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STANDARD CLEARANCE HOLE SIZES

by

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STANDARD CLEARANCE HOLE SIZES

by

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ABSTRACT

This study establishes standard clearance hole sizes for the common screw fastener sizes, positional tolerances and assembly applications. These clearance hole sizes are expressed as standard drill sizes in the tables. In arriving at these drill sizes, consideration was given to the fact that drills cut oversize and that deviations in the size of drilled holes must be expected even under ideal operating conditions.

Standardization of clearance hole sizes saves much time in preparing drawings and specifications since it eliminates laborious calculations by draftsmen and checkers. The saving is passed along to the manufacturing plant in the form of specifications which are easy to interpret and which indicate a standard drill size for the required hole. With standardization, fewer drills are needed, inspection procedures are simplified, and uniformity of the end product is improved.

With customary dimensioning and tolerancing, it has not been possible in the past to guarantee that components of an assembly using screw fasteners, however well designed, would assemble properly. Accumulated tolerances and lack of quantitative data on variations of hole oversize with different drills have introduced uncertainties which led occasionally to unavoidable misfits during final assembly.

Two recent developments make it possible now to predict the size of clearance hole needed for a given screw and to choose the best drill for that hole. The first of these, use of positional tolerances as adopted by the British Standards Institution and as proposed for this country by the American Society of Mechanical Engineers, eliminates uncertainties due to accumulated tolerances. By specifying the radius within which the individual hole center may vary from its true position in a datum plane, a draftsman can locate that hole unambiguously. The second development, publication of experimental data on hole oversize caused by drills of different sizes, eliminates uncertainty concerning the relationship of drill size to hole size.* In effect, tolerances of size as well as of position have become known instead of hoped-for quantities as they relate to a particular hole.

* See Drilled Holes for Tapping, published by the Drill and Reamer Division and the Tap and Die Division of the Metal Cutting Tool Institute, 1954.

FIGURE 1

General formulas may be stated for the minimum diameters of clearance holes in terms of diameters of screw fasteners and positional tolerances. Where both mating parts have clearance holes and are held together by bolts or machine screws (see Fig. 1), the minimum diameter of either clearance hole is

$$D_h = D_f + R_{th1} + R_{th2} \quad , \quad (1)$$

where D_h is the minimum diameter of either clearance hole, D_f the maximum major diameter of the fastener, R_{th1} the tolerance radius of the hole in one plate, and R_{th2} the tolerance radius of the hole in the other plate. In terms of the diameters,

$$2D_h = 2D_f + D_{th1} + D_{th2} \quad , \quad (2)$$

where the subscripts have the same meaning as before. Including errors of geometric form and the additional clearance needed to facilitate assembly, the complete formula is

$$2D_h = 2(D_f + E_f + C) + D_{th1} + E_{h1} + D_{th2} + E_{h2} \quad , \quad (3)$$

where E represents the error of geometric form e.g., straightness or squareness, of the part indicated by the subscript and C is the additional clearance.

Where the mating parts are held together by screws or studs with tapped holes in one part and clearance holes in the other (see Fig. 2), the minimum diameter of the clearance hole is

$$D_h = D_f + D_{th1} + E_f + D_{th2} + E_h + C \quad (4)$$

The following cases illustrate the use of these formulae:

Case I

Given: Two steel plates held together by a machine screw and nut. Intersection of TP (i.e., true position) centerlines of the plates coincident.

FIGURE 2

Identical clearance holes in each plate.
 Positional tolerance of each hole 0.014-inch diameter.
 Maximum diameter of screw (No. 6) 0.138 inch.

Find: Minimum clearance hole diameter and the drill to be used.

From the formula (1), since $R_{th1} = R_{th2}$, the minimum clearance hole diameter in inches is

$$\begin{aligned} D_h &= D_f + D_{th1} \\ &= 0.138 + 0.014 \\ &= 0.152 \end{aligned}$$

In order to determine the drill to be used, it is necessary to consult the curves of oversize in Fig. 3. These curves are a composite of the oversize for steel and cast iron published by the Metal Cutting Tool Institute and tests on aluminum performed at Sandia Corporation.

From these curves, it appears that for a hole 0.152 inch in diameter, several drill sizes are available as shown in Table I. A tolerance range of 0.006 is assumed; however, practice in different firms varies considerably in regard to tolerance schedules for drilled holes.

TABLE I

Desired size	Selected drill size	Probable oversize	Probable hole size
.152	#25 (.1495)	.000*-.006**	.150-.156
.152	#24 (.1520)	.000-.006	.152-.158
.152	#23 (.1540)	.000-.006	.154-.160
.152	5/32 (.1563)	.000-.006	.156-.162
.152	#22 (.1570)	.000-.006	.157-.163

The desired drill size is that which is nearest to, but not less than, the hole size. In the example, where the desired hole size is 0.152 inch, the nearest drill size not less than the hole size is No. 24 (0.1520 inch).

* Average minimum for aluminum (rounded value). See Fig. 3.

** Average maximum for steel and cast iron (stepped curve). See Fig. 3.

FIGURE 3

In order to specify the drilling process in a way which allows an alternative to drilling with No. 24, it is necessary to specify the limit dimensions or average maximum as well as the minimum hole size for drill No. 24. On the engineering drawing, this specification may be written as

$\begin{smallmatrix} .152 \\ +.003 \\ -.003 \end{smallmatrix}$ (#24-.1520 DRILL)

Data on recommended standard drill sizes to produce clearance holes for a variety of common bolt and screw diameters and assembly conditions are given in Tables II, III, and IV. For the conditions of Case I, which would arise in a situation calling for a number 6 screw, the complete information is found in Table II, line 3.

Case II

Given: Two steel plates held together by a machine screw.
Intersection of TP centerlines of the plates coincident.
Tapped hole in one plate, clearance hole in the other.
Positional tolerance for tapped and clearance holes 0.014-inch diameter.
Maximum diameter of screw (No. 6) 0.138 inch.

Find: Minimum clearance hole diameter and drill to be used.

From the formula (4), excluding errors of geometrical form and additional clearance needed to facilitate assembly, the minimum clearance hole diameter in inches is

$$\begin{aligned} D_h &= D_f + D_{th1} + D_{th2} \\ &= 0.138 + 2(0.014) \\ &= 0.166 \end{aligned}$$

For the desired drill size in this case see Table III, line 3.

The nomographs, Figures 4 and 5, present data by which minimum clearance hole diameters may be determined for any given values of dimensional tolerances and fastener diameters. Either the charts or the equations accompanying them may be used for cases not covered by Tables II, III & IV.

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TABLE II

Identical clearance holes in both mating parts ($D_{h1} = D_{h2}$).
 Positional tolerance diameter $D_{th1} = D_{th2} = 0.014$ (± 0.005)

Equation: $D_{h1} = D_f + D_{th1}$

Nominal Size of Screw	Max. Major Screw Diameter (D_f)	Minimum Diameter of Clearance Hole (D_h)	Drawing Callout (Limits & Recommended Drill Size)
2	.0860	.100	$\frac{.100}{.104}$ (#39-.0995 DRILL)
4	.1120	.126	* $\frac{.125}{.130}$ (1/8-.1250 DRILL)
6	.1380	.152	$\frac{.152}{.158}$ (#24-.1520 DRILL)
8	.1640	.178	* $\frac{.177}{.183}$ (#16-.1770 DRILL)
10	.1900	.204	* $\frac{.203}{.210}$ (13/64-.2031 DRILL)
1/4	.2500	.264	$\frac{.266}{.274}$ (17/64-.2656 DRILL)
5/16	.3125	.327	$\frac{.328}{.336}$ (21/64-.3281 DRILL)
3/8	.3750	.389	$\frac{.391}{.399}$ (25/64-.3906 DRILL)
7/16	.4375	.452	$\frac{.453}{.461}$ (29/64-.4531 DRILL)
1/2	.5000	.514	$\frac{.516}{.525}$ (33/64-.5156 DRILL)
5/8	.6250	.639	$\frac{.641}{.650}$ (41/64-.6406 DRILL)
3/4	.7500	.764	$\frac{.766}{.775}$ (49/64-.7656 DRILL)
1	1.0000	1.014	$\frac{1.016}{1.026}$ (1-1/64-1.0156 DRILL)

* Functional since screw is usually undersize.

TABLE III

Identical clearance holes in both mating parts ($D_{h1} = D_{h2}$). Positional tolerance diameter $D_{th1} = D_{th2} = 0.028$ (± 0.010).		Clearance hole in plate 1. Tapped hole in plate 2. Positional tolerance diameter $D_{th1} = D_{th2} = 0.014$ (± 0.005).	
Equation: $D_{h1} = D_f + D_{th1}$		Equation: $D_{h1} = D_f + 2D_{th1}$

Nominal Size of Screw	Max. Major Screw Diameter (D_f)	Minimum Diameter of Clearance Hole (D_c)	Drawing Callout (Limits & Recommended Drill Size)
2	.0860	.114	* $\frac{.113}{.118}$ (#33-.1130 DRILL)**
4	.1120	.140	$\frac{.141}{.146}$ (#28-.1405 DRILL)**
6	.1380	.166	$\frac{.166}{.172}$ (#19-.1660 DRILL)
8	.1640	.192	* $\frac{.191}{.197}$ (#11-.1910 DRILL)
10	.1900	.218	$\frac{.219}{.226}$ (7/32-.2188 DRILL)
1/4	.2500	.278	* $\frac{.277}{.284}$ (J-.2770 DRILL)
5/16	.3125	.341	* $\frac{.339}{.347}$ (R-.3390 DRILL)
3/8	.3750	.403	$\frac{.404}{.412}$ (Y-.4040 DRILL)
7/16	.4375	.466	$\frac{.469}{.477}$ (15/32-.4688 DRILL)
1/2	.5000	.528	$\frac{.531}{.540}$ (17/32-.5312 DRILL)
5/8	.6250	.653	$\frac{.656}{.665}$ (21/32-.6562 DRILL)
3/4	.7500	.778	$\frac{.781}{.790}$ (25/32-.7812 DRILL)
1	1.0000	1.028	$\frac{1.031}{1.041}$ (1-1/32-1.0312 DRILL)

* Functional since screw is usually undersize.

** Not suitable for fillister head screws. Use pan head or washer

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TABLE IV

<p>Clearance hole in plate 1. Tapped hole in plate 2. Positional tolerance diameter $D_{th1} = D_{th2} = 0.028$ (± 0.010).</p>		<p>Clearance hole in plate 1. Insert in plate 2. Positional tolerance diameter (clearance hole) $D_{th1} = 0.014$; (insert) $D_{th2} = 0.012$.</p>	
<p>Equation: $D_{h1} = D_f + 2D_{th1}$</p>		<p>Equation: $D_{h1} = D_{th1} + D_{th2} + D_f$</p>

Nominal Size of Screw	Max. Major Screw Diameter (D_f)	Minimum Diameter of Clearance Hole (D_{h1})	Drawing Callout (Limits & Recommended Drill Size)
2	.0860	.112	* $\frac{.141}{.146}$ (#28-.1405 DRILL)**
4	.1120	.168	* $\frac{.166}{.172}$ (#19-.1660 DRILL)**
6	.1380	.194	$\frac{.194}{.200}$ (#10-.1935 DRILL)***
8	.1640	.220	* $\frac{.219}{.226}$ (7/32-.2188 DRILL)***
10	.1900	.246	$\frac{.246}{.253}$ (D-.2460 DRILL)***
1/4	.2500	.306	$\frac{.313}{.321}$ (5/16-.3125 DRILL)
5/16	.3125	.369	* $\frac{.368}{.376}$ (U-.3680 DRILL)
3/8	.3750	.431	$\frac{.438}{.446}$ (7/16-.4375 DRILL)
7/16	.4375	.494	$\frac{.500}{.509}$ (1/2-.5000 DRILL)
1/2	.5000	.556	* $\frac{.563}{.572}$ (9/16-.5625 DRILL)
5/8	.6250	.681	$\frac{.688}{.697}$ (11/16-.6875 DRILL)
3/4	.7500	.806	$\frac{.813}{.822}$ (13/16-.8125 DRILL)
1	1.0000	1.056	$\frac{1.063}{1.073}$ (1-1/16-1.0625 DRILL)

* Functional since screw is usually undersize.

** Not suitable for any size head unless washers are used.

*** Not suitable for fillister head screws. Use pan head or washer.

FIGURE 4 Clearance hole in both plates 1 & 2

FIGURE 5 Clearance hole in plate 1, Tapped hole in plate 2

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