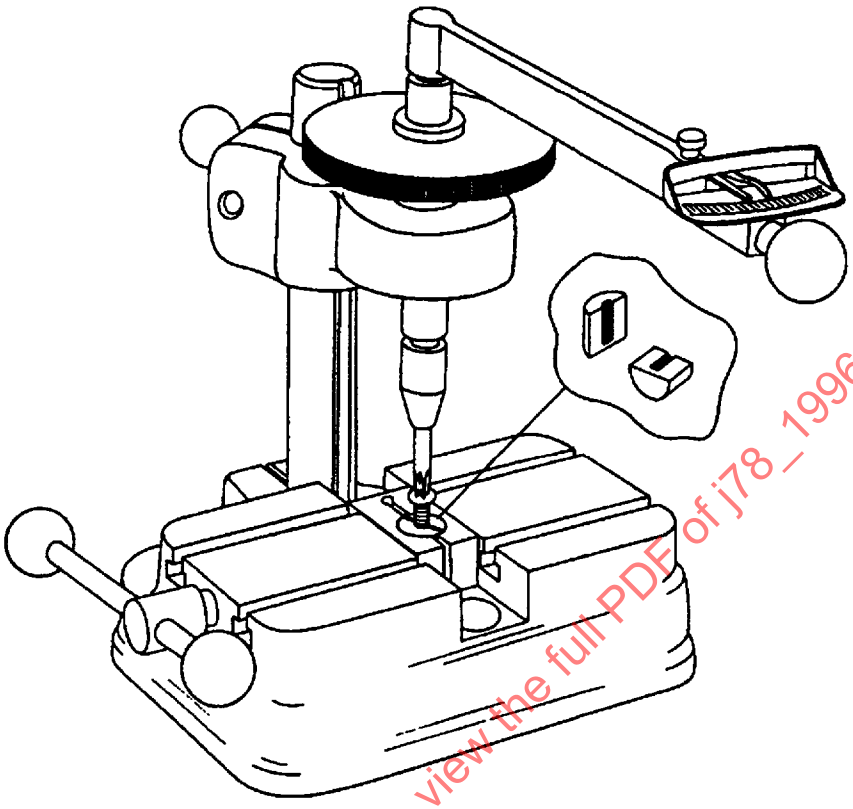

FIGURE 5—TYPICAL TORSIONAL STRENGTH TEST FIXTURE

5.2 Drill-Drive Test—Sample screws shall be selected at random from the lot and shall be used to drill holes and form or cut mating threads in a test plate. The time in seconds for the screw to drill and thread a hole completely through the test plate shall be recorded. The test plate material and thickness, and load applied against the screw during drilling and threading, and the other test conditions are specified in Table 6. Each screw shall be used to drill and thread only one hole. A typical drill drive test fixture is depicted in Figure 6.

TABLE 6—DRILL-DRIVE TEST CONDITIONS AND REQUIREMENTS FOR TYPES BSD AND CSD SELF-DRILLING TAPPING SCREWS

Nominal Screw Size	Test Plate Thickness,[1] in Max	Test Plate Thickness,[1] in Min	Axial Loading,[2] lb A Max	Axial Loading,[2] lb B Max	Axial Loading,[2] lb C Max	Time to Drill and Form Thread,[3] s Max
4	0.068	0.062	25	30	40	2.0
6	0.068	0.062	30	35	45	2.5
8	0.068	0.062	30	35	45	3.0
10	0.068	0.062	35	40	50	3.5
12	0.068	0.062	45	50	60	4.0
1/4	0.068	0.062	45	50	60	5.0

1 Test plates shall be low carbon, cold rolled steel having a hardness of Rockwell B60-85.

2 Axial loads are varied to offset the detrimental effects on drilling capability created by finishes applied to screws in accordance with the following:

Column A—Axial loads tabulated shall apply to plain, oiled, and commercial phosphate coating and cadmium and zinc platings up to 0.0003 in thickness.

Column B—Axial loads tabulated shall apply special electroplated finishes exceeding 0.0003 in thickness and to special coatings, such as thread sealing hot melts, etc.

Column C—Axial loads tabulated shall apply to chromium finish.

3 Tool speed shall be 2500 rpm for screw sizes No. 4 through No. 10. Tool speed of 1800 rpm is recommended for screw sizes No. 12 and 1/4; however, 2500 rpm may be used provided care is exercised to minimize influence of high heat buildup due to surface speed.

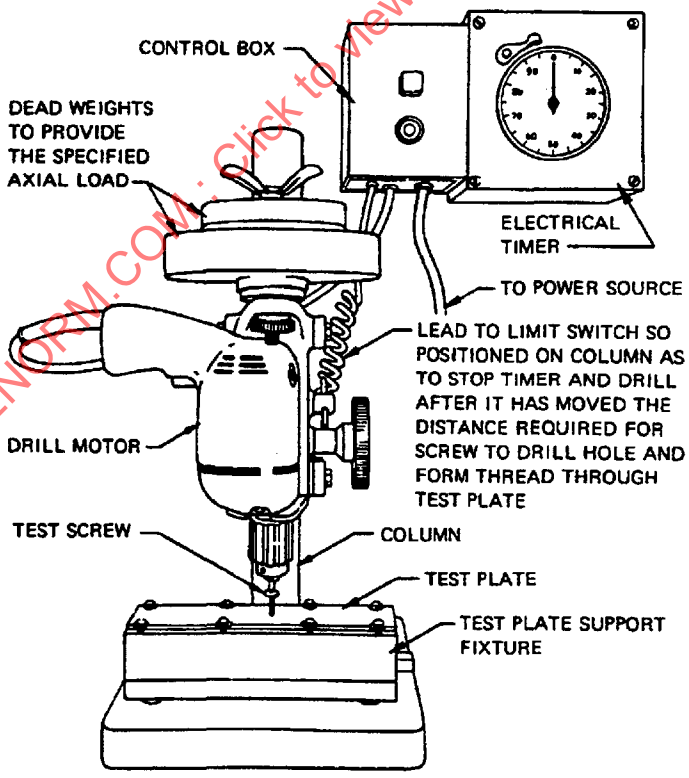

FIGURE 6—TYPICAL DRILL-DRIVE TEST FIXTURE

The drill-drive test shall be conducted in accordance with the sampling plan in Table 7:

TABLE 7—SAMPLING PLAN

Lot Size[1]	Sample Size
Up to 5 000	6
5 001 to 15 000	12
15 001 to 50 000	18
50 001 and over	25

[1] Lot size is defined as a quantity submitted for inspection.

If the actual time for each of the sample screws to drill and thread a hole does not exceed the maximum time specified in Table 6, the lot shall be acceptable. If one or more of the test times exceed the maximum specified in Table 6, a retest shall be made using twice the original sample size. The lot shall then be acceptable in accordance with Table 8:

TABLE 8—LOT ACCEPTANCE LIMITS

Sample Size	Slow Drive[1]	Excessive Drive[2]
12	1	0
24	1	0
36	2	1
50	3	1

[1] A "slow drive" is defined as a screw having a drilling and threading time in excess of, but less than, twice the specified maximum.

[2] An "excessive drive" is defined as a screw having a drilling and threading time twice the specified maximum or greater.

5.3 Drive to Failure Test—There shall be a satisfactory difference between starting torque and failure torque. The difference may be expressed as a ratio or range of torques.

(Test conditions and performance ratios or torque ranges are to be developed.)

5.4 Drill Hole Size—When desired to determine that the drill point does not drill an oversize hole that would cause a loss of thread engagement and result in premature stripping of the mating thread, a drill hole size test may be conducted in accordance with 5.4.1. The diameter of the hole drilled by the screw shall not exceed the point diameter of the test screw by more than 0.005 in.

5.4.1 DRILL HOLE SIZE TEST—The sample screw shall be inserted through a sleeve or collar (Figure 7) having an inside diameter of approximately 0.010 in greater than the major diameter of the screw. The length of sleeve or collar should be such that sufficient unthreaded point length extends through the sleeve or collar to drill a hole through the minimum thickness material specified in Table 6 without thread pickup. After the hole is drilled in the test plate the screw shall be removed and the diameter of the drilled hole gaged.

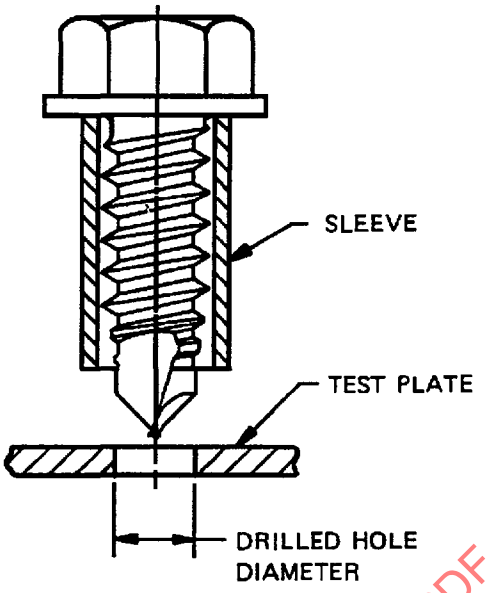

FIGURE 7—DRILL HOLE SIZE TEST

6. ***Screw Selection and Installation Considerations***—Screw point style selection should be made on the basis of the recommended panel thicknesses specified in Table 9. For multipanel applications which exceed the thickness tabulated, clearance holes should be provided in the uppermost panel or panels to reduce the thickness to be drilled by the screw.

TABLE 9—SELF-DRILLING TAPPING SCREW SELECTION CHART

Screw Type	Point Style	Nominal Screw Size	P[1] Recommended Panel Thickness, in
BSD and CSD	2	4	0.080 Max
		6	0.090 Max
		8	0.100 Max
		10	0.110 Max
		12	0.140 Max
		1/4	0.175 Max
	3	6	0.090-0.110
		8	0.100-0.140
		10	0.110-0.175
		12	0.110-0.210
		1/4	0.110-0.210

[1] If the panel to be drilled is comprised of two or more layers (see Figures 8B and 8C), the gap between the layers (which might consist of a sealing strip, airspace caused by warpage, etc., or just the separation caused by the pressure exerted by the driver) must be considered in determining the point style for the particular fastener. Using a self-drilling tapping screw as covered in this document in a multilayer application with an excessive gap could result in point breakage since the tapping in one layer begins before completion of the drilling of the other layers and since the advancement of the screw in the tapping operation is much faster than in the drilling operation.

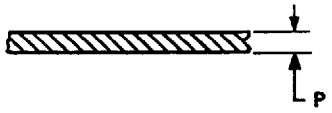

FIGURE 8A—SINGLE PANEL

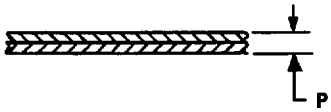

FIGURE 8B—DOUBLE PANEL

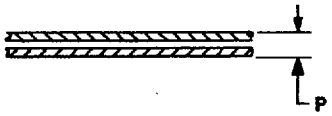

FIGURE 8C—SPACED PANEL

FIGURE 8—TYPICAL PANEL CONFIGURATIONS

Driving tools which operate between 1800 and 3000 rpm are commonly used for self-drilling tapping screw applications.

Figure A1 illustrates comparisons between the structure of case and core produced by the method recommended herein and a regular quenched and tempered structure. Case depths were measured on each of three screws after carbonitriding and microhardness traverses were run. The same parts were then water-quenched from 777 °C (1430 °F) and case depths were again measured. Results of each method appear under the photographs.

6.1 Optional Head Marking—For the purpose of identifying self-drilling tapping screws in assembled components, the consumer, at his option, may specify identifying head markings. Heads of self-drilling tapping screws, when specified by the consumer, shall be marked as shown in Figure 9.

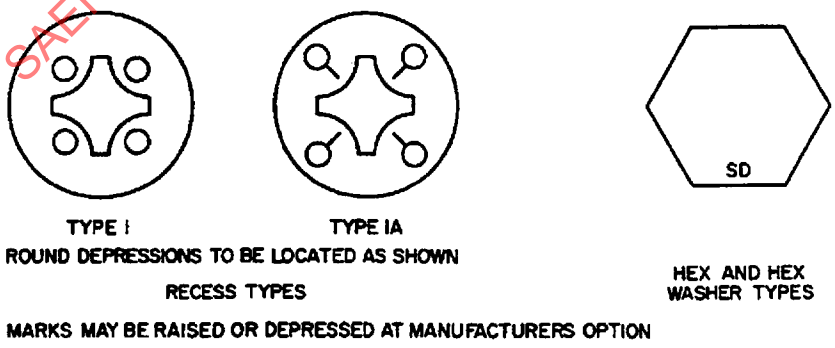

FIGURE 9—HEAD MARKING