STEEL SELF-DRILLING TAPPING SCREWS—SAE J78

SAE Standard

Report of Iron and Steel Technical Committee and Fasteners Committee approved July 1972.

1. Scope

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

It is the objective of this standard to insure 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 or service.

An Appendix 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 standard 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 Table 5.

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 Table 5. 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 SAE J478 and ANSI B18.6.4, Slotted and Recessed Head Tapping Screws and Metallic Drive Screws, except for slotted head and hex (nonwasher) head designs which are not recommended for self-drilling screws.

2. Dimensional Requirements

2.1 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 paragraphs 2.2-2.4.

2.2 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 Fig. 1 and Table 1.

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

2.3.1 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.

2.3.2 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.

2.4 Length of Thread

2.4.1 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 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.

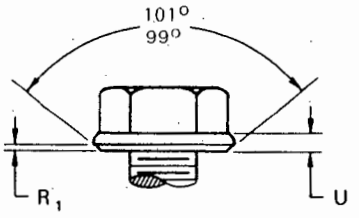


FIG. 1A—HEX WASHER HEAD

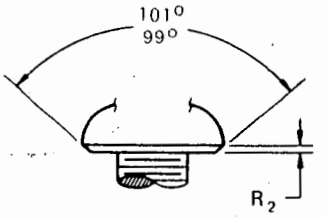


FIG. 1B—RECESSED HEADS

FIG. 1—HEAD CHAMFERS ON MILLED POINT SCREWS

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

Nominal Screw Size	U		R_1	R_2
	Washer Thickness		Chamfer Height Hex Washer Hds	Chamfer Height Recessed Heads
	Max	Min	Ref	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

2.4.2 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 Fig. 3. For screws of nominal lengths longer than 1.50 in, the length of full form thread shall be as specified by the purchaser.

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

3. Material and Process Requirements

3.1 Material and Chemistry—Screws shall be made from cold heading quality, killed steel wire conforming to the following chemical composition:

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

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

3.2 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.

3.2.1 TEMPERING TEMPERATURE—Minimum tempering temperature shall be 625 F.

When cyaniding systems are approved, the minimum tempering temperature shall be 450 F.

3.2.2 CASE DEPTH—Screws shall have a case depth conforming to the tabulation below:

Nominal Screw Size	Case Depth, in	
	Max	Min
4 and 6	0.007	0.002
8 thru 12	0.009	0.004
1/4	0.011	0.005

Case depth shall be measured at a midpoint between crest and root on the thread flank. A recommended technique for measuring case depth is given in the Appendix.

3.2.3 CASE HARDNESS—Screws shall have a case hardness equivalent to Rockwell C 52-58. For routine quality control purposes (where case depth and geometry of screw permit), case hardness may be measured on end, shank, or head using Rockwell 15 N. As an alternate, or where this method is not applicable, a microhardness instrument with a Knoop or diamond pyramid indenter and a 500 g load may be used.

FIG. 2

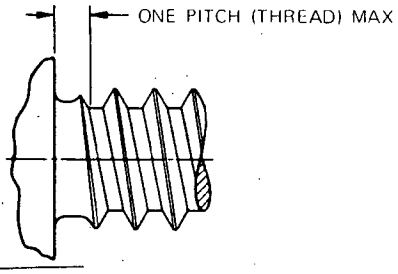
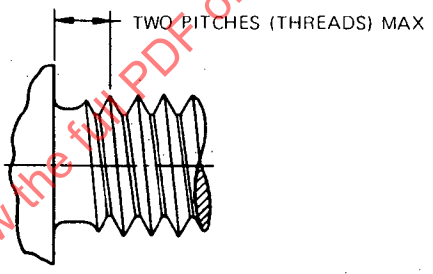


FIG. 3



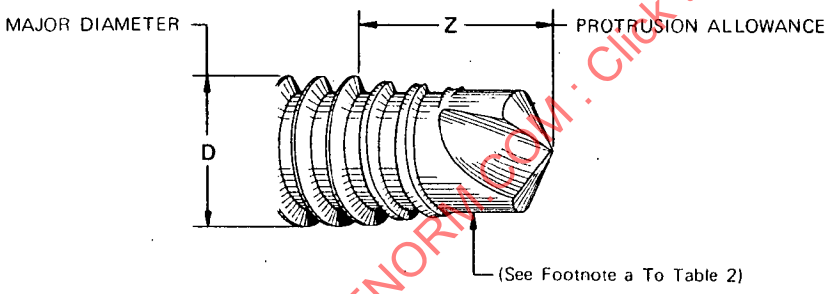


FIG. 4—TYPICAL SELF-DRILLING TAPPING SCREW POINT

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

Nominal Size[b] or Basic Screw Diameter		Type BSD							Type CSD					Types BSD and CSD							
		Threads Per Inch	D		d		Zc		Threads Per Inch	D		Zc		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			
														Formed		Milled		Formed		Milled	
			Max	Min	Max	Min	Style 2 Point	Style 3 Point		Max	Min	Style 2 Point	Style 3 Point	90 deg Heads	Csk Heads	90 deg Heads	Csk Heads	90 deg Heads	Csk Heads	90 deg Heads	Csk Heads
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	3/8	7/16	—	—	—	—
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	3/8	7/16	7/16	1/2
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	7/16	1/2	1/2	9/16
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	15/32	19/32	1/2	9/16	9/16	21/32
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	17/32	21/32	1/2	5/8	21/32	25/32
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	17/32	11/16	1/2	5/8	11/16	27/32

[a]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.

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

[c]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 encomposses 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:

$$Y = L \text{ min} - Z$$

In such cases, measurements shall be made on the thread profile of a properly prepared longitudinal metallographic specimen.

3.2.4 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.

3.3 **Ductility**—Heads of screws shall not separate completely from the shank when a permanent deformation of 5 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 3.3.1.

3.3.1 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 deg with respect to a plane normal to the axis of the screw.

3.4 **Finish**—Unless otherwise specified, screws shall be supplied with a natural (as processed) finish, unplated or uncoated. Where corrosion preventative 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 paragraph 3.4.1.

3.4.1 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 Table 5. The head of the screw shall be seated against one or more ANSI B27.2 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 3. 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.

3.4.2 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.

4. Performance Requirements and Tests

4.1 **Torsional Strength**—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 paragraph 4.1.1.

4.1.1 TORSIONAL STRENGTH TEST—The sample screw shall be securely clamped by suitable means (Fig. 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.

4.2 **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 4. Each screw shall be used to drill and thread only one hole. A typical drill drive test fixture is depicted in Fig. 6.

The drill-drive test shall be conducted in accordance with the fol-

TABLE 3—MECHANICAL AND PERFORMANCE REQUIREMENTS FOR TYPES BSD AND CSD SELF-DRILLING TAPPING SCREWS

Nominal Screw Size	Minimum Torsional Strength lb-in		Maximum Starting Torque, lb-in	Minimum Failure Torque, lb-in	Hydrogen Embrittlement Test Torque, lb-in	
					Cadmium Plated Screws	Zinc Plated Screws
	Type BSD	Type CSD	Types BSD and CSD	Types BSD and CSD	Types BSD and CSD	Types BSD and CSD
4	14	14	5	10	10.5	12
6	24	24	10	20	18	20
8	42	48	15	30	36	41
10	61	65	20	40	49	55
12	92	100	40	80	72	85
1/4	150	156	60	120	114	132

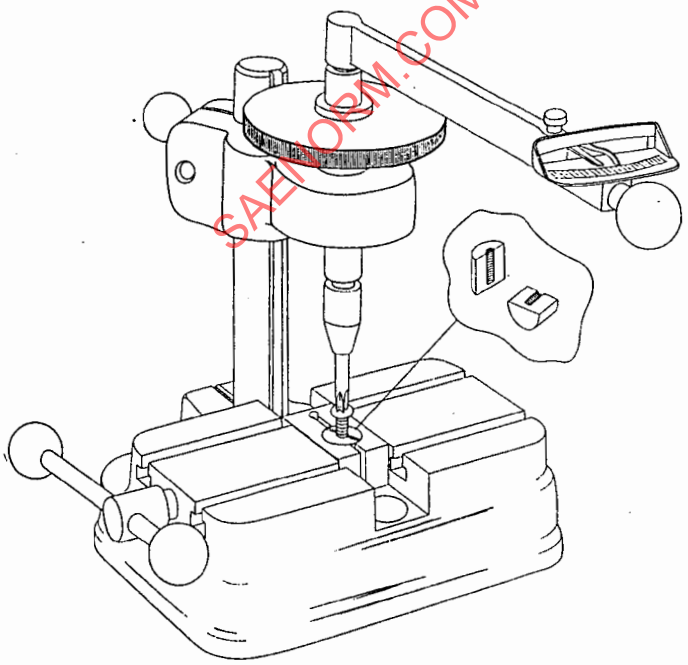


FIG. 5—TYPICAL TORSIONAL STRENGTH TEST FIXTURE

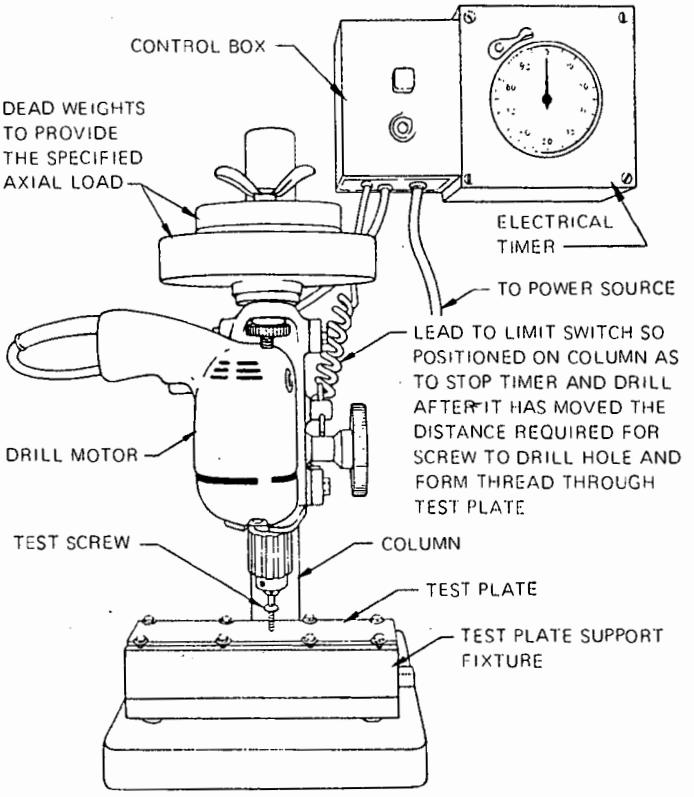


FIG. 6—TYPICAL DRILL-DRIVE TEST FIXTURE

TABLE 4—DRILL-DRIVE TEST CONDITIONS AND REQUIREMENTS FOR TYPES BSD AND CSD SELF-DRILLING TAPPING SCREWS

Nominal Screw Size	Test Plate Thickness,[a] in		Axial Loading,[b] lb			Time to Drill and Form Thread,[c] s
			A	B	C	
	Max	Min	Max	Max	Max	Max
4	0.064	0.060	25	30	40	2.0
6	0.064	0.060	30	35	45	2.5
8	0.064	0.060	30	35	45	3.0
10	0.064	0.060	35	40	50	3.5
12	0.064	0.060	45	50	60	4.0
1/4	0.064	0.060	45	50	60	5.0

[a]Test plates shall be low carbon cold rolled steel having a hardness of Rockwell B60-85.
[b]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.
[c]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.

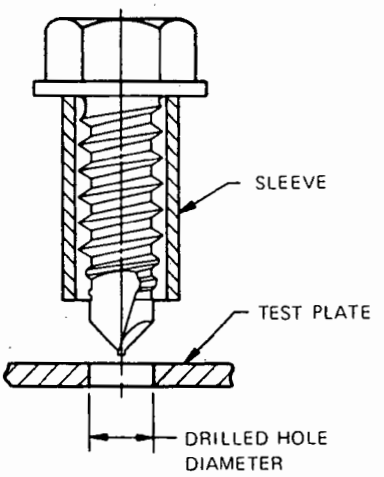


FIG. 7—DRILL HOLE SIZE TEST

lowing sampling plan:

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

[a]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 4, the lot shall be acceptable. If one or more of the test times exceed the maximum specified in Table 4, a retest shall be made using twice the original sample size. The lot shall then be acceptable in accordance with the following:

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

[a]A "slow drive" is defined as a screw having a drilling and threading time in excess of but less than twice the specified maximum.
[b]An "excessive drive" is defined as a screw having a drilling and threading time twice the specified maximum or greater.

4.3 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. If a ratio is used, the minimum failure torque shall be three times greater than the maximum starting torque. (Test conditions by screw diameter and performance ratios or ranges are to be developed.)

4.4 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 shall be conducted in accordance with paragraph 4.4.1. 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.

4.4.1 DRILL HOLE SIZE TEST—The sample screw shall be inserted through a sleeve or collar (Fig. 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 4 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.

5. Screw Selection and Installation Considerations—Screw point style selection should be made on the basis of the recommended panel thicknesses specified in Table 5. For multipanel applications which exceed the thicknesses tabulated, clearance holes should be provided in the uppermost panel or panels to reduce the thickness to be drilled by the screw.

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

Fig. A-1 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 1430 F and case depths were again measured. Results of each method appear under the photographs.

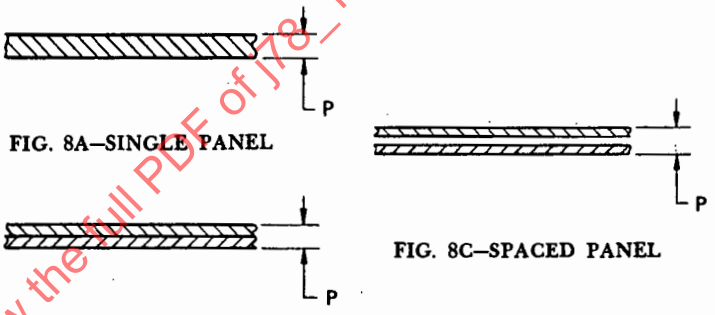


FIG. 8A—SINGLE PANEL

FIG. 8C—SPACED PANEL

FIG. 8B—DOUBLE PANEL

FIG. 8—TYPICAL PANEL CONFIGURATIONS

TABLE 5—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. 8B and 8C), 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 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.