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1.0 Scope

1.1 Scope. This inch series standard covers requirements for steel, self-drilling, tapping screws suitable for use in general engineering applications.

The objective of this standard is to ensure that 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.

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 met in an actual service application (such as different materials, thicknesses, etc.) drilling speed, drill load, starting torque, failure torque, and driving time values may require adjustment.

1.2 Designation. The two types of self-drilling tapping screws for which characteristics are covered in this standard are designated Types BSD and CSD.

1.2.1 BSD. BSD screws have spaced threads and are available with drill points of varying configuration, designated Style 2 and Style 3, designed to accommodate different panel thickness conditions as outlined in Table 6.

1.2.2 CSD. CSD screws have threads of machine screw diameter-pitch combinations approximating Unified form. CSD screws are not subject to thread gaging but shall meet the dimensional requirements of this standard. CSD screws are available with drill points of varying configuration, designated Style 2 and Style 3, designed to accommodate different panel thickness conditions as outlined in Table 6.

2.0 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 requirements of IFI-140. Selection of a given IFI steel grade from IFI-140 shall be based on compliance with the following chemical composition limits:

Analysis (1)	Composition Limits (% by weight) (2)			
	Carbon		Manganese	
	Min	Max	Min	Max
Ladle	0.15	0.25	0.70	1.65
Check	0.13	0.27	0.64	1.71

NOTES:

1. Ladle analysis may be used for routine reporting. Check analyses shall be used in case of dispute or as required.
2. Boron is permitted in the range of 0.0005-0.003.

2.1.2 Heat Treatment. Screws shall be heat treated in a carbonitriding or gas carburizing system.

2.1.3 Tempering Temperature. Minimum tempering temperature shall be 625°F.

2.1.4 Finish. Screws may be furnished plain or with a protective coating (electrodeposited or mechanical plating or chemical conversion coating) as specified by the user. At the option of the manufacturer screws may be provided with an additional supplementary lubricant as necessary to meet the performance requirements. ASTM F1941 shall be used for electrodeposited coatings.

Electroplated screws shall be baked for a minimum of one hour within the temperature range 375°-450°F as soon as practicable after plating to avoid hydrogen embrittlement. Alternately, ASTM F1940 may be used for process control to prevent hydrogen embrittlement.

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 failure of the screws to meet me-

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chanical 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.

2.2 Dimensional Requirements

2.2.1 Basic 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, in ASME B18.6.4, Slotted and Recessed Head Tapping Screws and Metallic Drive Screws, except as specified in Para. 2.2.4 thru Para. 2.2.6 of this standard.

2.2.2 Thread Dimensions. Dimensions of Type BSD screw threads shall conform to those for Type B screws, and dimensions of Type CSD screw threads shall conform to those for Type C screws, as specified in ASME B18.6.4.

2.2.3 Length of Thread

2.2.3.1 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 Fig. 1. For screws of nominal lengths longer than 1.50 in., the length of full form thread shall be as specified by the purchaser.

2.2.3.2 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 Fig. 2. For screws of nominal lengths longer than 1.50 in., the length of full form thread shall be as specified by the purchaser.

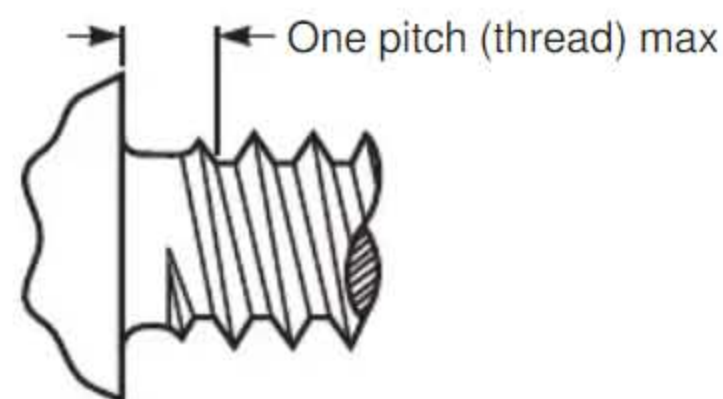


Fig. 1

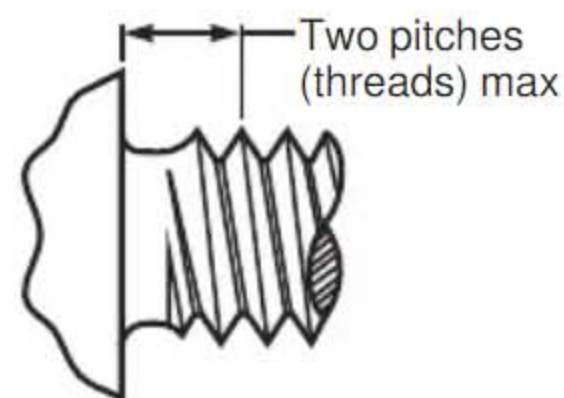


Fig. 2

2.2.4 Head Types. The head types covered by this standard include those specified in ASME B18.6.4.

2.2.5 Points. Dimensions of points for BSD and CSD screws are shown in Table 1 and shall be such as to ensure that specified performance requirements are met.

2.2.6 Recesses. Head recesses shall conform with the dimensional requirements of ASME B18.6.4.

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

2.2.7.1 Eccentricity of Hex and Hex Washer Heads. Hex and hex washer heads shall not be eccentric with the axis of the screw by an amount equal to or more than 6 percent of the basic screw diameter.

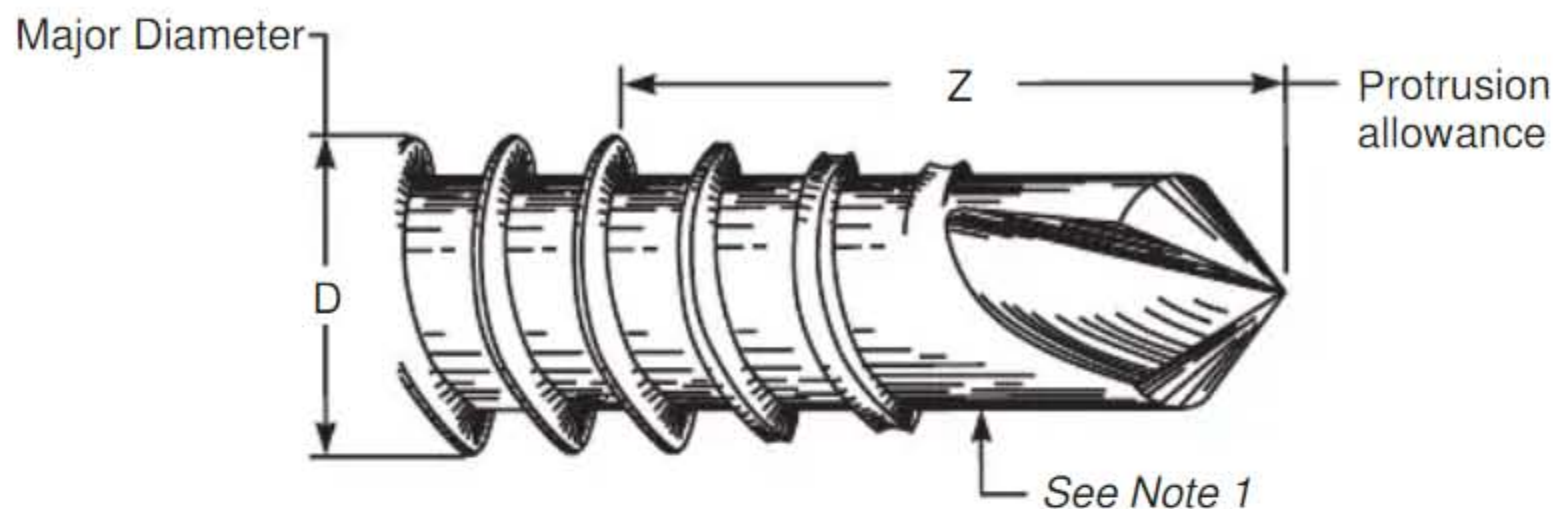
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Typical Self-Drilling Tapping Screw Point

Table 1 Dimensions of Threads and Points for Types BSD and CSD Self-Drilling Tapping Screws

Nominal Size or Basic Screw Diameter	Type BSD								Type CSD				Types BSD and CSD			
	Threads per Inch	D		d		Z		Threads per Inch	D		Z		L			
		Major Diameter		Minor Diameter		Protrusion Allowance (Ref)			Major Diameter		Protrusion Allowance (Ref)		Minimum Practical Nominal Screw Lengths (Ref)			
													Style 2 Points		Style 3 Points	
		Max	Min	Max	Min	Style 2 Point	Style 3 Point		Max	Min	Style 2 Point	Style 3 Point	Formed		Formed	
4 0.1120	24	0.114	0.110	0.086	0.082	0.163	—	40	0.1120	0.1072	0.130	—	5/16	3/8	—	—
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	5/16	3/8	3/8	7/16
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	3/8	7/16	7/16	1/2
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	7/16	1/2	1/2	9/16
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	1/2	5/8	1/2	5/8
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	1/2	5/8	1/2	5/8
See Notes 2						3					3					

NOTES:

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 6 prior to thread pick-up.
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:

$$Y = L_{\min} - Z$$

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2.2.7.2 Eccentricity of Recess. The recess in recessed head screws shall not be eccentric with the axis of the screw by an amount equal to or more than 6 percent of the basic screw diameter.

2.3 Mechanical and Performance Requirements

2.3.1 Hardness

2.3.1.1 Core Hardness. Screws shall have a core hardness of Rockwell C32-40, when tested as specified in Para. 3.1.

2.3.1.2 Case Hardness. Screws shall have a case hardness of Rockwell C52-58, when tested as specified in Para. 3.2.

2.3.1.3 Total Case Depth. Screws shall have a total case depth conforming to the following, when tested as specified in Para. 3.3:

Nominal Size	Total Case Depth (in.)	
	Min	Max
Nos. 4 and 6	0.002	0.007
Nos. 8 thru 12	0.004	0.009
1/4	0.005	0.011

2.3.2 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 Para. 3.4.

2.3.3 Drill-Drive Test. Screws shall meet the requirements of the time to drill and thread a hole completely through a test plate as specified in Table 3, when tested in accordance with Para. 3.5. The optional performance in Table 4 may be specified by the customer when specified in the inquiry and purchase order.

2.3.4 Drill Hole Size. When desired to determine that the drill point does not drill an oversize hole

Table 2 Torsional Strength Requirements

Nominal Screw Size	Minimum Torsional Strength (lb. in.)	
	Type BSD	Type CSD
4	14	14
6	24	24
8	42	48
10	61	65
12	92	100
1/4	150	156

that would cause a loss of thread engagement and result in premature stripping of the mating thread, a drill hole size test shall be conducted in accordance with Para. 3.6. 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.

2.3.5 Ductility. Heads of screws shall not separate completely from the shank when a permanent deformation is induced between the plane of the underhead bearing surface and a plane normal to the axis of the screw, when tested as specified in Para. 3.7.

2.3.6 Hydrogen Embrittlement. Electroplated screws shall be tested as specified in Para. 3.8.

3.0 Test Methods

3.1 Core Hardness. Core hardness shall be determined at mid-radius of a transverse section thru 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 screw permit), case hardness may be measured on end,

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Table 3 Required Drill-Drive Time Performance

Nominal Screw Size	Test Plate Thickness +/- .002 in.	Axial Loading, lb.			Maximum Time to Drill and Form Thread (seconds)
		A	B	C	
4	0.062	25	30	40	2.0
6	0.062	30	35	45	2.5
8	0.062	30	35	45	3.0
10	0.062	35	40	50	3.5
12	0.062	45	50	60	4.0
1/4	0.062	45	50	60	5.0
See Notes	1	2			3

Table 4 Optional Drill-Drive Performance

Nominal Screw Size	Test Plate Thickness +/- .005 in.	Axial Loading, lb. D	Maximum Time to Drill and Form Thread (seconds)	Drill Speed
		+/- 5%	Seconds	RPM
6	0.080	35	4.5	1800 to 2500
8	0.120	55	5.0	1800 to 2500
10	0.160	55	7.0	1800 to 2500
12	0.200	80	11.0	1000 to 2500
1/4	0.200	80	13.0	1000 to 2500
See Notes	1, 2	3		

NOTES:

- Test plates shall be low carbon cold rolled steel having a hardness of Rockwell B60 to 85. Thickness may be single plate or a combination of two plates.
- 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 zinc platings up to 0.0003 in. thickness in accordance with ASTM F1941.
 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.
 Column D – The axial load is the same regardless of finish.
- 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 build-up due to surface speed. (NOTE: These speeds are for test purposes and are not necessarily suited for all service applications. Refer to Appendix A, Para. (e) and to special note in Scope, Para. 1.1.)

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shank or head using Rockwell 15N. As an alternate, or where this method is not applicable, a microhardness instrument with a Knoop or diamond pyramid indenter and a 500 gram 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 a midpoint between crest and root on the thread flank using the method described in SAE J423.

3.4 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, 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.

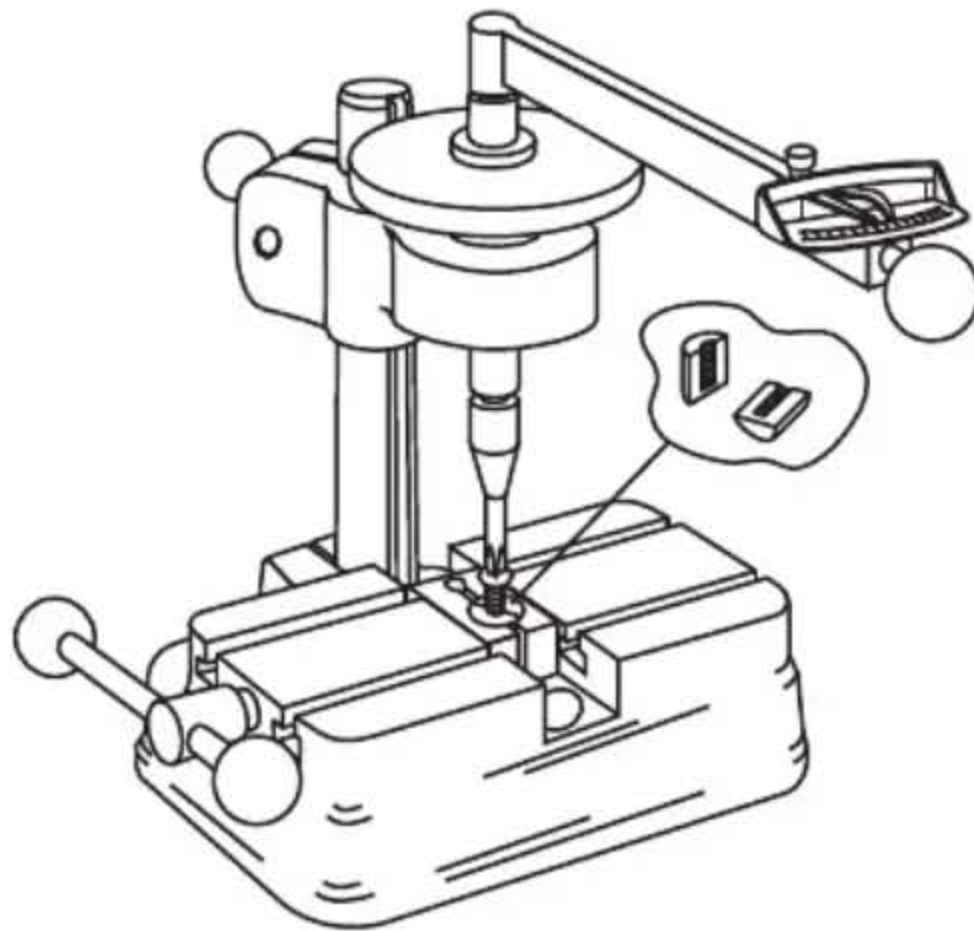


Fig. 3

3.5 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 3. Each screw shall be used to drill and thread only one hole. A typical drill-drive test fixture is shown in Fig. 5.

The drive test shall be conducted in accordance with the following sampling plan:

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

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 3, the lot shall be acceptable. If one or more of the times exceed the maximum specified in Table 3, a re-test shall be made using twice the original sample size. The lot shall then be acceptable in accordance with the following:

Sample Size	Slow Drive*	Excessive Drive**
12	1	0
24	1	0
36	2	1
50	3	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.

** An "Excessive Drive" is defined as a screw having a drilling and threading time twice the specified maximum or greater.

3.6 Drill Hole Size Test. The sample screw shall be inserted through a sleeve or collar (Fig. 4) having an inside diameter of approximately 0.010 in. greater than the major diameter of the screw. The

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sleeve length or collar adjustment should be such that sufficient unthreaded point length extends through the sleeve or collar to drill a hole through 0.035 in. thick material without thread pick-up. After the hole is drilled in the test plate, the screw shall be removed and the diameter of the drilled hole measured.

3.7 Ductility. The sample screw shall be inserted into a hardened 5 deg wedge block, having hole sizes .020 to .040 inches larger than the nominal screw diameter. An axial compressive (or impact) load shall be applied against the top of the screw head. Loading shall be continued until the plane of the underhead bearing surface is bent permanently through with respect to a plane normal to the axis of the screw.

3.8 Hydrogen Embrittlement Test. Electroplated screws shall be installed into the hydrogen embrittlement test plates as specified in Table 5. If the reference hole size in the test plate is smaller than the screw drill point diameter, drive the screw through the existing hole to size the hole. Seat the

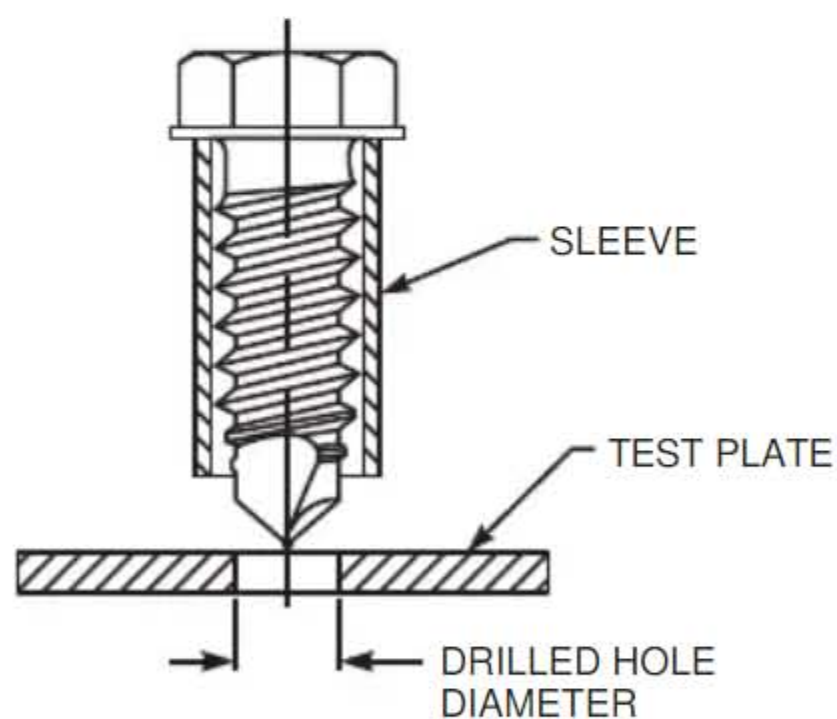


Fig. 4

head of the screw against a hardened steel flat washer or split lock washer. If the screws are not threaded to the head, additional washers and/or spacers (hardened or unhardened) shall be used under the bearing washer to provide a minimum stack thickness corresponding to the length of the maximum unthreaded length on screw plus the distance equal to two to three thread pitches. Full form screw threads must be engaged through the test plate's thickness. Screws shall be tightened to a test torque equal to 80% of the average failure torque of five screws driven into the test plate until they break into two pieces. The screws shall remain in the tightened state for a minimum of 24 hours, after which all screws will be retightened to the original test torque. The lot is acceptable if no screws break during the waiting period or during retightening.

3.8.1 Underhead Bearing Test Surface. The surface condition of plain commercially available flat washers is normally suitable for the test specified in Para. 3.8. For referee purposes, the surface shall conform to 0.50 to 0.75 μm (AA roughness range.)

3.9 Torque Wrenches. Torque wrenches used in all tests shall be accurate within plus or minus 2 percent of the maximum of the specified torque range of the wrench.

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

4.0 Inspection

4.1 Inspection Procedure. Screws shall be inspected to determine conformance with the requirements of this standard. Inspection shall be performed in accordance with sampling plans given in ASME B18.18.2M, except where otherwise specified in this standard. Alternate inspection procedures may be specified by the purchaser on the purchase order or engineering drawing.

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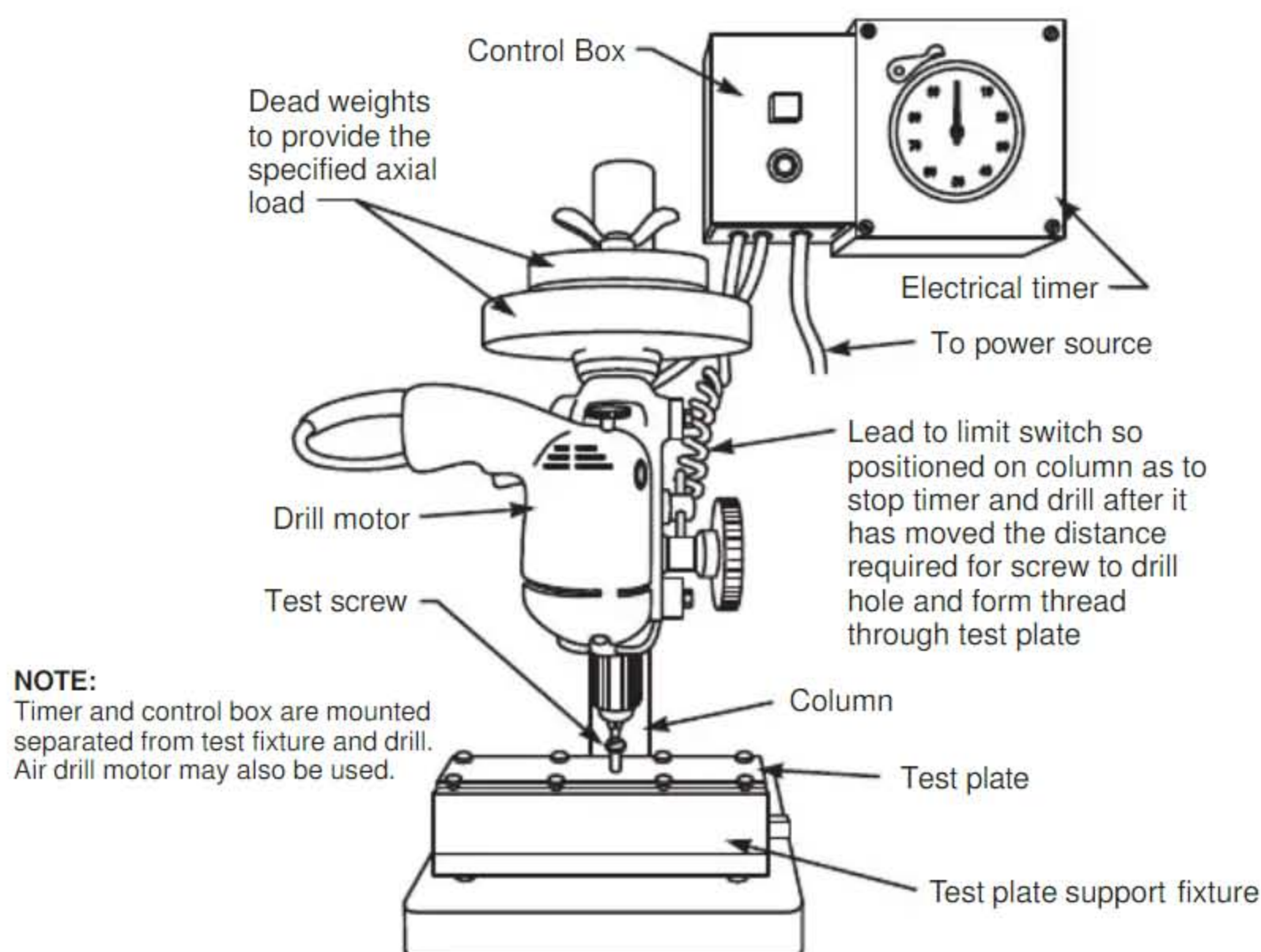


Fig. 5 Typical Drill-Drive Test Fixture

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Table 5 Hydrogen Embrittlement Test Plate

Nominal Screw Size	Test Plate Thickness (in.)	Test Plate Hole Size (in.)
	ref.	ref.
4	0.048	0.086
6	0.075	0.116
8	0.125	0.136
10	0.125	0.159
12	0.125	0.187
1/4	0.187	0.216

Test plates shall be low carbon cold rolled steel having a hardness of HRB 70-85.

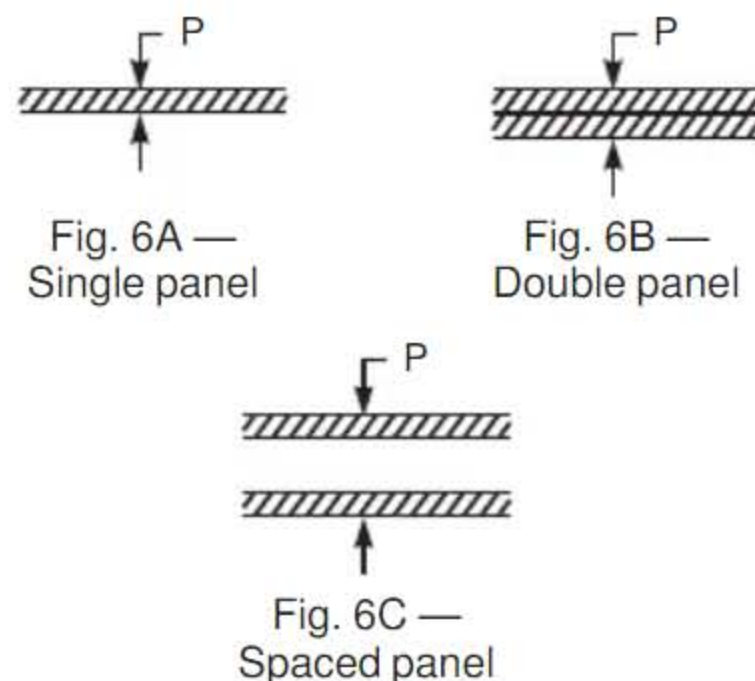


Fig. 6 Typical Panel Configurations

Table 6 Self-Drilling Tapping Screw Selection Chart

Screw Type	Point Style	Nominal Screw Size	P ^a
			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

- a If the panel to be drilled is comprised of two or more layers. See Figs. 6B and 6C, the gap between the layers (which might consist of a sealing strip, air space 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 standard in a multi-layer 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.

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APPENDIX A

ASSEMBLY CONSIDERATIONS

a. Screw Selection Chart. Table 6 represents a screw selection chart recommending panel thicknesses which can be fastened with various screw types and sizes.

b. Bits and Sockets. Magnetic bits and sockets are not recommended for sealing applications or when material thicknesses are near the maximum drilling limit of the particular screw (see Table 6), because of possible chip collection around the area being sealed and in the socket.

c. Driving Technique. End pressures of 25 to 65 pounds are required for efficient drilling of self-drilling tapping screws. Excessive pressure, especially during the initial penetration of the drill point, increases the amount of material being removed by the flutes and could result in drilling torques in excess of the strength of the drill point.

For applications involving several layers of material, certain design considerations must be made.

If one of the layers has a clearance hole, this hole size must be larger than the drill point diameter and preferably larger than the screw thread major diameter. Clearance holes smaller than the drill point diameter result in a concentrated load on the edge of the point which results in the same problems

associated with excessive pressures.

If both layers (or several layers) are to be drilled, the gap between the layers (which might consist of a sealing strip, air space caused by warpage, etc., or just the separation caused by the pressure exerted by the driver) must be considered in determining the unthreaded point length for the particular fastener. Using a self-drilling tapping screw as covered in this standard in a multi-layer 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. The net result would be the same as when exerting excessive pressure.

d. Torque Output. Torque output of the driver should be equivalent to the torque required to drive a comparable standard thread forming or thread cutting tapping screw in a predrilled hole.

e. Driving Speed. Driving tools which operate between 2000 and 3000 rpm are satisfactory for most applications. Driving speed should be consistent with good drilling practice when using carbon steel drills.

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