SAE Aerospace
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AEROSPACE STANDARD

SAE MA1518 | REV. B

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Reaffirmed 2012-11

Superseding MA1518A

Bolts, Screws and Nuts - External Wrenching, Metric Threads - Design Parameters for

RATIONALE

MA1518B has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE:

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 document 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 AS1370. For thread runout and lead threads, see AS3062.

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 AS1370.

This document 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 AS1370.

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1.1 Purpose:

To establish design requirements for metric aerospace bolts, screws and nuts primarily for use on propulsion systems.

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. APPLICABLE DOCUMENTS:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications:

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

MA1549	Wrenching Configuration, 12 Spline, for Metric Threaded Fasteners
AS1370	Screw Threads - MJ Profile, Metric
AS3062	Bolts, Screws and Studs - Screw Thread Requirements
AS3063	Bolts, Screws and Studs - Geometric Control Requirements

2.2 ASME Publications:

Available from ASME, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900.

ANSI B4.2	Preferred Metric Limits and Fits
AMSE B46.1	Surface Texture (Surface Roughness, Waviness and Lay)
AMSE Y14.36	Surface Texture Symbols

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

3.1 Head Dimensions:

3.1.1 Spline wrenched bolts shall have a head configuration in accordance with Figure 1 and Table 1 or Figure 2 and Table 2.

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

3.1.1.2 Where heads required without a lockwire hole, the particulars in Figure 2 and Table 2 shall apply.

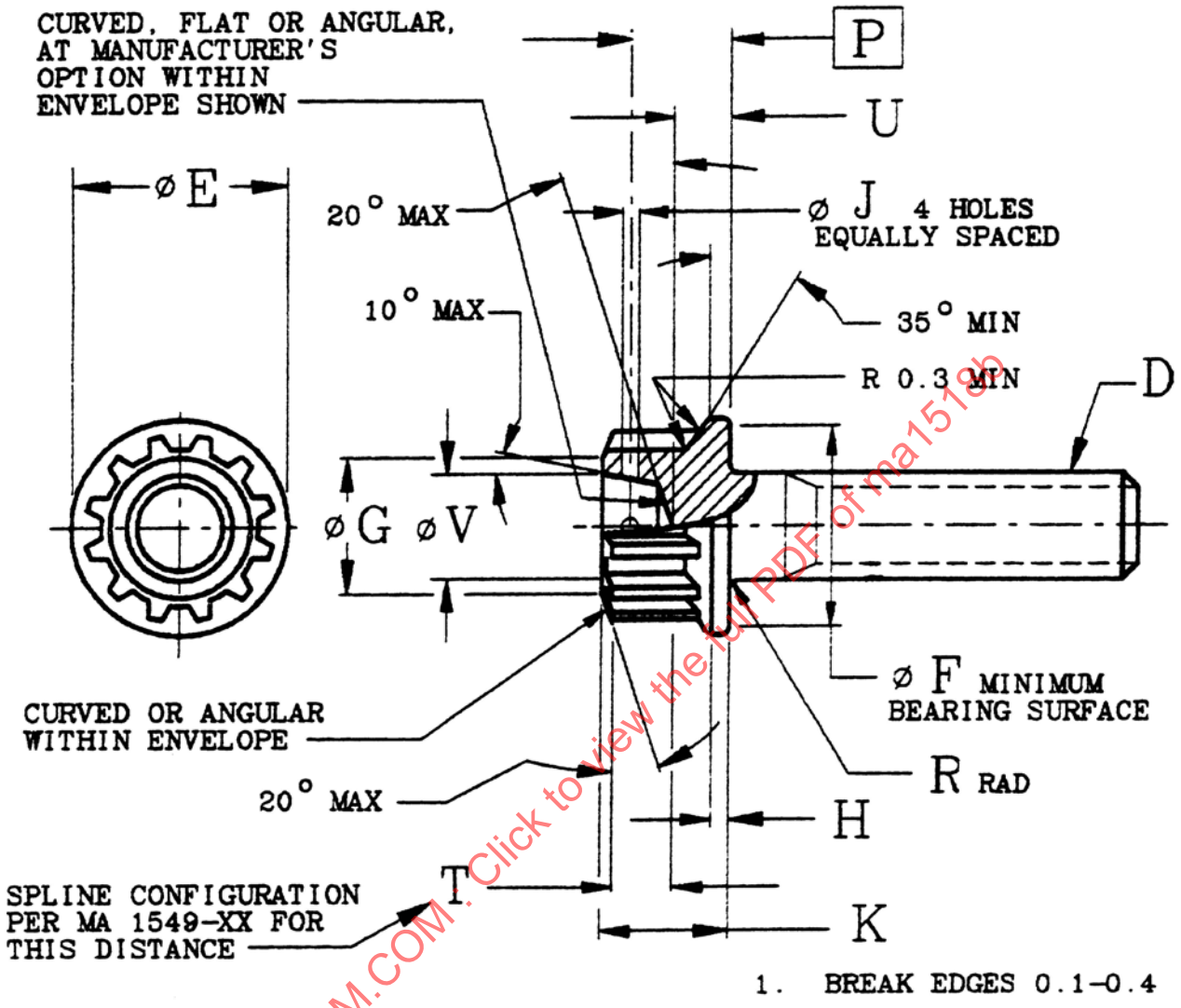

FIGURE 1

TABLE 1

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	4.4-3.92	3.5	0.2-0.4	1.68	---	---
5 x 0.8	07	9.1	8.3	7	1.0	1.00-1.14	5.4-4.92	4.5	0.3-0.5	2.51	2.5-2.9	3.2-3.7
6 x 1	08	10.6	9.8	8	1.2	1.40-1.54	6.0-5.52	5.2	0.5-0.7	2.98	2.8-3.2	4.1-4.6
7 x 1	09	12.1	11.3	9	1.4	1.40-1.54	6.7-6.12	5.9	0.5-0.7	2.85	3.3-3.7	4.9-5.4
8 x 1	10	13.6	12.8	10	1.6	1.40-1.54	7.1-6.52	6.3	0.5-0.7	2.72	3.7-4.1	5.2-5.7
10 x 1.25	12	16.7	15.7	12	2.0	1.60-1.74	8.4-7.92	7.7	0.6-0.8	3.08	4.7-5.1	6.7-7.2
12 x 1.25	14	19.9	18.8	14	2.4	1.60-1.74	9.7-8.12	8.8	0.6-0.9	4.13	5.6-6.0	8.0-8.5

[1] Tolerance grade to ANSI B4.2-1978.

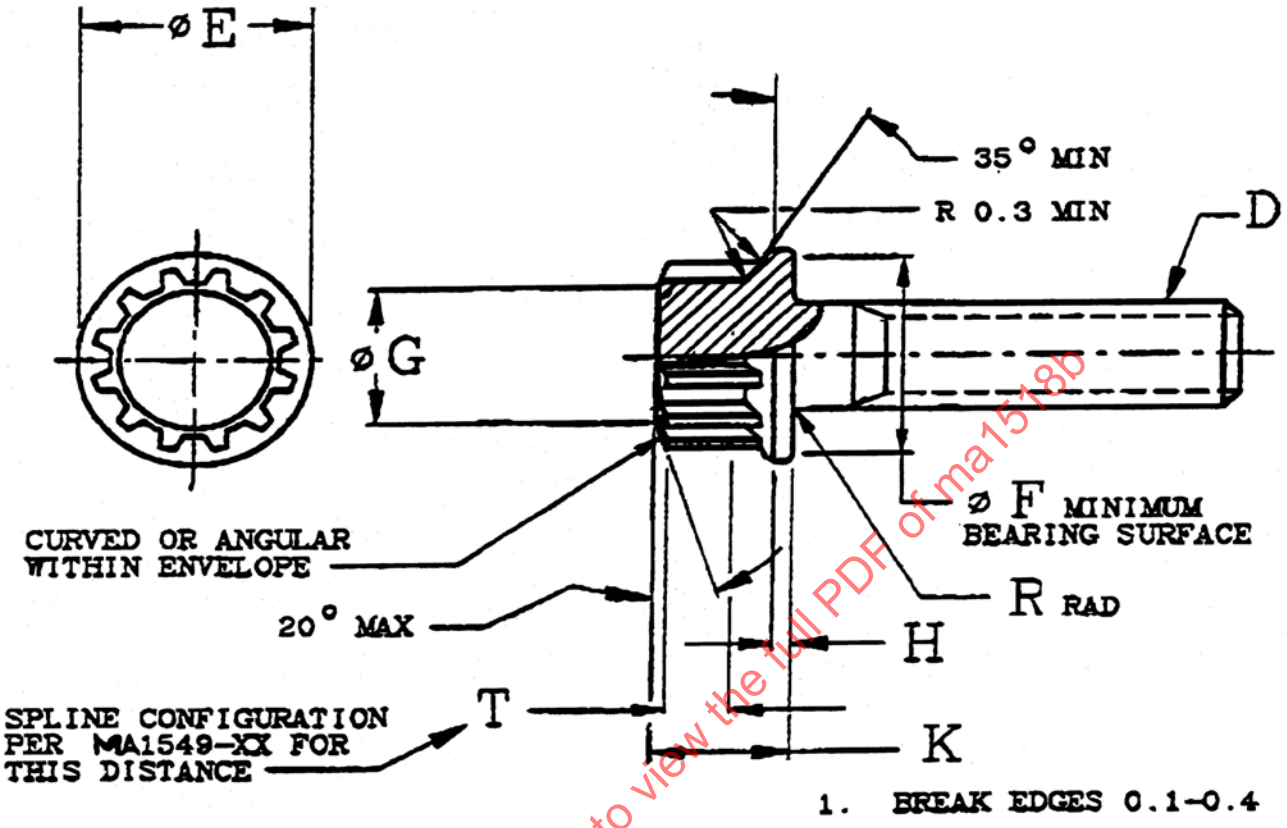

FIGURE 2

TABLE 2

D Thread Size	Wrench Dash No.	E Max	F Min	G Min	H Min	K[1] h15	R	T Min
4 x 0.7	06	8.3	7.5	6	0.8	4.4-3.92	0.2-0.4	1.68
5 x 0.8	07	9.1	8.3	7	1.0	5.4-4.92	0.3-0.5	2.51
6 x 1	08	10.6	9.8	8	1.2	6.0-5.52	0.5-0.7	2.98
7 x 1	09	12.1	11.3	9	1.4	6.7-6.12	0.5-0.7	2.85
8 x 1	10	13.6	12.8	10	1.6	7.1-6.52	0.5-0.7	2.72
10 x 1.25	12	16.7	15.7	12	2.0	8.4-7.92	0.6-0.8	3.08
12 x 1.25	14	19.9	18.8	14	2.4	9.7-8.12	0.6-0.9	4.13

[1] Tolerance grade to ANSI B4.2-1978.

3.1.2 Hexagon headed bolts shall have a head configuration in accordance with Figure 3 and Table 3.

3.1.2.1 Where heads are required to be drilled for lockwire, the particulars in Figure 3 and Table 3 shall apply.

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

$$E \text{ min (Table 3)} = (1.14 \times AF \text{ min}) - 0.2 \qquad \text{(Eq.1)}$$

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)

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 4A and 4B) 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 4.

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.
b = 6 mm

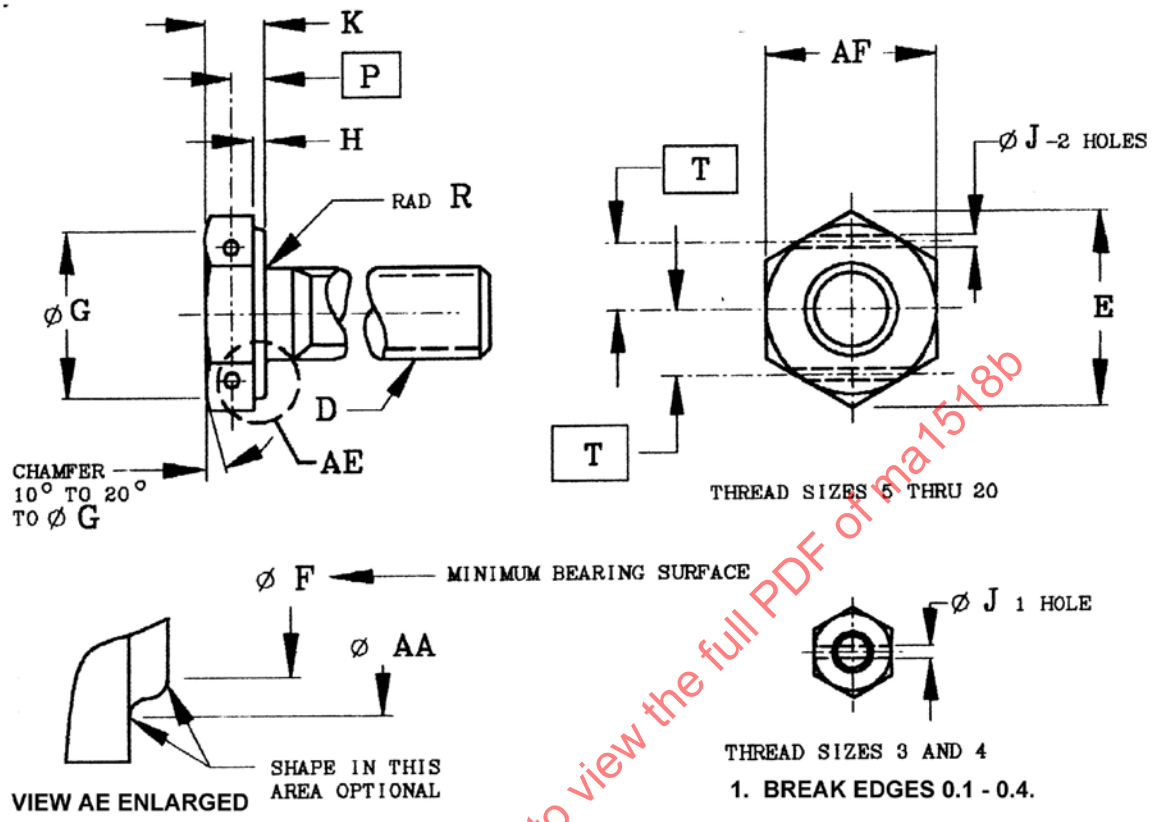

FIGURE 3

TABLE 3

D Thread Size	E Min	F Min	G Min	H	J H13[1]	K[2]	P	R	AF[1]	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	h12	---	7.25
4 x 0.7	8.7	7.4	7.5	0.2-0.5	1.00-1.14	4.02- 4.5	1.80	0.2-0.4	7.85- 8.00	h12	---	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	h13	3.7	9.25
6 x 1	12.0	10.2	10.3	0.2-0.5	1.40-1.54	5.82- 6.4	1.60	0.5-0.7	10.73-11.00	h13	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	h13	4.95	12.25
8 x 1	15.5	13.2	13.3	0.3-0.6	1.40-1.54	6.42- 7.0	2.10	0.5-0.7	13.73-14.00	h13	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	h13	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	h13	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	h13	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	h13	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	h13	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	h13	12.6	30.25

[1] Tolerance grades to ANSI B4.2.

[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 3.

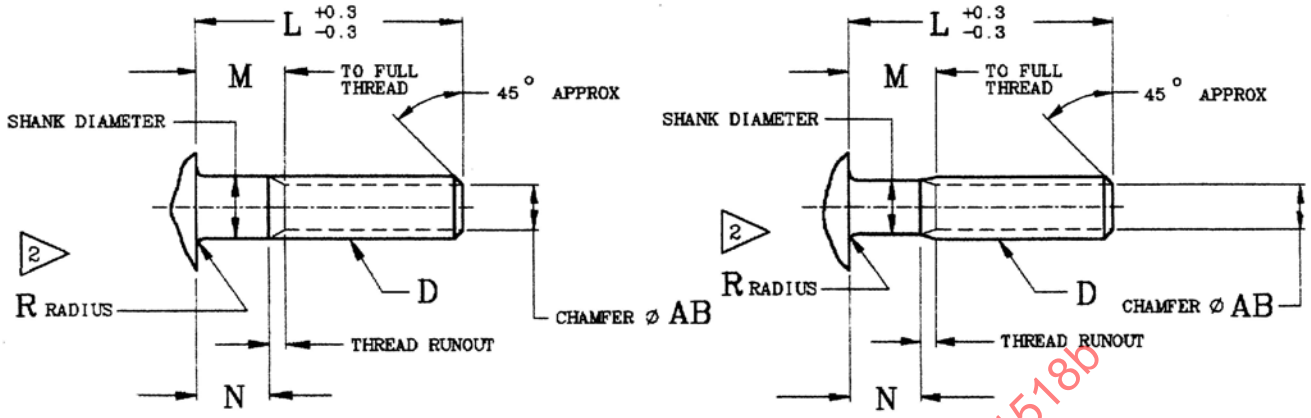

FIGURE 4A - COARSE TOLERANCE-FULL SHANK

FIGURE 4B - COARSE TOLERANCE-PITCH DIAMETER SHANK

FIGURE 4

TABLE 4

D Thread Size	Underhead Length (L) Range Full Shank	Underhead Length (L) Range Pitch Diameter Shank	Underhead Length at Transition Stage See 3.2.1.3.2 L	Shank Diameter for Coarse Tolerance Full Shank Bolts h12[1]	Shank Diameter for Pitch Diameter Shank Bolts	Chamfer AB
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.
[2] See Tables 1 and 3 for values.

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:

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

$$N\ min = M\ max - (2P + 1.5\ mm)$$

except for transitional sizes. See 3.2.1.3.2 and Table 4.

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:

$$N\ min = R\ max \quad \text{(Eq.3)}$$

$$M\ max = R\ max + 2P$$

Where:

R = Underhead radius (Tables 1 and 3)

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

3.2.1.3.4 At this transition stage, the following formulae apply:

$$N\ min = R\ max \text{ for bolts threaded to head} \quad \text{(Eq.4)}$$

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

The underhead lengths L at which this transition occurs are shown in Table 4.

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 4A) shall have tolerance grade h12 applied to the plain shank (see Table 4).

3.2.1.4.2 Pitch Diameter Shank Bolts: Pitch diameter shank bolts (see Figure 4B) shall have a shank diameter equal to the maximum pitch diameter with a ±0.13 tolerance (see Table 4).

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 4) shall be designed with pitch diameter shanks.

3.2.1.5 Lead Thread Chamfer: Particulars of chamfer diameter are given in Table 4; for other particulars, refer to AS3062.

3.2.2 Close Tolerance Shank Bolts (see Figure 5): 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 100 mm

The range of lengths shall be in accordance with Table 5.

3.2.2.2 The maximum length of shank to full thread:

$$M\ max = N\ min + 2P + 0.25 \quad \text{(Eq.5)}$$

Where:

P = Pitch of thread

3.2.2.3 Nominal Length of Thread (see Figure 5): This shall be computed as follows:

$$\text{Length of thread} = A + (\text{maximum nut height} - B) + 3P \text{ rounded to the nearest } 0.5 \quad \text{(Eq.6)}$$

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 (Eq.7)

Where:

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 5) 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 5: For uncoated bolts, the close tolerance shanks shall have the size and tolerance given by class 'f7' (ANSI B4.2) 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.

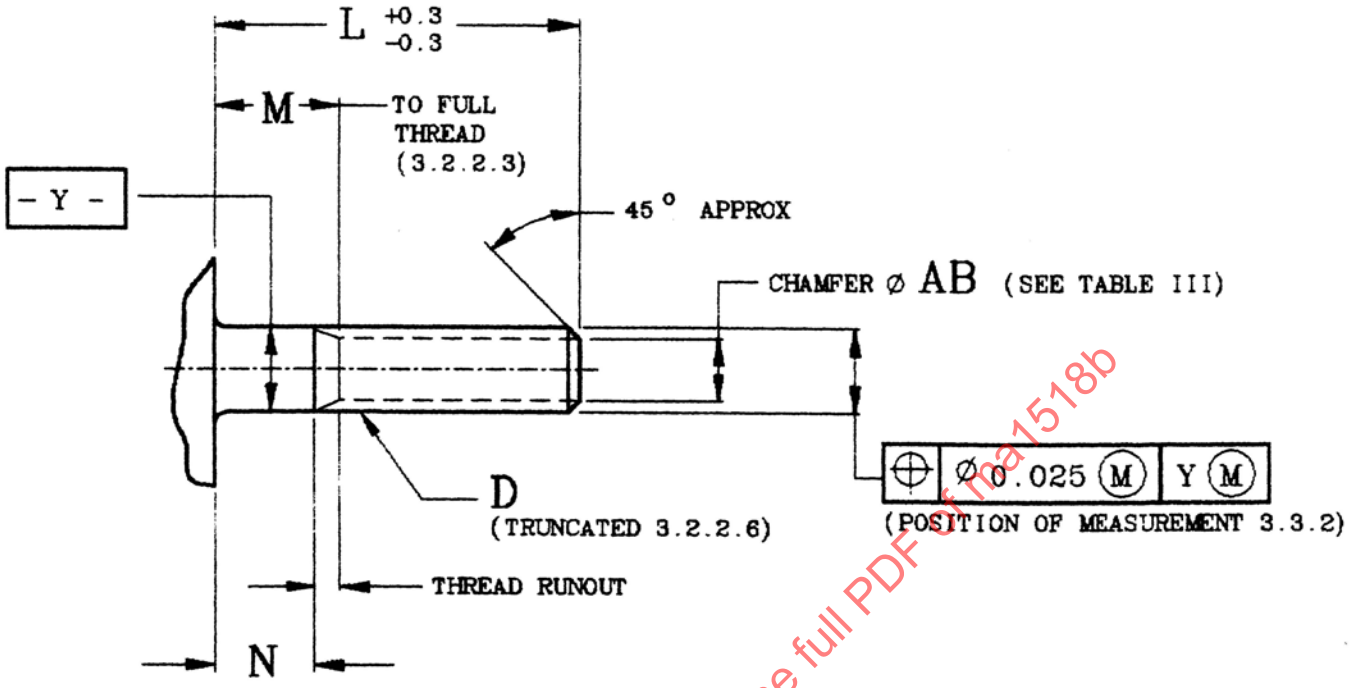

FIGURE 5 - Close Tolerance Shank

TABLE 5

D Thread Size	Underhead Length Range N Min	Shank Diameter for Close Tolerance Bolts Uncoated f7	Shank Diameter for Close Tolerance Bolts Coated	Truncated Major Dia of Thread[2] Uncoated	Truncated Major Dia of Thread[2] 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.

[2] This diameter must always be at least 0.025 mm less than the actual (measured) shank diameter. See also 3.2.2.6.

3.2.2.6 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 5 for details.

3.2.2.7 Lead Thread Chamfer: Particulars of chamfer diameters 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 6 and 7, refer to 3.2.1 and 3.2.2.

For interpretation of geometry, refer to AS3063.

TABLE 6 - Straightness of Shank and Thread

Nominal Thread Size	Coarse Tolerance Shank	Coarse Tolerance Shank
3 to 8	ø0.003L	ø0.002L
10 to 20	ø0.0025L	ø0.0015L

L = Bolt underhead length.

TABLE 7

Runout of Shank in Relation to Thread Pitch Diameter Nominal Thread Size	Runout of Shank in Relation to Thread Pitch Diameter Coarse and Close Tolerance Shank	Runout of Washer Face Diameter and Splines, or Hexagon Outside Diameter, in Relation to Shank Hexagon Head	Runout of Washer Face Diameter and Splines, or Hexagon Outside Diameter, in Relation to Shank 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

3.3.1 Straightness of shank and thread shall be in accordance with Table 6.

3.3.2 Relationship of shank to thread pitch diameter shall be in accordance with Table 7.

When the shank length AD is less than AC shown in Figure 6, 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 7.

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 6 and the tolerances in Table 7 related to the thread pitch diameter.

3.3.4 Relationship of thread major diameter to shank shall be as shown in Figure 5.

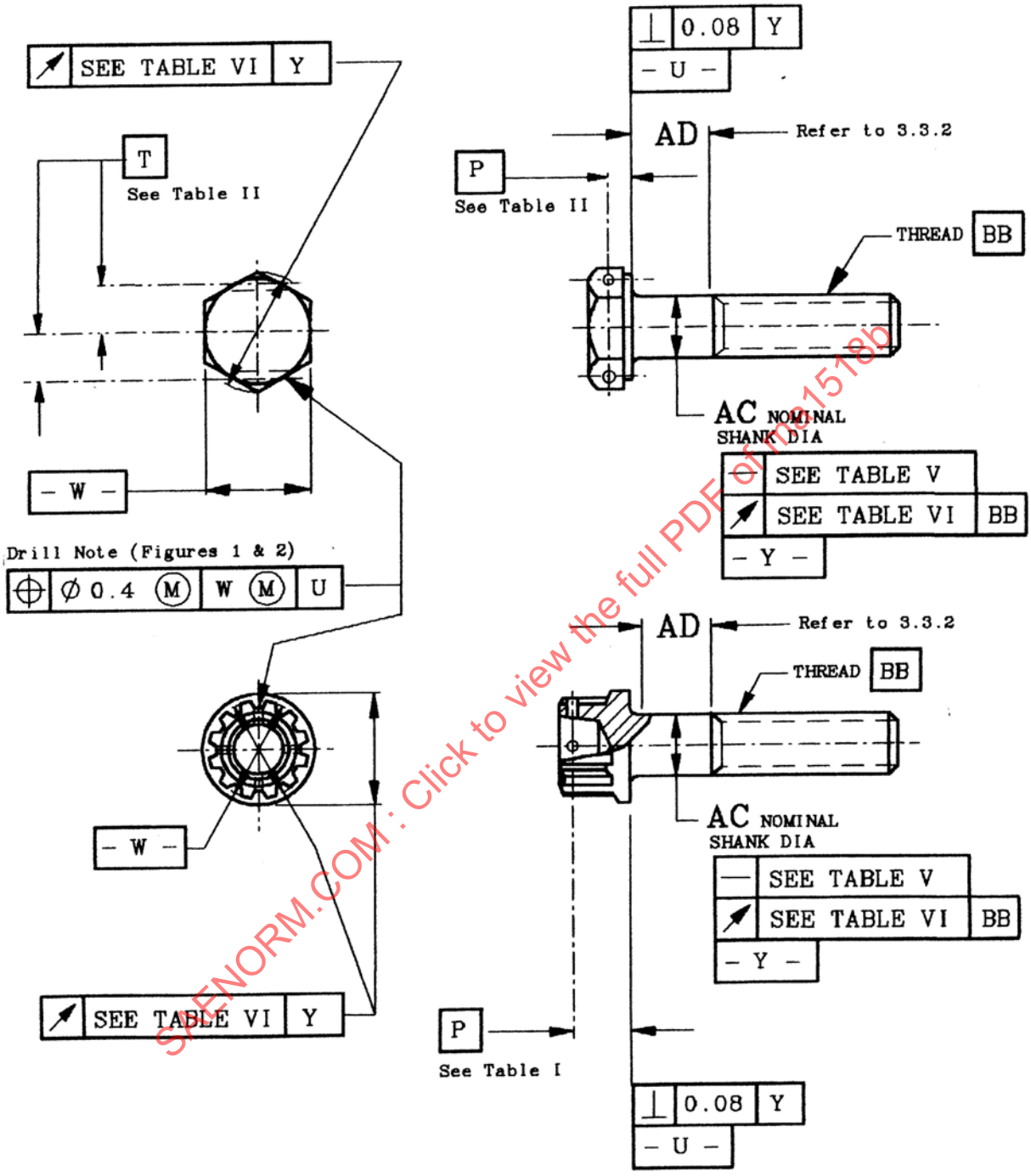

FIGURE 6

3.4 Surface Texture:

Symbols per ASME Y14.36; requirements per ASME B46.1.

3.4.1 Surfaces to be 3.2 µm except where specified otherwise (see Figure 7).

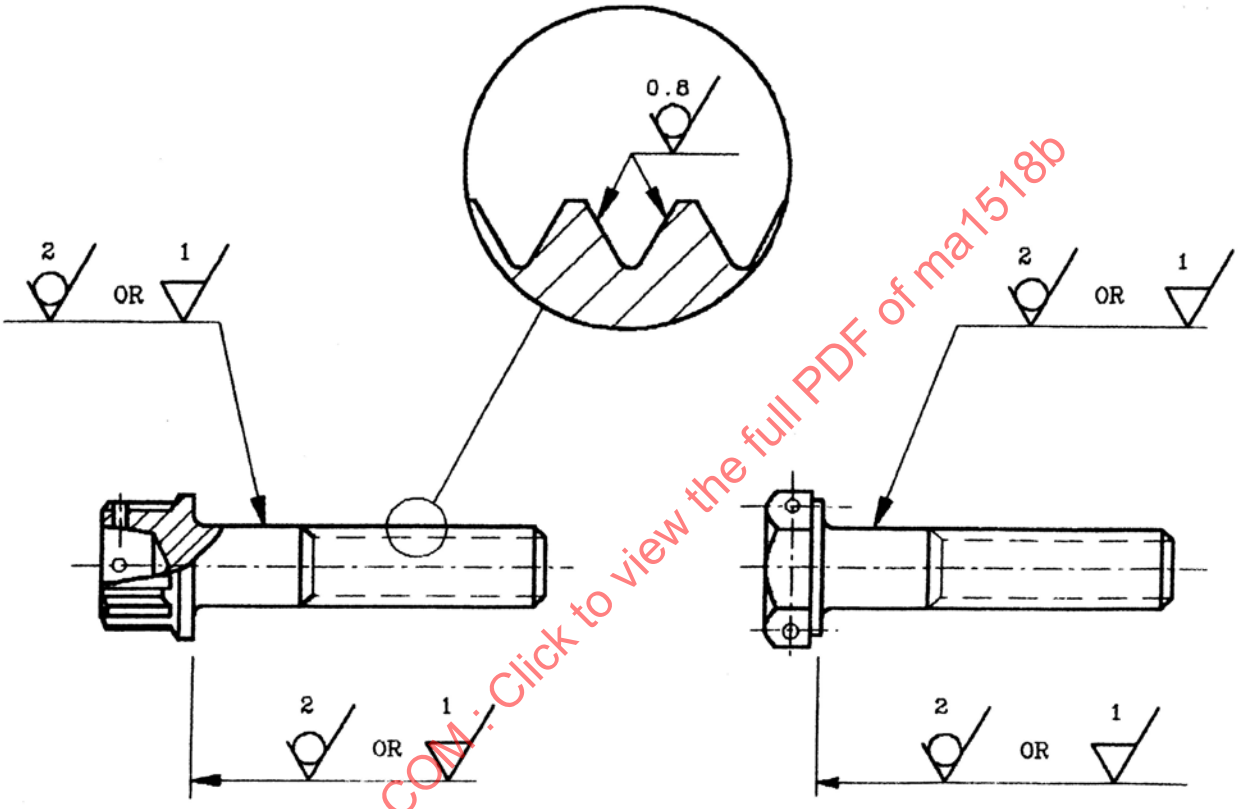

FIGURE 7

3.4.2 Underhead Radius:

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

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 µm.

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 µm.

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

4.1 Nut Dimensions:

4.1.1 Spline drive nut configuration shall be in accordance with Figure 8 and Table 8 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 9 and Table 9 for nuts of strength class up to 1250 MPa.

4.1.3 Castellated nuts shall be in accordance with Figure 10 and Table 10 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 11 and Table 11.

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 ASME Y14.36.

Requirements per ASME B46.1.

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