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Metric Countersunk Holes for Cutting Edges and End Bits

RATIONALE

The technical report covers technology, products, or processes which are mature and not likely to change in the foreseeable future.

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE MTC1, Loaders, Crawlers, Scrapers and Mounted Attachments Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

Foreword—This Document has not changed other than to put it into the new SAE Technical Standards Board Format.

1.   *Scope*—this document is to be used on cutting edges and end bits in conjunction with metric bolts (reference ISO 7852-1982) typically used on off-road, self-propelled work machines as described in SAE J1116.

The cutting edges are further defined in SAE J737, J739, J1304, and J1581.

The end bits are further defined in SAE J63.

1.1   **Purpose**—This document specifies the principle shapes and dimensions for countersunk square holes. (See Figure 1 and Figure 2 and Table 1).
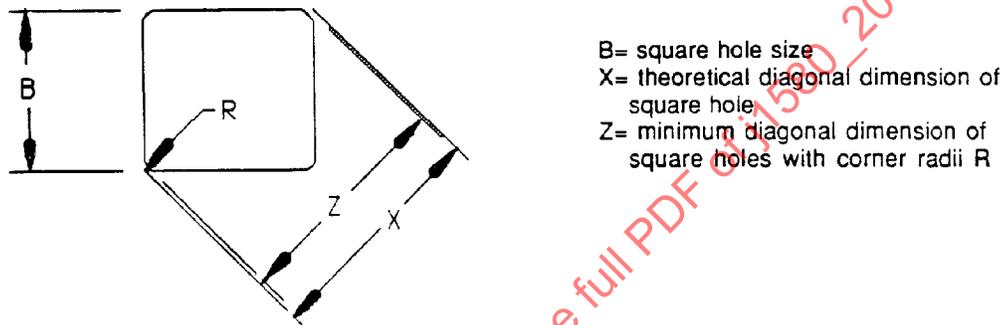

B= square hole size
X= theoretical diagonal dimension of
    square hole
Z= minimum diagonal dimension of
    square holes with corner radii R

FIGURE 1—SQUARE HOLE DIMENSIONS

**TABLE 1—DIMENSIONS FOR COUNTERSUNK HOLES USING METRIC BOLTS BASED ON
ISO 7129-1982 AND MODIFIED HEREWITH**

Bolt Size Ref.	H min csk one side	H Min w/rev csk[1]	D (min)	B basic	B tolerances	R approx.	Z min calculated	F approx.
M12	10.9	13.5	24.0	14.0	+ 0.8 − 0.0	2.5	17.624	24
M16	12.6	14.8	29.0	18.0	+ 1.5 − 0.0	2.5	23.281	29
M20	12.8	18.2	36.0	22.0	+ 2.0 − 0.0	3.0	28.503	36
M24	19.1	22.7	44.0	26.0	+ 2.4 − 0.0	3.0	34.160	44
M30	—	—	—	—		—	—	—
M36	20.8	33.0	65.0	38.0	+ 3.6 − 0.0	3.0	51.131	65

1. 2.0 min flat in square hold
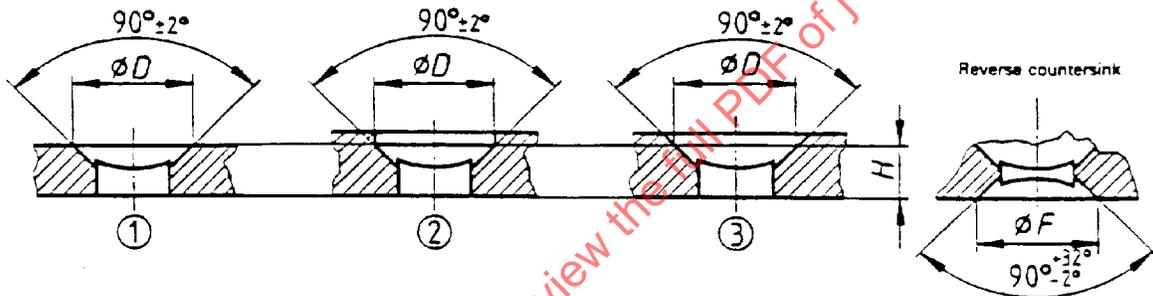
(For back face relief
only excluding the case
of 90 degrees ± 2)

D = diameter of countersink or counterbore for effective thickness H
H = minimum material thickness for bolt retention
F = diameter of reverse countersink of square hole

FIGURE 2—CROSS SECTION DRAWINGS

NOTE—The inscribed circle of the square holes shall be concentric with the countersink or counterbore within
φ 1.6 mm.

2. *References*

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

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

SAE J63—Hole Placement on Dozer End Bits
SAE J737—Hole Spacing for Scraper and Dozer Cutting Edges
SAE J739—Cutting Edge - Curved Grader
SAE J1116—Categories of Off-Road Self-Propelled Work Machines
SAE J1304—Cutting Edge - Cross Sections Loader Straight with Bolt Holes
SAE J1581—Cutting Edge - Optional Cross-Sections and Dimensions Loader Straight

2.1.2   ISO PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ISO 6165
ISO 7129-1982
ISO 7852-1982

PREPARED BY THE SAE ORTMC SUBCOMMITTEE 8
OF THE SAE OFF-ROAD MACHINERY TECHNICAL COMMITTEE

STABILIZED BY THE SAE MTC1, LOADERS, CRAWLERS, SCRAPERS
AND MOUNTED ATTACHMENTS COMMITTEE

A.1   *Objective*—The objective is to verify the minimum material thickness of cutting edges and end bits using metric "plow" bolts from ISO 7852-1982.

A.2   *Background*—The last revision of SAE J740 used a method to verify the required minimum material thickness for the ANSI English plow bolts. The values in ISO 7129-1982 are to be checked with the same criteria before considering adoption in this document.

The following conditions determine the minimum acceptable material thickness H in Table A1:

   a.   Minimum countersink angle, 88 deg.
   b.   Maximum countersink diameter, ϕ CSK maximum
   c.   Minimum bolt head diameter, ϕ bolt minimum
   d.   Maximum bolt head and square shank length, h maximum
   e.   Bolt head recess from edge surface, Δ max at bottom of shoulder F.

$$\Delta \ \text{Max} = \frac{(\phi \ \ \text{CSK Max} - \phi \ \text{Bolt Min})}{2(\text{Tan } 88°/2)} \qquad \text{(Eq. A1)}$$

   f.   X min = Distance from bottom of cutting edge to square shank of bolt.
   g.   H Min = h max −F+ Δ max, X = 0 (Reference Figure A1).
   h.   The 30 mm bolt dimensions are not in any published table.

A.3   *Explanation Of Calculations*

A.3.1 Table A1

   Δ Min-F positive indicates that the bolt will not protrude above the surface of the cutting edge.
   Δ Max is used for calculating minimum material thickness.
   X   Min positive indicates that the end of the square shank will not protrude below the cutting edge surface. If negative, ISO H min must change.
   H   Min assumes that the end of the square shank is flush with the edge of the cutting edge, thereby not interfering with tightening of the bolt.

NOTE—A negative value in the clearance column indicates a problem with the values in the table as originally specified in ISO 7129-1982. The table values are corrected as shown. Appendix B has reference ISO 7129-1982.

A.3.2 Table A2—The corner fits of the bolts in the square holes were also checked. It is assumed that the sharp corners of the bolt shank will fit in the radii of the square hole at worse case conditions. Only approximate values are given for the radii in the tables. It is, therefore, assumed that ±5% of a given radius will be used for these calculations.

Z max for the bolt is then compared to Z min of the hole, from Table A1.

A.3.3 Table A3—The minimum material thickness needed for the cutting edges with a countersink on both sides is calculated and compared with the values from ISO 7129-1982.

TABLE A1—CALCULATIONS

	BOLT				HOLE				X min.		H	H	ISO	
SIZE nom.	d-Φ Head min.	d-Φ Head max.	h-Head sq. height max.	F csk FLAT	Φ CSK max.	Φ CSK min.	Δ max. @88° CSK	Δ min. @92° CSK			min. calc. (x = 0)	ISO min.mat.C.E.	clearance H spec-H calc	*
M12	22.35	23.65	10.45	1	25.09	24	1.419	0.169	1.131		10.869	12.000	1.131	1
M16	27.35	28.65	12.55	1.5	30.32	29	1.537	0.169	−0.587		12.587	12.000	−0.587	2
M20	34.2	35.8	12.55	1.5	37.64	36	1.779	0.097	−0.829		12.829	12.000	−0.829	3
M24	41.2	42.8	18.65	2	46.00	44	2.485	0.579	−1.135		19.135	18.000	−1.135	4
M30	-	-	-	-	-	-	-	-	-		-	-	-	
M36	59	61	19.2	3	67.95	65	4.636	1.931	−2.836		20.836	18.000	−2.836	5

Formulae:

$\Delta = [.5 (\Phi\ CSK - \Phi\ head) / \tan(csk°/2)]$

$x = H - (h - F + \Delta)$

$\Phi\ hole\ csk\ max/92 = \Phi\ hole\ csk\ min/88$ OR $\Phi\ hole\ csk\ max = \Phi\ hole\ csk\ min(92/88)$

*

      NOTE 1—Value of H min. for cutting edge may be decreased to 10.9.
      NOTE 2—Value of H min. for cutting edge must be increased to 12.6.
      NOTE 3—Value of H min. for cutting edge must be increased to 12.9.
      NOTE 4—Value of H min. for cutting edge must be increased to 19.2.
      NOTE 5—Value of H min. for cutting edge must be increased to 20.9.
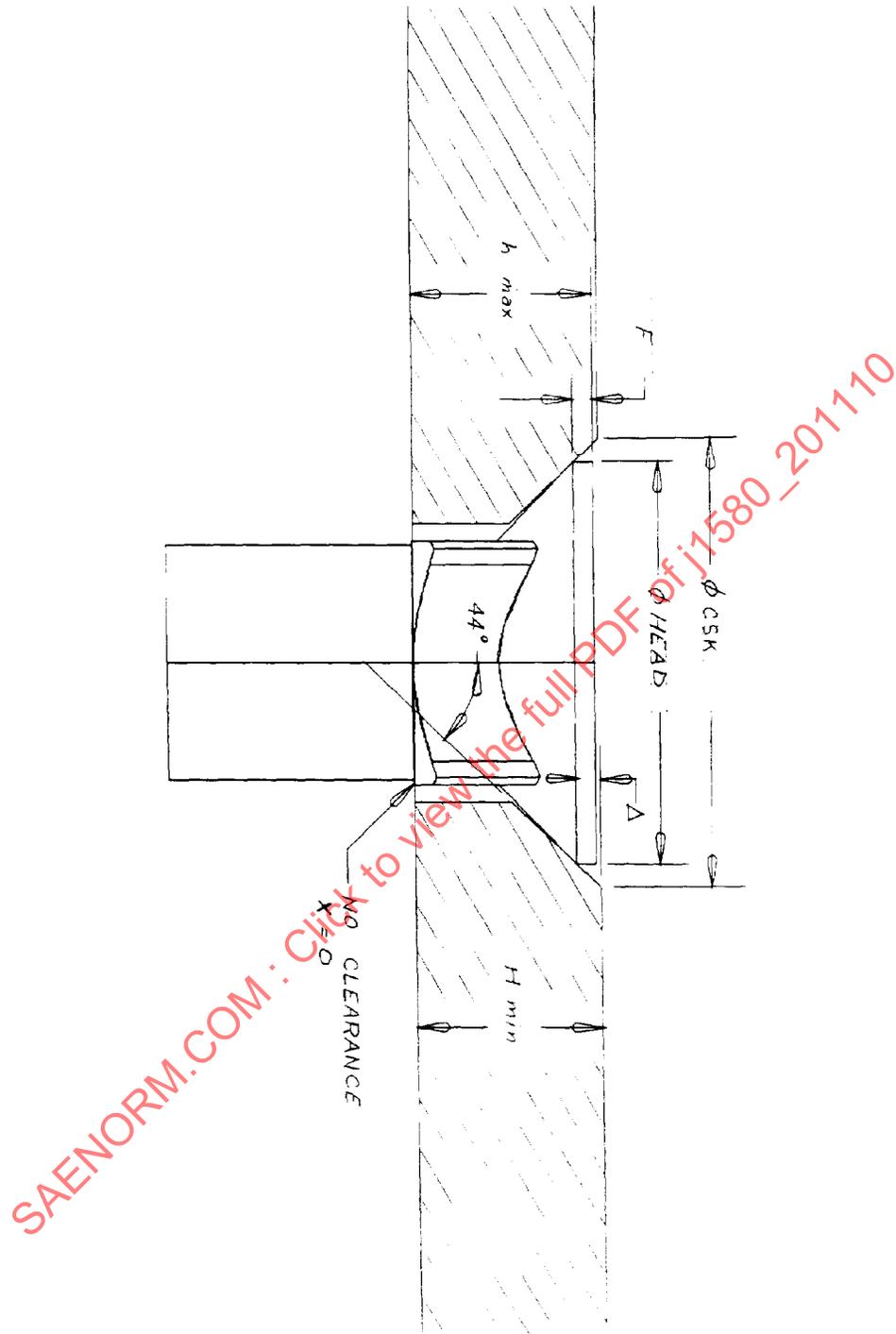
FIGURE A1—M24 WORST CASE (SCALE 2:1)

TABLE A2—DIMENSIONS FOR METRIC BOLTS TAKEN FROM ISO 7852-1982

Bolt Size	H		D		B		R	F	Z max. Bolt	Z min. Hole
Ref.	nominal	tolerances	nominal	tolerances	basic	tolerances	approx.		calculated	Table 1
M12	10.0	+ 0.45 − 0.45	23.0	+ 0.65 − 0.65	12.0	+ 0.7 − 0.0	2.0	1.0	16.387	17.624
M16	12.0	+ 0.55 − 0.55	28.0	+ 0.65 − 0.65	16.0	+ 0.7 − 0.0	2.0	1.5	22.043	23.281
M20	12.0	+ 0.55 − 0.55	35.0	+ 0.80 − 0.80	20.0	+ 0.8 − 0.0	2.0	1.5	27.842	28.503
M24	18.0	+ 0.65 − 0.65	42.0	+ 0.80 − 0.80	24.0	+ 0.8 − 0.0	2.4	2.0	33.184	34.160
M30	-		-		-		-	-	-	-
M36	17.5	+ 1.70 − 1.70	60.0	+ 1.00 − 1.00	36.0	+ 0.8 − 0	3.0	3.0	49.682	51.131

Formulae:

$$c = (R\sqrt{2}) - R = [(\sqrt{2}) - 1]R = .4142R$$
$$x = B\,(\sqrt{2})$$
$$Z = x - 2c$$

TABLE A3—CALCULATE MINIMUM MATERIAL THICKNESS FOR EDGE WITH REVERSE COUNTERSINK

Bolt Size Ref.	Depth of CSK calculated [1] max	H min NEW Calculated 2(depth)+2.0	H min old REFERENCE
M12	5.742	**13.485**	12.00
M16	6.378	**14.756**	16.00
M20	8.096	**18.192**	18.00
M24	10.355	**22.711**	25.00
M30	-		-
M36	15.509	**33.019**	30.00

1. Formula:
   Depth of CSK = $[(\Phi csk\ max/2) - (sq\ hole\ min/2)]/(\tan 88/2)$