

Submitted for recognition as an American National Standard

**BOLTS, SCREWS AND NUTS - EXTERNAL WRENCHING,
METRIC THREADS - DESIGN PARAMETERS FOR**

1. PURPOSE:

- 1.1 To establish design requirements for metric aerospace bolts, screws and nuts primarily for use on propulsion systems.
- 1.2 The smaller thread sizes are usually referred to as screws. For the purpose of this document, the term bolt will be used for all sizes.

2. SCOPE:

- 2.1 To fully define the following requirements for bolts with spline and hexagon heads of strength class up to but not including 1250 MPa:
 - (a) Head dimensions (See 3.1).
 - (b) Shank dimensions (See 3.2).
 - (c) Geometric control (See 3.3).
 - (d) Surface texture (See 3.4).

This standard is based on one class of thread after all processing, including coating or plating, has been completed as follows: Tolerance class 4h6h.

For particulars of thread, see AS 1370. For thread runout and lead threads, see AS 3062.

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- 2.2 To fully define the following requirements for nuts with spline, plain hexagon and castellated configurations of strength class up to and including 1100 MPa:

- (a) Nut dimensions (See 4.1).
- (b) Geometric control (See 4.2).
- (c) Surface texture (See 4.3).

For particulars of threads, see AS 1370.

This standard is based on the following classes of internal threads after all processing, including coating or plating, has been completed:

Tolerance class 4H6H for sizes up to and including 5 mm.
Tolerance class 4H5H for size 6 mm and larger.

For particulars of thread, see AS 1370.

3. GENERAL REQUIREMENTS FOR BOLTS (All dimensions are in millimetres):

3.1 Head Dimensions:

- 3.1.1 Spline wrenched bolts shall have a head configuration in accordance with Figure 1 and Table I.

- 3.1.1.1 Where heads are required to be drilled for lockwire, the particulars in Figure 1 and Table I shall apply.

- 3.1.2 Hexagon headed bolts shall have a head configuration in accordance with Figure 2 and Table II.

- 3.1.2.1 Where heads are required to be drilled for lockwire, the particulars in Figure 2 and Table II shall apply.

- 3.1.3 For hexagon bolts, the minimum distance across corners (Dimension E) is established by the following formula:

$$E \text{ min (TABLE II)} = (1.14 \times AF \text{ min}) - 0.2$$

AF = Across Flats

3.2 Shank Dimensions - Definitions:

- 3.2.1 Coarse Tolerance Shank Bolts: These are bolts having the following shank diameter tolerances:

Uncoated bolts - A tolerance greater than Grade F7 (ANSI B4.2-1978)

Coated bolts - A tolerance greater than 0.025 mm for sizes up to and including Ø30 mm and a tolerance of F7 for sizes over Ø30 mm. Both full shank and pitch diameter shank are included in this category.

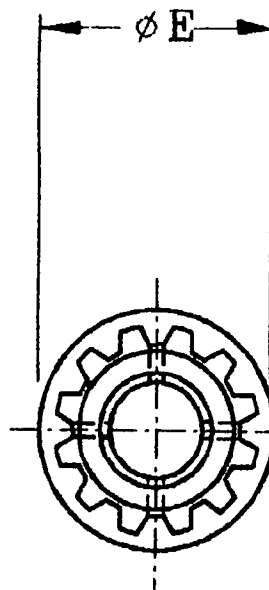
3.2.1.1 Length of bolt from under the head (Dimension L, Figures 3A and 3B) shall be in increments as follows:

- | | | |
|---|-----|--|
| D | Ø12 | 2 mm for lengths up to and including 60 mm |
| | | 4 mm for lengths over 60 mm |
| D | Ø14 | 4 mm for lengths up to and including 60 mm |

Lengths of standard range shall be in accordance with Table III.

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CURVED, FLAT, OR ANGULAR,
AT MANUFACTURER'S
OPTION WITHIN
ENVELOPE SHOWN



CURVED OR ANGULAR
WITHIN ENVELOPE

SPLINE CONFIGURATION
PER MA 1549-XX FOR
THIS DISTANCE

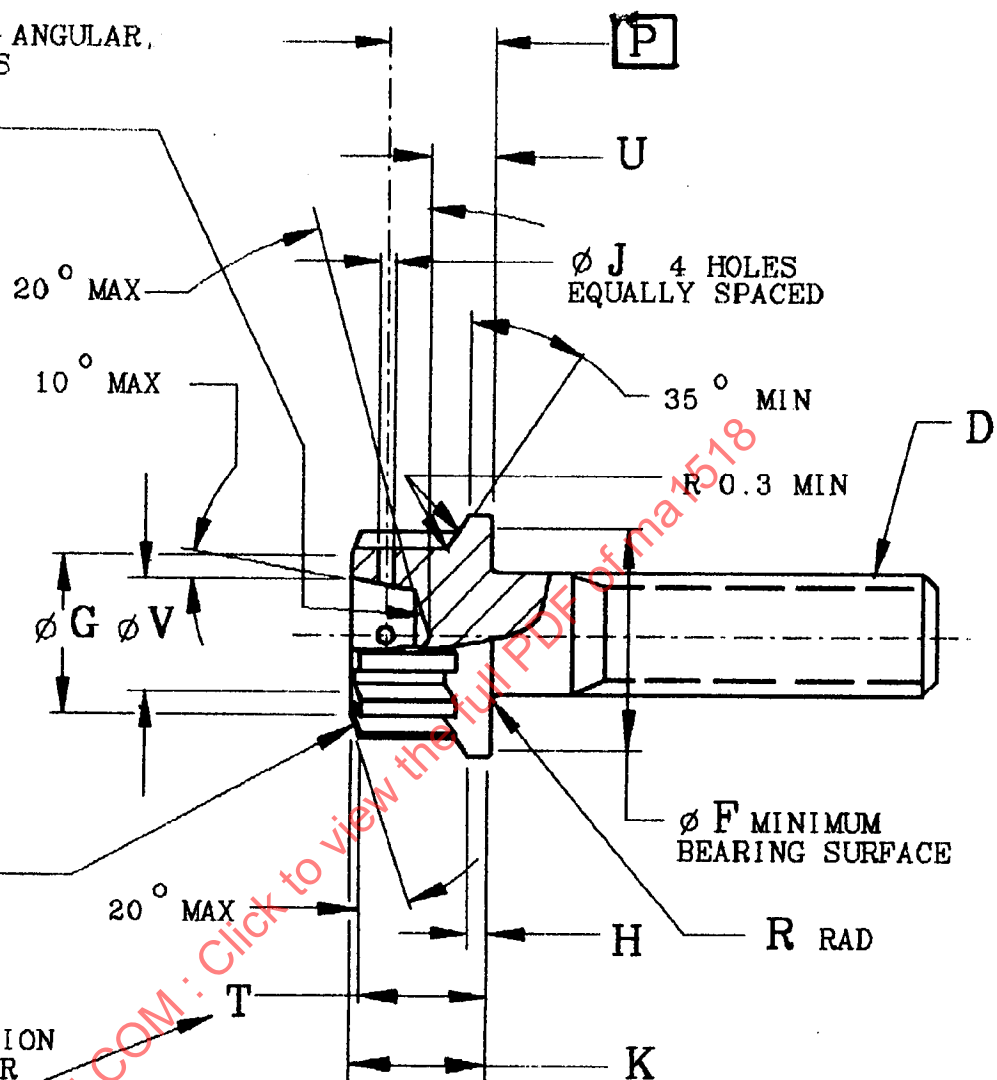


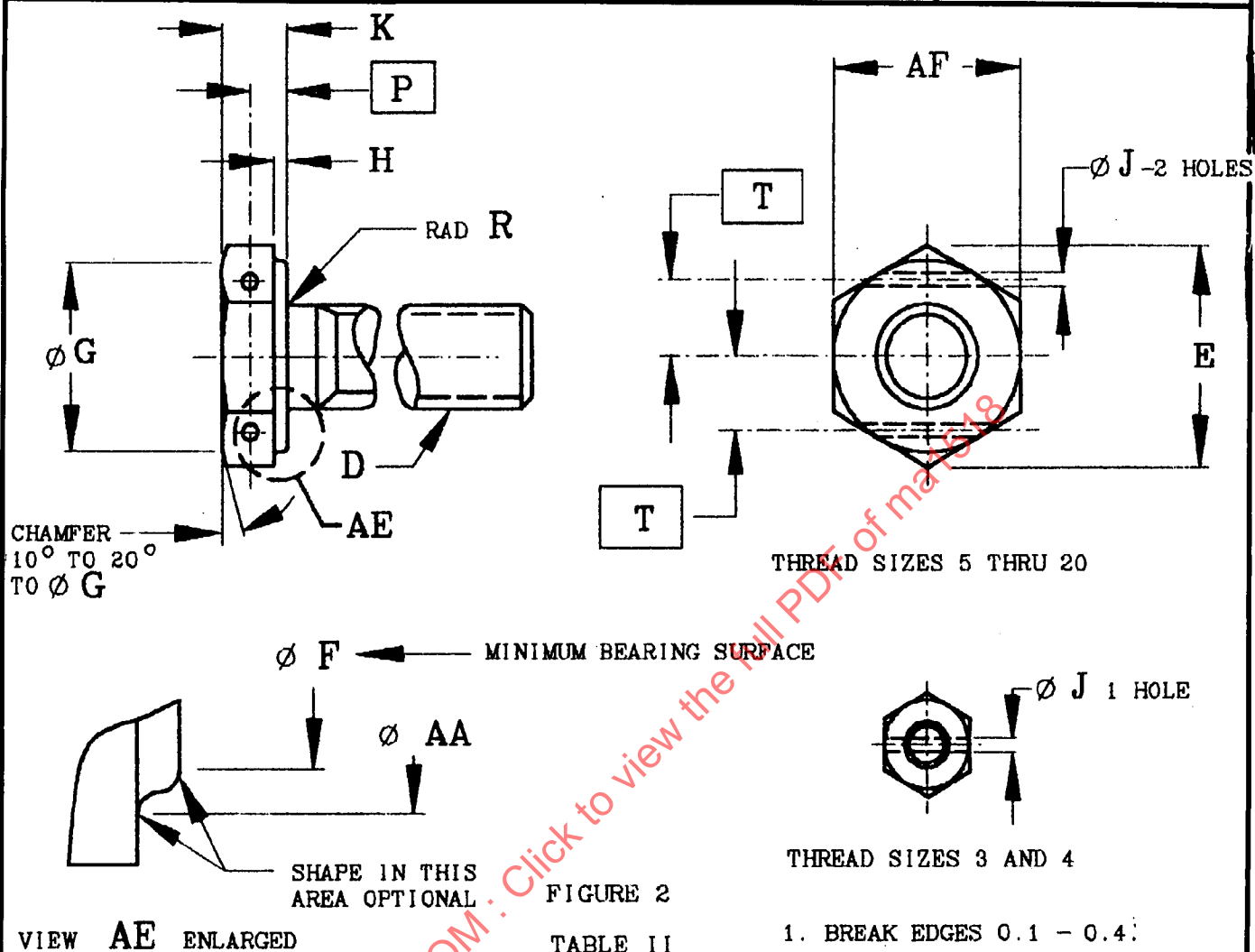
FIGURE 1

1. BREAK EDGES 0.1 - 0.4

TABLE I

D Thread Size	Wrench Dash No	E MAX	F MIN	G MIN	H MIN	J ¹ H13	K ¹ h15	P	R	T MIN	U	V
4 x 0.7	06	8.3	7.5	6	0.8	1.00 - 1.14	5.02 - 5.5	3.5	0.2 - 0.4	2.5	- -	- -
5 x 0.8	07	9.1	8.3	7	1.0	1.00 - 1.14	5.92 - 6.5	4.5	0.3 - 0.5	2.8	2.5 - 2.9	3.2 - 3.7
6 x 1	08	10.6	9.8	8	1.2	1.40 - 1.54	6.92 - 7.5	5.2	0.5 - 0.7	3.5	2.8 - 3.2	4.1 - 4.6
7 x 1	09	12.1	11.3	9	1.4	1.40 - 1.54	7.62 - 8.2	5.9	0.5 - 0.7	3.8	3.3 - 3.7	4.9 - 5.4
8 x 1	10	13.6	12.8	10	1.6	1.40 - 1.54	8.02 - 8.6	6.3	0.5 - 0.7	3.9	3.7 - 4.1	5.2 - 5.7
10 x 1.25	12	16.7	15.7	12	2.0	1.60 - 1.74	9.4 - 10.1	7.7	0.6 - 0.8	4.2	4.7 - 5.1	6.7 - 7.2
12 x 1.25	14	19.9	18.8	14	2.4	1.60 - 1.74	10.7 - 11.4	8.8	0.6 - 0.9	4.5	5.6 - 6.0	8.0 - 8.5

¹ Tolerance grade to ANSI B4.2 - 1978



D THREAD SIZE	E MIN	F MIN	G MIN	H	J H13 ¹	K ²	P	R	AF ¹	T	AA MAX
3 x 0.5	7.6	6.4	6.5	0.2 - 0.5	1.00 - 1.14	3.1 - 3.4	1.55	0.2 - 0.4	6.85 - 7.00	-	7.25
4 x 0.7	8.7	7.4	7.5	0.2 - 0.5	1.00 - 1.14	3.6 - 3.9	1.80	0.2 - 0.4	7.85 - 8.00	-	8.25
5 x 0.8	9.8	8.3	8.4	0.2 - 0.5	1.00 - 1.14	2.7 - 3.0	1.35	0.3 - 0.5	8.78 - 9.00	3.7	9.25
6 x 1	12.0	10.2	10.3	0.2 - 0.5	1.40 - 1.54	3.2 - 3.5	1.60	0.5 - 0.7	10.73 - 11.00	4.5	11.25
7 x 1	13.2	11.2	11.3	0.2 - 0.5	1.40 - 1.54	3.7 - 4.0	1.85	0.5 - 0.7	11.73 - 12.00	4.95	12.25
8 x 1	15.5	13.2	13.3	0.3 - 0.6	1.40 - 1.54	4.2 - 4.5	2.10	0.5 - 0.7	13.73 - 14.00	5.8	14.25
10 x 1.25	18.9	16.0	16.3	0.3 - 0.6	1.60 - 1.74	4.7 - 5.0	2.35	0.6 - 0.8	16.73 - 17.00	7.1	17.25
12 x 1.25	21.1	18.0	18.3	0.3 - 0.6	1.60 - 1.74	5.7 - 6.0	2.85	0.6 - 0.9	18.67 - 19.00	7.9	19.25
14 x 1.5	24.5	21.0	21.3	0.3 - 0.6	1.60 - 1.74	6.7 - 7.0	3.35	0.8 - 1.1	21.67 - 22.00	9.2	22.25
16 x 1.5	26.8	23.0	23.3	0.3 - 0.6	1.60 - 1.74	7.7 - 8.0	3.85	0.8 - 1.1	23.67 - 24.00	10.05	24.25
18 x 1.5	30.2	26.0	26.3	0.3 - 0.6	1.60 - 1.74	8.7 - 9.0	4.35	1.0 - 1.3	26.57 - 27.00	11.3	27.25
20 x 1.5	33.6	29.0	29.3	0.3 - 0.6	1.60 - 1.74	9.7 - 10.0	4.85	1.0 - 1.3	29.67 - 30.00	12.6	30.25

¹ Tolerance grades to ANSI B4.2 - 1978

² The head height for thread sizes 3 and 4 is greater in proportion to other sizes to accommodate lockwire drilling through center of flats. See Figure 2.

- 3.2.1.2 Lengths of Thread: Bolts not threaded to head shall have a thread length equal to $2D + b$.

Where D = Nominal thread size.

- 3.2.1.3 Length of shank plain portion (Dimension N) and length of shank to start of full thread (Dimension M) fall into two categories with a transitional stage depending on underhead length L as described below:

- 3.2.1.3.1 Bolts not threaded to head:

$$M \text{ max} = L - (2D + 6)$$

$$N \text{ min} = M \text{ max} - (2P + 1.5 \text{ mm}) \text{ except for transitional sizes. See 3.2.1.3.2 and Table III.}$$

Where L = Underhead length of bolt

D = Nominal thread size

P = Pitch of thread

1.5 mm = tolerance on length of plain shank

- 3.2.1.3.2 Bolts threaded to head:

$$N \text{ min} = R \text{ max}$$

$$M \text{ max} = R \text{ max} + 2P$$

Where R = Underhead radius (Tables I and II)

- 3.2.1.3.3 The transition for bolts threaded to the head occurs when $N \text{ min}$ obtained from the formula $N \text{ min} = M \text{ max} - (2P + 1.5 \text{ mm})$ provides a value less than the underhead radius, $R \text{ max}$ and is therefore not acceptable.

- 3.2.1.3.4 At this transition stage, the following formulae apply:

$$N \text{ min} = R \text{ max for bolts threaded to head}$$

$$M \text{ max} = L - (2D + 6) \text{ for bolts not threaded to head}$$

The underhead lengths L at which this transition occurs are shown in Table III.

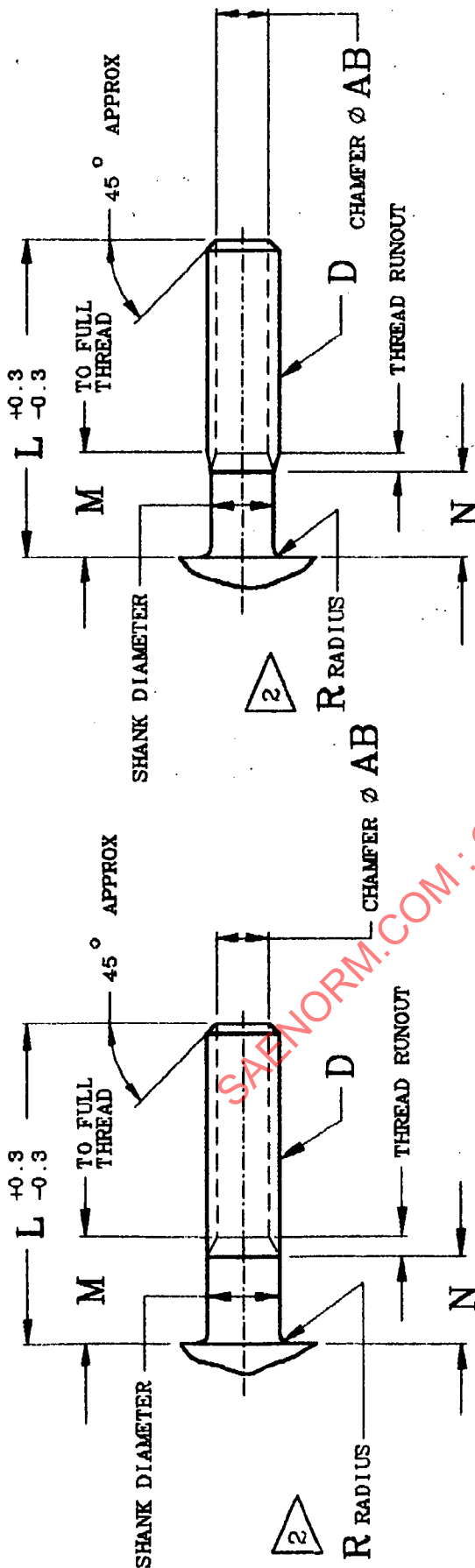


FIGURE 3A - COARSE TOLERANCE-FULL SHANK

FIGURE 3B - COARSE TOLERANCE-PITCH DIAMETER SHANK

TABLE 111

D THREAD SIZE	UNDERHEAD LENGTH (L) RANGE		UNDERHEAD LENGTH AT TRANSITION STAGE. SEE PARAGRAPH 3.2.1.3.2	SHANK DIAMETER FOR COARSE TOLERANCE FULL SHANK BOLTS ht2	SHANK DIAMETER FOR PITCH DIAMETER SHANK BOLTS	CHAMFER AB
	FULL SHANK	PITCH DIAMETER SHANK				
3 x 0.5	14 thru 42	4 thru 42	14	2.90 - 3.00	2.55 - 2.81	1.8 - 2.3
4 x 0.7	18 thru 56	6 thru 56	16	3.88 - 4.00	3.42 - 3.68	2.6 - 3.1
5 x 0.8	20 thru 68	8 thru 68	NOT APPLICABLE	4.88 - 5.00	4.35 - 4.61	3.0 - 4.0
6 x 1	22 thru 84	10 thru 84	22	5.88 - 6.00	5.22 - 5.48	3.7 - 4.7
7 x 1	24 thru 96	10 thru 96	24	6.85 - 7.00	6.22 - 6.48	4.7 - 5.7
8 x 1	26 thru 112	10 thru 112	26	7.85 - 8.00	7.22 - 7.48	5.7 - 6.7
10 x 1.25	32 thru 140	14 thru 140	30	9.85 - 10.00	9.06 - 9.32	7.4 - 8.4
12 x 1.25	36 thru 168	16 thru 168	34	11.82 - 12.00	11.06 - 11.32	9.4 - 10.4
14 x 1.5	40 thru 198	20 thru 198	NOT APPLICABLE	13.82 - 14.00	12.90 - 13.16	11.1 - 12.1
16 x 1.5	44 thru 222	20 thru 222	NOT APPLICABLE	15.82 - 16.00	14.90 - 15.16	13.1 - 14.1
18 x 1.5	48 thru 252	24 thru 252	46	17.82 - 18.00	16.90 - 17.16	15.1 - 16.1
20 x 1.5	52 thru 276	24 thru 276	50	19.79 - 20.00	18.90 - 19.16	17.1 - 18.1

1 Tolerance grades to ANSI B4.2 - 1978

2 See Tables I and II for values

3.2.1.4 Diameter of Shank: Coarse tolerance shank bolts

3.2.1.4.1 Full Shank Coarse Tolerance Bolts: Full shank coarse tolerance bolts (see Figure 3A) shall have tolerance grade h12 applied to the plain shank (see Table III).

3.2.1.4.2 Pitch Diameter Shank Bolts: Pitch diameter shank bolts (see Figure 3B) shall have a shank diameter equal to the maximum pitch diameter with a ± 0.13 tolerance (see Table III).

3.2.1.4.3 Threaded to Head Bolts: All bolts where plain shank N min = R max (this includes transitional sizes, see 3.2.1.3.2 and Table III) shall be designed with pitch diameter shanks.

3.2.1.5 Lead Thread Chamfer: Particulars of chamfer diameter are given in Table III; for other particulars, refer to AS 3062.

3.2.2 Close Tolerance Shank Bolts (See Figure 4): In the case of uncoated bolts, these are bolts having a tolerance on the shank diameter equal to or less than f7. In the case of coated bolts, these are bolts having a tolerance on the shank equal to or less than 0.025 mm for shank sizes equal to or less than 30 mm and a tolerance equal to or less than f7 for shank sizes greater than 30 mm.

3.2.2.1 Length of plain shank from underhead (Dimension N) shall be in steps of:

- 1 mm up to and including 30 mm)
 - 2 mm above 30 and up to 100 mm)
 - 4 mm above 100mm)
- The range of lengths shall be in accordance with Table IV.

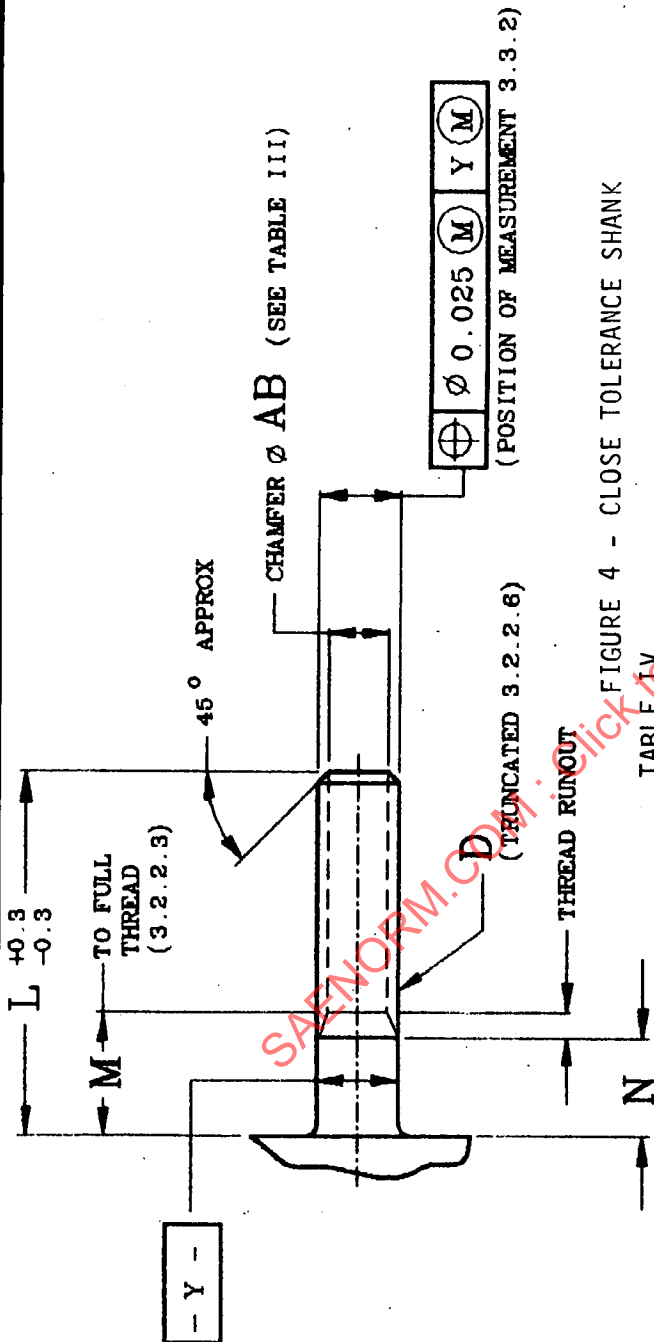


FIGURE 4 - CLOSE TOLERANCE SHANK

TABLE IV

D THREAD SIZE	UNDERHEAD LENGTH RANGE N MIN	SHANK DIAMETER FOR CLOSE TOLERANCE BOLTS		TRUNCATED MAJOR DIA OF THREAD ²	
		UNCOATED f7 ¹	COATED	UNCOATED	COATED
3 x 0.5	2 thru 30	2.984 - 2.994	2.969 - 2.994	2.894 - 2.959	2.984 - 2.944
4 x 0.7	2 thru 40	3.978 - 3.990	3.965 - 3.990	3.860 - 3.953	3.860 - 3.940
5 x 0.8	3 thru 50	4.978 - 4.990	4.965 - 4.990	4.850 - 4.953	4.850 - 4.940
6 x 1	3 thru 60	5.978 - 5.990	5.965 - 5.990	5.820 - 5.953	5.820 - 5.940
7 x 1	4 thru 70	6.972 - 6.987	6.962 - 6.987	6.820 - 6.947	6.820 - 6.937
8 x 1	4 thru 80	7.972 - 7.987	7.962 - 7.987	7.820 - 7.947	7.820 - 7.937
10 x 1.25	5 thru 100	9.972 - 9.987	9.962 - 9.987	9.788 - 9.947	9.788 - 9.937
12 x 1.25	6 thru 120	11.966 - 11.984	11.959 - 11.984	11.788 - 11.941	11.788 - 11.934
14 x 1.5	7 thru 140	13.966 - 13.984	13.959 - 13.984	13.764 - 13.941	13.764 - 13.934
16 x 1.5	8 thru 160	15.966 - 15.984	15.959 - 15.984	15.764 - 15.941	15.764 - 15.934
18 x 1.5	9 thru 180	17.966 - 17.984	17.959 - 17.984	17.764 - 17.941	17.764 - 17.934
20 x 1.5	10 thru 200	19.959 - 19.980	19.955 - 19.980	19.764 - 19.934	19.764 - 19.930

¹ Tolerance grades to ANSI B4.2 - 1978.² This diameter must always be at least 0.025 mm less than the actual (measured) shank diameter.
See also 3.2.2.6.

3.2.2.2 The Maximum length of shank to full thread:

$$M \text{ max} = N \text{ min} + 2P + 0.25$$

Where P = Pitch of thread

3.2.2.3 Nominal length of thread (See Figure 4):

This shall be computed as follows:

Length of thread = A + (maximum nut height - B) + 3P rounded to the nearest 0.5

Where A = bolt length increment

B = The minimum summation of all counterbores and all chamfers or countersinks at the bearing surface whose nominal diameter is greater than the basic major diameter of the nut thread. Chamfers and countersinks which are equal to the basic major diameter of the nut thread are not included.

3P = 1.5P for lead threads and 1.5P for tolerances on clamped parts and bolt overall length

P = Pitch of thread

Note: The 1.5P lead threads take account of the fact that the thread pitch diameter may not conform with the thread specification for a distance up to 1.5P from the end of the bolt and therefore will not be effective screw threads.

3.2.2.4 The nominal length of bolt from underhead (Dimension L, Figure 4) equals:

M max + nominal length of thread.

This length should be rounded up to the nearest 0.5 mm.

3.2.2.5 Diameter of Shank - Close Tolerance Shank Bolts, See Table IV: For uncoated bolts, the close tolerance shanks shall have the size and tolerance given by class 'f7' (ANSI B4.2 - 1978) applied to the basic bolt diameter.

Coated close tolerance shank bolts shall have a maximum shank diameter given by class 'f' fundamental deviation, applied to the basic bolt diameter, with a tolerance of 0.025 mm for sizes up to and including 30 mm basic bolt diameter.

Coated close tolerance shank bolts over 30 mm diameter shall have shank sizes and tolerances given by class 'f7' applied to the basic bolt diameter.

3.2.2.6 The maximum thread major diameter shall be modified and made equal to the minimum shank diameter less 0.025. The minimum thread major diameter shall remain unchanged. See Table IV for details.

3.2.2.7 Lead Thread Chamfer: Particulars of chamfer diameter are the same as for coarse tolerance shank bolts (see 3.2.1.5.)

3.3 Geometric Control: For definitions of the terms "coarse tolerance" and "close tolerance shank bolts" as used in Tables V and VI, refer to 3.2.1 and 3.2.2.

For interpretation of geometry, refer to AS 3063.

3.3.1 Straightness of shank and thread shall be in accordance with Table V.

3.3.2 Relationship of shank to thread pitch diameter shall be in accordance with Table VI.

When the shank length AD is less than AC shown in Figure 5, the coaxiality tolerance shall be measured at a distance of half of the actual full shank length from the end of the incomplete thread.

3.3.3 Relationship of washer face diameter and spline/hexagon form to shank shall be in accordance with Table VI.

For bolts having an unthreaded shank length less than 1 diameter, the thread pitch diameter should replace the shank diameter as datum Y in Figure 5 and the tolerances in Table VI related to the thread pitch diameter.

3.3.4 Relationship of thread major diameter to shank shall be as shown in Figure 4.

TABLE V

STRAIGHTNESS OF SHANK AND THREAD		
Nominal Thread Size	Coarse Tolerance Shank	Coarse Tolerance Shank
3 to 8	$\varnothing 0.003L$	$\varnothing 0.002L$
10 to 20	$\varnothing 0.0025L$	$\varnothing 0.0015L$

L = BOLT UNDERHEAD LENGTH

TABLE VI

RUNOUT OF SHANK IN RELATION TO THREAD PITCH DIAMETER		RUNOUT OF WASHER FACE DIAMETER AND SPLINES, OR HEXAGON OUTSIDE DIAMETER, IN RELATION TO SHANK	
Nominal Thread Size	Coarse and Close Tolerance Shank	Hexagon Head	Washer Face and Spline
3 x 0.5	0.1	0.15	0.08
4 x 0.7	0.12	0.2	0.1
5 x 0.8	0.12	0.25	0.13
6 x 1	0.12	0.3	0.15
7 x 1	0.15	0.35	0.18
8 x 1	0.15	0.4	0.2
10 x 1.25	0.15	0.5	0.25
12 x 1.25	0.18	0.6	0.3
14 x 1.5	0.18	0.7	0.35
16 x 1.5	0.18	0.75	0.4
18 x 1.5	0.18	0.75	0.45
20 x 1.5	0.21	0.75	0.5

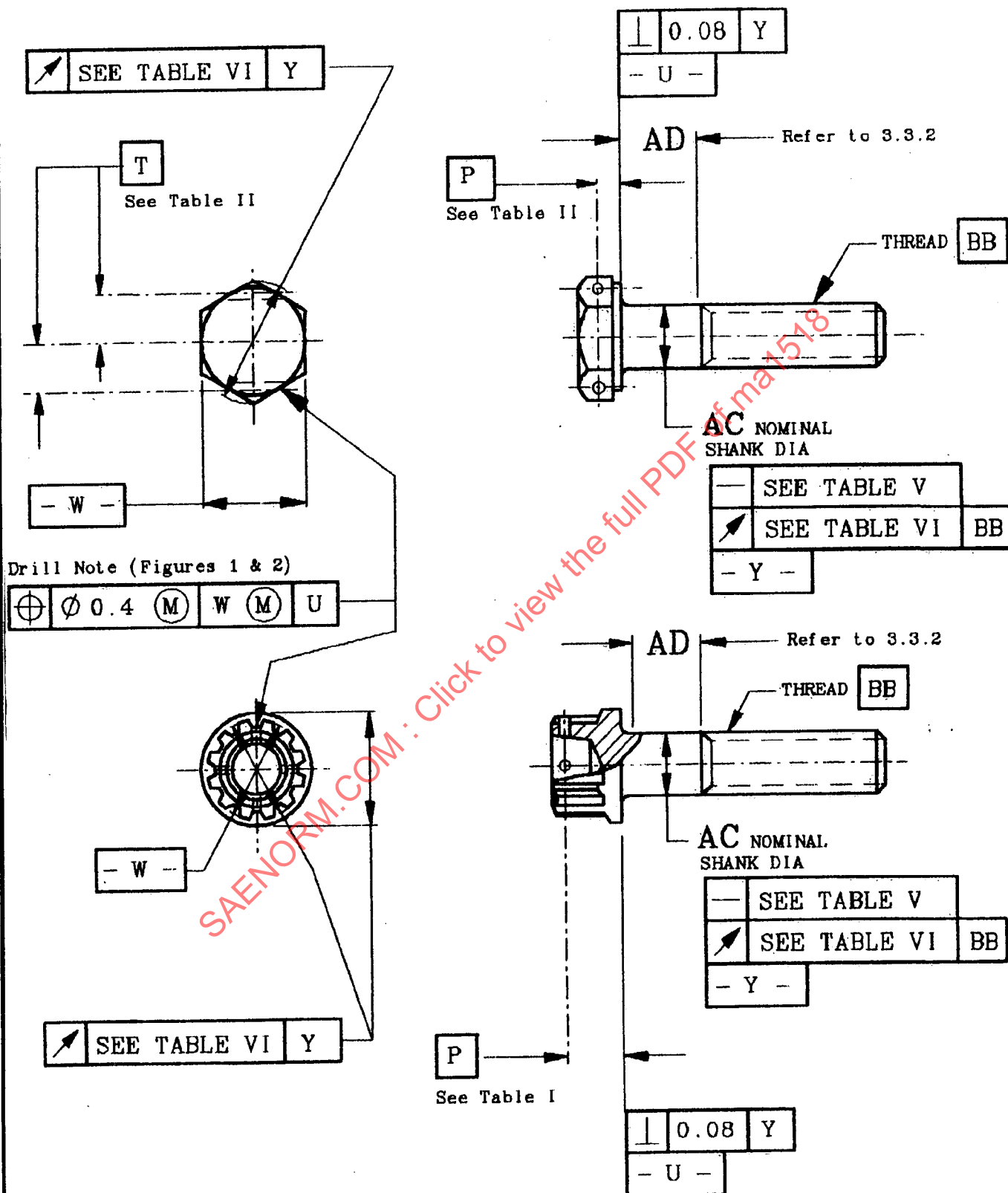


FIGURE 5

3.4 Surface Texture: Symbols per ANSI Y14.36-1978; requirements per ANSI B46.1-1978.

3.4.1 Surfaces to be 3.2 micrometres except where specified otherwise (see Figure 6).

3.4.2 Underhead Radius.

3.4.2.1 When cold rolled, surface roughness to be 0.8 micrometres.

3.4.2.2 When not cold rolled, surface roughness to be same as that specified for shank and washer face.

3.4.3 Shank and Washer Face.

3.4.3.1 For bolts that require removal of decarburization and/or oxide from shank and washer face, surface roughness to be 0.8 micrometres.

3.4.3.2 For bolts that do not require removal of decarburization and/or oxide from shank and washer face, surface roughness to be 1.6 micrometres.

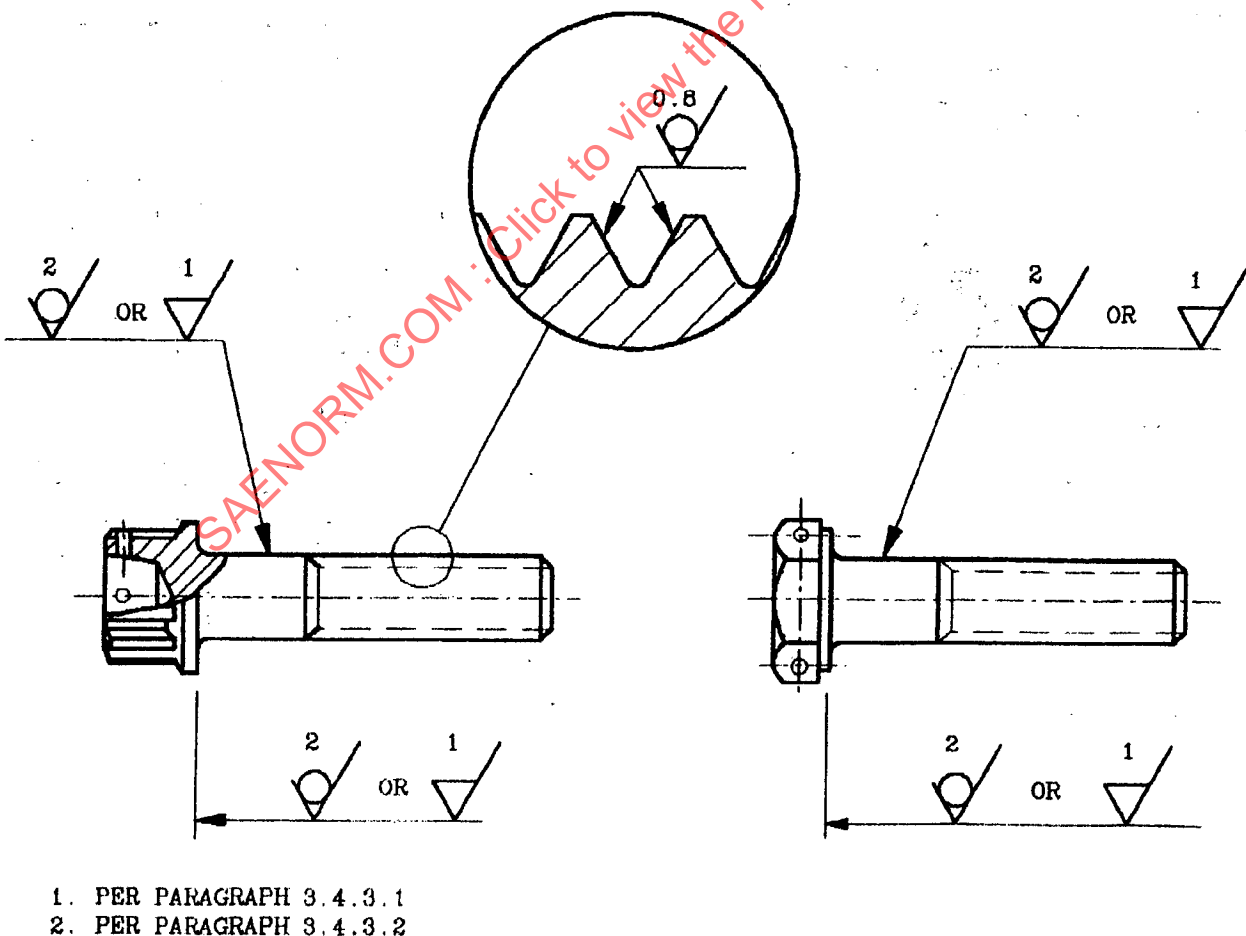


FIGURE 6

4. GENERAL REQUIREMENTS FOR NUTS (All dimensions are in millimetres):

4.1 Nut Dimensions

4.1.1 Spline drive nut configuration shall be in accordance with Figure 7 and Table VII for nuts of strength class up to 1250 MPa. Higher strength nuts may require increased flange diameter and thickness.

4.1.2 Plain hexagon nuts shall be in accordance with Figure 8 and Table VIII for nuts of strength class up to 1250 MPa.

4.1.3 Castellated nuts shall be in accordance with Figure 9 and Table IX for nuts of strength class up to 1250 MPa.

4.2 Geometric Control.

4.2.1 Geometric Control of splined, castellated and hexagon nuts to be in accordance with Figure 10 and Table X.

4.2.2 Chamfer diameter at the end of the thread shall be concentric with the thread within an amount that permits the chamfer to be eccentric down to the major diameter.

4.3 Surface Texture: Symbols per ANSI Y14.36-1978
Requirements per ANSI B46.1-1978

4.3.1 Surfaces to be 3.2 micrometres Ra except where shown otherwise.