Specification for

Bolting for flanges and pressure containing purposes

BSI
British Standards

Committees responsible for this British Standard

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British Constructional Steelwork Association Ltd
British Industrial Fasteners Federation
British Railways Board
British Steel Industry
British Steel Industry (Wire Section)
Gauge and Tool Makers' Association
Ministry of Defence
Society of Motor Manufacturers and Traders Limited
Washer Manufacturers' Association of Great Britain

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British Gas
British Valve and Actuator Manufacturers Association
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Energy Industries Council
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Foreword

This British Standard has been prepared under the direction of the General Mechanical Engineering Standards Policy Committee. It is a revision of BS 4882 : 1973 which is withdrawn. It differs from the 1973 edition in the following respects.

(a) The recommended bolting temperature limits have been deleted from tables 1 and 2 for the following reasons.

(1) This standard, in keeping with other standards for components and materials, does not state limiting or recommended maximum service temperatures for alloys other than plain carbon steel (see **1.3.1**). It was decided to adopt this policy on revision of BS 4882 : 1973, and to refer purchasers and users to the design and construction specifications where limiting temperatures are related to design stresses and other conditions of service. The specifications also indicate the relation between initial stress to be applied and the other components comprising an assembly for given service conditions, and in some cases indicate what is acceptable practice in stressing bolts. It is considered that bolting will be used correctly only after examination of the whole joint in relation to an appropriate code (see appendix A).

(2) Service at low temperature entails considering the notch toughness (notch ductility) of steels in order to avoid risk of failure by brittle fracture. The design and construction codes differ somewhat in their application of steels on which notch toughness has been determined by the Charpy impact test.
Bolting materials (L grades) are available with given Charpy impact energy values at specific temperatures and such properties should be compared with the requirements of the design code in order to ensure correct application of the bolting (see appendix B).

(b) All material specifications and material analysis for bolts and nuts, with the exception of those quoted in table 5, have been derived from BS 1506. Appendix B of BS 4882 : 1973 has been deleted as reference will be direct to BS 1506.

(c) Materials suitable for bolts and nuts for use in sour gas applications have been included and are designated by the suffix M.

(d) The metric series of studbolts has been extended to include sizes up to M100 and the inch series by the addition of sizes 3¾ in and 4 in, this will align this standard with the proposed revision of USA standards.

Metric sizes M14, M22, M42 and M70 have also been included to conform to established usage and for the same reason the pitch for M72 has been changed from 6 mm to 4 mm.

(e) Studs, one end of which screws into the parent metal, have been included in both the metric and inch series. This has been done because, although BS 4439 and BS 2693 : Part 1 relate to 'studs for general purposes', the designs of studs within those standards are not suitable for use at high temperatures, these latter conditions necessitating designs similar to those for the studbolts.

(f) Table 5 of the 1973 edition detailing the properties of cold-worked bars has been deleted and its contents now form part of tables 1 and 2.

(g) Note that the bearing surfaces of BS 4190 bolts and nuts now have to be full-faced if intended for use with BS 4504 flanges.

(h) The marking requirements for bolting have been extended to include the manufacturer's identification for sizes M16 and larger and ⅝ in and larger.

(i) For heavy series nuts, inch series, the minimum width across flats and the washer face diameter (maximum and minimum) have been altered to agree with USA standards and will therefore allow nuts produced by non-UK sources to the USA standards, to conform to this standard.

For bolts grade B7A, there have been significant changes in properties and limiting ruling sections resulting from the publication of BS 1506 in 1986.

For bolts grade B6K, the designation K has been added to indicate that all sizes are now subject to the Izod impact test.

Production certification. Users of this British Standard are advised to consider the desirability of third party certification of product conformity with this British Standard based on testing and continuing surveillance, which may be coupled with assessment of a supplier's quality systems against the appropriate Part of BS 5750.

Enquiries as to the availability of third party certification schemes will be forwarded by BSI to the Association of Certification Bodies. If a third party certification scheme does not already exist, users should consider approaching an appropriate body from the list of association members.

Obsolescent British Standards. Although new design work should preferably incorporate 'metric bolting' references are made within the text of this standard to obsolescent British Standards since there is still a heavy demand for 'imperial bolting' from industry.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Section 1. General

1.1 Scope

This standard specifies the general requirements for bolting for flanges and pressure containing purposes, and gives details of dimensions for metric and inch series of bolting.

Materials have been selected for use at temperatures over the range −250 °C to 750 °C (see appendices A and B).

Information to be supplied by the purchaser is given in appendix C.

NOTE 1. This standard is necessarily largely concerned with studbolts and studs because of their application at higher temperatures etc., but, where appropriate, bolts may be used.

NOTE 2. The titles of the publications referred to in this standard are listed on the inside back cover.

1.2 Definitions

For the purposes of this British Standard, the following definitions apply.

1.2.1 General terms

1.2.1.1 bolt

A fastener with a head integral with the shank and which is threaded at the opposite end.

1.2.1.2 studbolt

A fastener threaded at both ends, or threaded for the whole of its length.

1.2.1.3 stud

A fastener threaded at both ends, one end of which is screwed into the parent metal and the other end of which takes a nut.

1.2.1.4 bolting

Bolts, threaded studbolts and studs made to the designs shown in figures 1 and 2 (for metric series bolting) and figures 4 and 5 (for inch series bolting).

NOTE. The term bolting also refers to nuts.

1.2.2 Terms relevant to studbolts

1.2.2.1 nominal length

(a) Of metric series bolting. The length of a studbolt including the point at each end.

(b) Of inch series bolting. The length of a studbolt excluding the point at each end.

1.2.2.2 length of thread

(a) Of metric series bolting. The distance from the end of a studbolt, including the point, to the last full thread.

(b) Of inch series bolting. The distance from the end of a studbolt, excluding the point, to the last full thread.

1.2.2.3 length of reduced diameter portion

The distance from the end of the thread to the end of the adjacent plain portion.

1.2.2.4 length of thread plus length of reduced diameter portion

(a) Of metric series bolting. The distance from the end of a studbolt, including the point, to the end of the reduced diameter adjacent to the plain portion.

(b) Of inch series bolting. The distance from the end of a studbolt, excluding the point, to the end of the reduced diameter adjacent to the plain portion.

1.2.2.5 length of point

The distance from the end of a studbolt to the position where the approximate 90° point meets the nominal diameter.

1.2.3 Terms relevant to studs

1.2.3.1 nominal length

(a) Of metric series bolting. The length of a stud including the point at each end to figure 2(b), but excluding the length of ring portion to figure 2(c).

(b) Of inch series bolting. The length of a stud including the point at the metal end, but excluding the point at the nut end.

1.2.3.2 length of thread, nut end

(a) Of metric series bolting. The distance from the end of a stud, including the point, to the start of the reduced diameter, all full threads.

(b) Of inch series bolting. The distance from the end of a stud, including the point to the end of the thread, including the runout thread.

1.2.3.3 length of thread, metal end

(a) Of metric series bolting. The distance from the end of a stud, including the point, to the end of the thread, and including the runout thread to figure 2(b), or the distance from the start of the ring portion to the start of the reduced diameter, all full threads, to figure 2(c).

(b) Of inch series bolting. The distance from the end of a stud, excluding the point, to the start of the reduced diameter, all full threads.

1.2.3.4 length of reduced diameter portion

(a) Of metric series bolting. The distance from the end of the thread at the nut end of a stud to the adjacent body diameter portion to figure 2(b), or to

the start of the metal end thread to figure 2(c).

(b) Of inch series bolting. The distance from the end of the thread at the nut end of a stud to the adjacent body diameter portion to figure 5(b).

1.2.3.5 length of thread plus length of reduced diameter portion

(a) Of metric series bolting. The distance from the nut end of a stud, including the point, to the end of the reduced diameter adjacent to the plain portion.

(b) Of inch series bolting. The distance from the nut end of a stud, excluding the point, to the end of the reduced diameter adjacent to the plain portion.

1.2.3.6 length of point

The distance from the nut end of a stud to the position where the approximate 90° point meets the nominal diameter.

1.3 Bolts, studbolts and studs

1.3.1 Materials

Bolts, studbolts and studs shall be manufactured from the materials specified in tables 1, 2 and 3.

NOTE 1. Bolting made from low or medium carbon steels should not be used at temperatures above 300 °C. This limit applies to bolts of grades 4.8, 6.8 and 8.8 of BS 6104 : Part 1 or BS 3692 and the equivalent Imperial grades, respectively grades B, P and S of BS 1768 and bolts to BS 1769.

Service above 300 °C could result in significant, permanent reduction in the strength of the bolting. If the temperature is likely to exceed 300 °C the purchaser should seek guidance from the manufacturer about the steel to be used for the bolting.

NOTE 2. Austenitic stainless steels are available in both the solution treated and the higher strength, cold worked and warm worked conditions.

1.3.2 Threading method

Threads shall be rolled, machine cut or ground.

NOTE. The purchaser should indicate at the time of enquiry and order if a particular method is to be used (see appendix C).

1.3.3 Heat treatment

Materials shall be heat-treated in accordance with the relevant clause of the material standards and as given in tables 1 and 2. For sour gas applications the final heat treatment process shall be carried out after all machining or forming operations have been completed on all ferritic and austenitic steels, in order to remove all hardening effects of cold work.

1.3.4 Check analysis

If a check chemical analysis from samples representing the materials of the bolting is made, the chemical composition thus determined shall be in accordance with the requirements of the relevant material specified (see tables 1, 2 and 3).

NOTE. Where the purchaser requires a check chemical analysis, this should be stated at the time of enquiry and order (see appendix C).

1.3.5 Marking

For bolts, studbolts or studs M16 and larger, or ⅝ in and larger, symbols identifying the grade of bolt and the manufacturer shall be applied to one end of the studbolt, on the head of the bolt, or on the nut end of the stud.

For bolts, studbolts or studs M10 and M12 or ½ in, symbols identifying the grade of bolt shall be applied to one end of the studbolt, on the head of the bolt, or on the nut end of the stud.

The identifying marking symbol shall be as shown for the respective grades in table 4.

Metric bolts, studbolts and studs shall have the prefix M in the grade numbers, e.g. MB7, MB7M.

The marking shall be clearly legible with symbols evenly spaced and the symbols shall, where possible, be not less than 3 mm (⅛ in) high for all sizes of bolting.

Marking by electrolytic etching shall not be permitted.

1.4 Nuts

1.4.1 General

Nuts for bolts, studbolts and studs shall be manufactured from the materials given in tables 3 and 4.

1.4.2 Manufacturing process

Nuts shall be made by hot forging, cold forging or by machining from the bar.

1.4.3 Heat treatment

All nuts (except mild or carbon steel nuts, see table 3) shall be heat treated or machined from heat-treated bar as in table 4. Where nuts are machined from bar heat treated in accordance with those requirements, the nuts shall not require further heat treatment. For sour gas applications, the final heat treatment process shall be carried out after all machining or forming operations have been completed on all ferritic and austenitic steels, in order to remove all hardening effects of cold work.

1.4.4 Check analysis

If a check chemical analysis from samples representing the nuts is made, the chemical composition thus determined shall be in accordance with the relevant material standard (see table 4).

NOTE. Where the purchaser requires a check chemical analysis, this should be stated at the time of enquiry and order (see appendix C).

1.4.5 Marking

Nuts shall be marked on one end face (not the bearing face) or on one flat, to indicate the grade of nut and the manufacturer. The identifying marking symbol shall be as shown for the respective grades in table 4.

Metric nuts shall have the prefix M in the grade numbers, e.g. M2H, M2HM.

The marking shall be clearly legible with symbols evenly spaced. These symbols where practicable shall be not less than 3 mm (⅛ in) high for all sizes of nuts.

Marking by electrolytic etching shall not be permitted.

1.5 Inspection and testing

1.5.1 General

Tests shall be carried out on raw material samples in a condition corresponding to that of finished bolting, or on representative finished bolts, studbolts, studs and nuts in the finally heat-treated condition, to ensure compliance with the mechanical properties detailed in tables 1, 2, 3 and 4.

NOTE. Any additional property requirements required by the purchaser should be stated at the time of enquiry and order (see appendix C).

1.5.2 Preparation of test pieces

The preparation of test pieces and method of testing shall be in accordance with the relevant clauses of the appropriate material standards.

1.5.3 Manufacturer's certificate

The manufacturer of the bolting shall supply a certificate stating the following:

(a) the number and date of this British Standard, i.e. BS 4882 : 1990[1)];

(b) whether bolts, studbolts, studs or nuts are supplied;

(c) the grade of fastener supplied;

(d) heat treatment conditions;

(e) results of the tests specified in **1.5.1** and **1.5.4** or **1.5.5.1** and **1.5.5.2**.

1.5.4. Bolts, studbolts and studs

1.5.4.1 *General*

Tests shall be required only when bolts are heat treated after forming and machining. Tests on finished bolts shall not be required when the components have been made by machining from fully heat-treated bar.

NOTE. Where testing of finished bolts is required by the purchaser, this should be stated at the time of enquiry and order (see appendix C).

Studbolts or studs in the following grades, as specified in table 2, are suitable for use down to −196 °C, without impact tests, but shall be of impact tested material for service between −196 °C and −250 °C.

B8	B8C	B8T	B8M
B8X	B8CX	B8TX	B8MX
MB8	MB8C	MB8T	MB8M
MB8X	MB8CX	MB8TX	MB8MX

1.5.4.2 *Batch sizes for testing*

Where tensile tests and impact tests are to be made, they shall be made at the rate of one from each batch of studbolts or studs of the same diameter from the same cast and heat treated together.

A batch shall be defined as the following:

680 kg (1500 lb) or fraction thereof for diameters up to and including M27 (1⅛ in);

2040 kg (4500 lb) or fraction thereof for diameters over M27 (1⅛ in) up to and including M45 (1¾ in);

2720 kg (6000 lb) or fraction thereof for diameters over M45 (1¾ in) up to and including M64 (2½ in);

100 pieces or fraction thereof for diameters exceeding M64 (2½ in).

1.5.4.3 *Retests*

If the results of any mechanical tests do not comply with the requirements specified, twice the number of tests shall be made for the test that failed. The results of each retest shall comply with this standard.

1.5.5 Nuts

1.5.5.1 *General*

Tests shall be required only when nuts are heat treated after forming and machining. Tests on finished nuts shall not be required when the components have been made by machining from fully heat-treated bar.

NOTE. Where testing of finished nuts is required by the purchaser this should be stated at the time of enquiry and order (see appendix C).

1.5.5.2 *Number of tests*

Where tests are made (see **1.5.5.1**), the number of tests shall be as follows:

two nuts per 2000 or fraction thereof for each size M16 (⅝ in) and smaller;

[1)] Marking BS 4882 : 1990 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

two nuts per 1000 or fraction thereof for each size over M16 (⅝ in) up to and including M36 (1½ in);

two nuts per 200 or fraction thereof for sizes larger than M36 (1½ in).

The nuts shall be subjected to the tests specified in **1.5.1** and, where stated in the order, **1.5.5.3.**

1.5.5.3 *Cone stripping test*

Where required the grade of nuts specified in tables 28 and 29 up to 30 mm diameter (1¼ in) shall be submitted to the cone stripping test described in appendix D.

NOTE. Where the purchaser requires a cone stripping test, this should be stated at the time of enquiry and order (see appendix C).

1.5.5.4 *Retests*

If the results of any tests do not comply with the requirements specified, twice the number of tests specified in **1.5.5.2** shall be made for the test that failed. The results of each retest shall comply with the requirements of this standard.

1.5.6 Hardness testing, grade suffix M

1.5.6.1 *General*

The hardness values of bolting including nuts shall be in accordance with the requirements of tables 1, 2 and 4. The number of tests carried out shall be as given in **1.5.6.2** to **1.5.6.4.**

1.5.6.2 *Number of tests: grades B7M, MB7M, 2HM and M2HM*

Providing in-process sampling, as part of a quality plan, is used, either a final sample of 100 parts, or 10 % of the batch (whichever is the greater), selected at random from each heat treatment batch shall be subjected to indentation hardness testing. Where required an additional test shall be carried out on 100 % of the batch. Failure of any one part to meet the hardness requirements of tables 1, 2 and 4 shall result in the batch being rejected or subject to 100 % indentation hardness testing.

NOTE. Where the purchaser requires the test to be carried out on 100 % of the batch, this should be stated at the time of enquiry and order (see appendix C).

1.5.6.3 *Number of tests: grades L7M, ML7M, L4M, ML4M, M7M, M4M, 7M and 4M*

Bolting including nuts shall be subjected to 100 % indentation testing, or 100 % electromagnetic hardness testing followed by sample indentation testing; all parts shall satisfy the requirements of tables 1, 2 and 4.

NOTE. When specified by the purchaser at the time of enquiry and order (see appendix C) 100 % electromagnetic hardness testing qualified by sample indentation hardness testing may be used. The sample is to consist of a minimum of 100 parts selected at random from the batch. Failure of any one part to satisfy the requirements of tables 1, 2 and 4 will result in rejection of the batch or 100 % indentation hardness testing of the complete batch.

1.5.6.4 *Governing criteria in cases of dispute*

In the event of a dispute, indentation not electromagnetic hardness testing shall be used.

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Table 1. Bolts in low alloy and martensitic stainless steels complying with BS 1506

Bolt grade identification marks		Material designations (from BS 1506)	Alloy type	Mechanical properties at room temperature (1)							
				Limiting ruling section (4)	Tensile strength R_m		Yield strength R_e	Elongation A (6) (based on a gauge length of $5.65\sqrt{s_o}$)	Izod impact strength (mean of three values)		Hardness HB	
Metric series	Inch series				min.	max.	min.				min.	max.
				mm	N/mm²	N/mm²	N/mm²	% min.	ft lb	J		
MB7, ML7	B7 L7	630-790	1% Cr¼%Mo	>63<100	790	1000	655	14	40	54	223	302
		630-860	1% Cr¼%Mo	<63	860	1070	725	14	40	54	248	331
MB7M(3) ML7M	B7M(3) L7M	630-690	1% Cr¼%Mo	<63	690	800	550	16	40	54	201	235
MB7A	B7A	631-850	1% Cr½%Mo	>100<200	850	1000	635	14	20	27	248	302
				>63<100	850	1000	665	14	40	54	248	302
				>63	850	1000	695	14	40	54	248	302
MB16	B16	670-860	1% Cr½%Mo¼%V	<100	860	1000	725	16	35	47	248	302
MB16A	B16A	681-820	1% CrMoVBTi	<250	820	1000	660	15	20	27	241	302
MB16B	B16B	671-850	1¼% CrMoV	>100<200	850	1000	635	14	20	27	248	302
				<100	850	1000	665	14	35	47	248	302
MB6	B6	410S21-690	12% Cr	>100<200	690	840	540	15	—	—	197	248
		410S21-760		<100	760	910	585	15	—	—	217	269
MB6K	B6K	410S21-720		>63<100	720	870	570	15	25	34	212	262
		410S21-750		>29<63	750	900	580	14	20	27	215	262
		410S21-770		<29	770	930	590	12	20	27	223	227
ML9	L9	509-650	9% Ni	<75	650	850	480	18	—	—	—	—
ML9A	L9A	509-690	9% N	<100	690	850	580	18	—	—	—	—

(1) Room temperature properties: time dependent properties to be taken into account for high temperature service see appendix A and **1.3.1**).

(2) Charpy impact tests for bolt B7/L7 grade. Charpy impact tests are only required for L7 grade.

(3) Grades for sour gas service:
bolts: MB7M, ML7M, B7M, L7M
nuts: M2HM, M4M, M7M, M8A : 2HM, 4M, 7M, 8A : ML4M, ML7M : L4M, L7M
Treatment:
(a) all bolting heat treated after all machining and forming completed;
(b) nut grades 2H, 4, L4, 7 and L7 to be treated to HB 235 max. (HRC 22).

Table 1. Bolts in low alloy and martensitic stainless steels complying with BS 1506 (*continued*)

Charpy V-notch (KCV) impact strength at sub-zero temperatures		**Heat treatment**				**Suitable grades of nuts**	
		Harden		**Temper (6)**		**for metric bolts**	**for inch bolts**
Temperature	**Mean of three values**	**Temperature**	**Cooling media**	**Temperature**	**Cooling media**		
°C	J	°C		°C			
−100	20(2)	850 to 880(5)	Oil	600 (min)	Air	M2H M4 M7 M8	2H 4 7 8
−75	27(2)						
−100	27(2)	850 to 880(5)	Oil	600 (min)	Air	ML4 ML7 or 8 with ML7 bolts	L4 L7 or 8 with L7 bolts
		(5)				(3)	(3)
−100	27(2)	850 to 880	Oil	620 (min)	Air	M2HM M4M M7M M8A ML4M ML7M M8A with ML7M bolts	2HM 4M 7M 8A L4M L7M 8A with L7M bolts
—	—	850 to 900	Oil or water	600 (min)	Air	M2H M4 M7 M8	2H 4 7 8
—	—	850 to 900	Oil or water	600 (min)	Air		
—	—	850 to 900	Oil or water	600 (min)	Air		
—	—	930 to 970	Oil	650 (min)	Air	M4 M7 M8	4 7 8
—	—	660 to 700 followed by 970 to 990	Air <50 mm water or oil >50 mm water	680 to 720	Air	M7 M7A M8 M16 M16B	7 7A 8 16 16B
—	—	930 to 970	Oil or water	650 (min)	Air	M7 M7A M8	7 7A 8
—	—	930 to 970	Oil	650 (min)	Air		
—	—	950 to 1020	Oil or air	600 (min)	Air	M6 M6K M8	6 6K 8
—	—	950 to 1020	Oil or air	600 (min)	Air		
—	—	950 to 1020	Oil or air	600 (min)	Air	M6K M8	6K 8
—	—	950 to 1020	Oil or air	600 (min)	Air		
—	—	950 to 1020	Oil or air	600 (min)	Air		
−196	40	880 to 930 followed by 770 to 820	Air Air	540 to 600	Air or water	ML9 ML9A	L9 L9A
−196	40	770 to 820	Oil or water	540 to 600	Air or water	ML9A	L9A

(4) Limiting ruling section as defined in BS 1506.
(5) Information extracted from BS 1506 and given for guidance. Austenitizing at temperatures outside this range may significantly effect stress rupture values.
(6) Minimum tempering temperatures are mandatory.
NOTE: See table 4 for general notes.

Table 2. Bolts in austenitic stainless steels and precipitation-hardenable alloys complying with BS 1506 and BS 3076

Bolt grade identification marks				Material designation (from BS 1506)	Alloy type	Mechanical properties at room temperature				
						Limiting ruling section	Tensile strength R_m		Tensile strength R_m	0.2 % proof stress $R_{po.2}$
Metric series		Inch series					min.	max.	min.	
						mm	N/mm²	N/mm²	N/mm²	N/mm²
Austenitic stainless steel										
MB 8	ML8	B 8	L 8	304S31	1 8Cr10Ni	160	520	—	—	205
MB 8H		B 8H		304S51		160	520	—	—	205
MB 8LN	ML 8LN	B 8LN	L 8LN	304S61	1 8Cr10Ni N	160	550	—	—	270
MB 8N	ML 8N	B 8N	L 8N	304S71		160	550	—	—	270
MB 8M	ML 8M	B 8M	L 8M	316S31	1 8Cr12Ni2Mo 2.5Mo	160	520	—	—	205
MB 8M1	ML 8M1	B 8M1	L 8M1	316S33		160	520	—	—	205
MB 8MH		B 8MH		316S51	1 8Cr12Ni2Mo 2.5Mo	160	520	—	—	205
MB 8M1H		B 8M1H		316S53		160	520	—	—	205
MB 8MJN	ML 8MLN	B 8MLN	L 8MLN	316S61	1 8CNi2Mon 2.5MoN	160	580	—	—	280
MB 8ML1N	ML 8MLIN	B 8MLIN	L 8MLIN	316S63		160	580	—	—	280
MB 8M1N	ML 8MN	B 8MN	L 8MN	316S65	1 8Cr12Ni2MoN 2.5MoN	160	580	—	—	280
MB 8M1N	ML 8MIN	B 8M1N	L 8M1N	316S67		160	580	—	—	280
MB 8T	ML 8T	B 8T	L 8T	321S31	1 8Cr10NiTi	160	520	—	—	205
MB 8TH		B 8TH		321S51-490	1 8Cr10NiTi	160	490	—	—	155
MB 8TH1		B 8TH1		321S51-520		160	520	—	—	205
MB 8C	ML 8C	B 8C	L 8C	347S31	1 8Cr10NiNb	160	520	—	—	205
MB 8CH		B 8CH		347S51	1 8Cr10NiNb	160	520	—	—	205
Precipitation-hardenable alloys										
MB 17B	ML 17B	B 17B	L 17B	286S31	1 5Cr25NiMoVTiA1B	200	900	—	—	590
MB 17BM	ML 17BM	B 17BM	L 17BM	286S31	1 5Cr25NiMoVTiA1B	200	900	—	—	590
MB 80A	ML 80A	B 80A	L 80A	BS 3076-NA20	Ni20Cr	300	1000	—	—	620
Bolts metric and inch series available in the cold or warm-worked condition (selected alloys)										
Steels to BS 1506										
304S31	316S31	316S33	321S31	347S31		19	860	—	—	695
MB 8X	MB 8MX	MB 8MIX	MB 8TX	MB 8CX		>19 to 25	790	—	—	555
ML 8X	ML 8MX	ML 8MIX	ML 8TX	ML 8CX		>25 to 32	730	—	—	450
B 8X	B 8MX	B 8MIX	B STX	B 8CX		>32 to 38	690	—	—	345
L 8X	L 8MX	L 8MIX	L 8TX	L 8CX		>38 to 44	650	—	—	310

(1) Charpy impact tests for L-grade bolts, only where specified on enquiry and order.
(2) Sensitization test not applicable.
(3) Sensitization test not applicable to cold drawn state but applicable to solution treated bar before cold drawing, if specified as in **3.2** of BS 1506 : 1986.
(4) The corresponding metric series are prefixed with 'M'.
(5) Sour gas service, sulphide stress-cracking resistance.
(a) Austenitic stainless steel bolting ordered for such service should be heat treated after all forming and machining are completed. Maximum hardness should be 35 HRC.
(b) Marking. Bolts made for such service should be marked 'A' in addition to, but separated from the grade identity marks.
(6) Sensitization test to be noted on enquiry for separate proposal by manufacturer.
(7) Bolts for sour gas service.
NOTE. See table 4 for general notes.

Table 2. Bolts in austenitic stainless steels and precipitation-hardenable alloys complying with BS 1506 and BS 3076 (*continued*)

Elongation A **(based on a gauge length of** $5.65\sqrt{s_o}$**)**	**Hardness** HB		**Charpy V-notch** (KCV) **impact strength at sub-zero temperatures for L grade bolting** (1)		**Heat treatment**		**Sensitization time for inter-crystalline corrosion test**	**Corresponding grades of nuts** inch series (4)				
	min.	**max.**	**Temper-ature**	**Mean of three values**	**Solution treatment** (5)	**Precipitation hardening**						
%			°C	J	°C	°C	min.					
40	—	—	−196	70	1000 to 1100	—	15	8	L8			
40	—	—	—	—	1000 to 1100	—	n/a (2)	8 H				
35	—	—	−196	50	1000 to 1100	—	30	8LN	L 8LN			
35	—	—	−196	50	1000 to 1100	—	15	8N	L 8N			
40	—	—	−196	70	1000 to 1100	—	15	8M	LBM			
40	—	—	−196	70	1000 to 1100	—	15	8MI	L 8M1			
40	—	—	—	—	1000 to 1100	—	n/a (2)	8MH				
40	—	—	—	—	1000 to 1100	—	n/a (2)	8MIH				
35	—	—	−196	50	1000 to 1100	—	30	8MLN	L 8MLN			
35	—	—	−196	50	1000 to 1100	—	30	8M1LN	L 8M1LN			
35	—	—	−196	50	1000 to 1100	—	15	8MN	L 8MN			
35	—	—	−196	50	1000 to 1100	—	15	8M1N	L 8M1N			
35	—	—	−196	60	1000 to 1100	—	30	8T	L 8T			
35	—	—	—	—	1070 to 1140	—	30	8TH				
35	—	—	—	—	950 to 1070	—	30	8TH1				
30	—	—	−196	60	1000 to 1100	—	30	8C	L 8C			
30	—	—	—	—	1000 to 1100	—	15	8CH				
12	248	341	−196	20	970 to 990	710 to 760	n/a (2)	17B	L17B			
12	248	321	−196	20	water quench	16 h min. air	n/a (2)	17BM	L17BM (7)			
20	285	360	−196	20	1080°C soak up to 8 h, air cool or quench	850°C 24 h air cool, 700°C 16 h air cool	n/a (2)	80A	L80A			
12	—	320	−196	27	All bars solution treated			304	316	316	321	347
15	—	320	−196	27	1000°C to 1100°C before		n/a (3)	S31	S31	S33	S31	S31
20	—	320	−196	27	cold drawing. Properties			8X	8MX	8MIX	8TX	8CX
28	—	320	−196	27	may be obtained by		(6)	L 8X	L 8MX	L 8MIX	L 8TX	L 8CX
28	—	320	−196	27	warm working							

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Table 3. British Standard specifications for steels to be used in the manufacture of bolting complying with BS 1768, BS 1769, BS 3692 and BS 6104 : Part 1 for pressure containing applications

Steel		Bolting		Bolting specification [1]		
British Standard	Steel type/grade	Nominal size		BS 1768 strength grade	BS 1769 strength grade	BS 3692 BS 6104 : Part 1 strength grade
		Metric series	Inch series			
		mm	in			
BS 3111	0/3	≤ 24	≤ 1	B	B	4.8
BS 970	070M20	> 24	> 1			
BS 970	080M40	≤ 20	≤ ¾	P	—	6.8
BS 3111	1/3	≤ 20	≤ ¾			
BS 3111	10/2	≤ 30	≤ 1⅛			
BS 970	135M44	> 20	> ¾			
BS 1506	630	≤ 68	≤ 2½	S	—	8.8
BS 970	708M40	≤ 68	≤ 2½			
BS 970	135M44	≤ 29	≤ 1⅛			
BS 3111	1/3	≤ 20	≤ ¾			
BS 3111	10/2	≤ 30	≤ 1⅛			

[1] See **1.4.1** and **1.3.1**
NOTE. See table 4 for general notes.

Table 4. Nuts in ferritic, austenitic and precipitation-hardenable alloys complying with BS 1506 and BS 3076

Nut grade identification marks		Material designation (from BS 1506)	Alloy type	Limiting ruling section of nut		Heat treatment and cold working condition (1) (6) (7)	Hardness		Charpy V-notch impact strength (4)	
Metric series	Inch series			Metric series	Inch series		HB	HV	Test temperature	Mean of three values
				mm	in				°C	J
Ferritic steels										
M2H	2H	162	Carbon steel	63	2½	Harden 830 °C to 860 °C OQ(9) Temper 450 °C (min.)	248 to 352	261 to 371		
M2HM (5)	2HM (5)					Harden 830 °C to 860 °C OQ Temper 620 °C (min.)	159 to 235	168 to 247		
M4 ML4	4 L4	253	C¼%Mo	38	1½	Harden 880 °C to 910 °C OQ or WQ Temper 550 °C (min.)	248 to 352	261 to 371	−100	27
M4M (5)	4M (5)			63	2½	Harden 880 °C to 910 °C OQ or WQ Temper 600 °C (min.)	159 to 235	168 to 247		
ML9	L9	509-650	9%Ni	75	3	Normalize 880 °C to 930 °C AC 770/870 °C AC	187 to 248	197 to 261	−196	40
ML9A	L9A	509-690	9%Ni	100	4	Harden 770 °C to 820 °C OQ or WQ Temper 540 °C to 660 °C	207 to 255	217 to 268	−196	40
M7 ML7	7 L7	630-860	1%Cr¼%Mo	63	2½	Harden 850 °C to 880 °C OQ Temper 600 °C (min.)	248 to 331	261 to 348	−100	27
M7M ML7M (5)	7M L7M (5)	630-690		63	2½	Harden 850 °C to 880 °C OQ Temper 620 °C (min.)	201 to 235	211 to 247	−100	27
M7A	7A	631-850	1%Cr½%Mo	200	8	Harden 850 °C to 900 °C OQ or WQ Temper 600 °C (min.)	248 to 302	261 to 318		
M16	16	670-860	1%Cr½Mo¼%V	100	4	Harden 930 °C to 970 °C OQ Temper 650 °C (min.)	248 to 302	261 to 318		
M16B	16B	671-850	1¼%CrMoV	200	8	Harden 930 °C to 970 °C OQ Temper 650 °C (min.)	248 to 302	261 to 318		
M6	6	410S21-760	12%Cr	100	4	Harden 950 °C to 1020 °C OQ or AC Temper 600 °C (min.)	228 to 269	240 to 283		
M6K M6K M (2)	6K 6KM (2) M	410S21-690		200	8	Harden 950 °C to 1020 °C OQ or AC Temper 620 °C (min.) (2)	201 to 235	211 to 247		

Table 4 *(concluded)*

Nut grade identification marks		Material designation (from BS 1506)	Alloy type	Limiting ruling section of nut		Heat treatment and cold working condition (1) (6) (7)	Hardness		Charpy V-notch impact strength (4)	
Metric series	Inch series			Metric series	Inch series		HB	HV	Test temperature	Mean of three values
				mm	in				°C	J
Austenitic stainless steels										
M8 M8A (3)	8 8A (3)	304S31	18Cr10Ni			Solution treated 1000 °C to 1100 °C (3)			−196	27
M8X	8X			See table 2		Solution treated before cold working	320 max.	337 max.	−196	27
M8M M8MA (3)	8M 8MA (3)	316S31	18Cr12Ni2Mo			Solution treated 1000 °C to 1100 °C (3)			−196	27
M8MX	8MX			See table 2		Solution treated before cold working	320 max.	337 max.	−196	27
M8T M8TA (3)	8T 8TA (3)	321S31	18Cr10NiTi			Solution treated 1000 °C to 1100 °C (3)			−196	27
M8TX	8TX			See table 2		Solution treated before cold working	320 max.	337 max.	−196	27
M8C M8CA (3)	8C 8CA (3)	347S31	18Cr10NiNb			Solution treated 1000 °C to 1100 °C (3)			−196	27
M8CX	8CX			See table 2		Solution treated before cold working	320 max.	337 max.	−196	27
Precipitation-hardenable alloys										
M17B ML17B	17B L17B	286S31	15Cr25NiMoV	200	8	Solution treated 970 °C to 990 °C	248 to 341	261 to 360	−196	20
M17BM (8) ML17BM	17BM L17BM (8)		TiAlB			Precipitation hardened 710 °C to 760 °C 16 h min. AC	248 to 321	261 to 339	−196	20
M80A ML80A	80A L80A	BS 3076 – grade NA20	Ni20Cr	399	12	Solution treated 1080 °C, soak up to 8 h AC or quench Precipitation 850 °C 24 h, AC. 700 °C 16 h AC	286 to 360	300 to 380	−196	20

(1) Cold working austenitic stainless steel, bar material properties see table 2 which details effect of bar size.

(2) 12% Cr steel (grades M6KM and 6KM) for sour gas service, nuts should be double tempered, first treatment should be above 620 °C, second at a lower temperature at or above 620 °C.

(3) Austenitic stainless steel for sour gas (sulphide stress cracking resistance) all nuts should be solution treated after all forming and machining are completed, designated 'A' condition, and maximum hardness HB 235, HV 247.

(4) Charpy V-notch impact tests:
(a) where stated on enquiry and order,
(b) average of three tests minimum individual value to be not less than 70 % of specified average (minimum) value.

(5) Ferritic steels: (designated 'M' grade, 2HM, 4M, 7M etc.) for sour gas service nuts should be heat treated after all forming and machining are completed.

(6) Information extracted from BS 1506 and given for guidance. Austenitizing at temperatures outside this range may significantly effect stress rupture values.

(7) Minimum tempering temperatures are mandatory.

(8) Nuts for sour gas service.

(9) Oil quench (OQ); water quench (WQ); air cool (AC).

General notes to tables 1, 2, 3 and 4

NOTE 1. For the bolt property classes reference to be made to BS 1768, BS 1769 and BS 6104 : Part 1.

NOTE 2. 'B' grade numbers refer to the normal condition manufactured for elevated temperature service. 'L' grade numbers refer to grades where the material has been specially approved for sub-zero temperature service.

NOTE 3. All sub-zero temperature impact tests are Charpy V-notch tests in accordance with BS 131 : Part 2. Tests at room temperature are Izod impact tests in accordance with BS 131 : Part 1.
The minimum average value for the impact tests is to be obtained from the results of three tests, the lowest of which shall not be less than 70% of the specified average value.
Brinell hardness test (see BS 240), Rockwell hardness test (see BS 891) and Vickers hardness test (see BS 427) should be used.
See **1.5** for tests for bolts and nuts.

NOTE 4. Low and medium carbon steel bolts, studbolts, studs and nuts for service temperatures not exceeding 300 °C should be selected from the materials and grades listed in table 3.

NOTE 5. The hardness of solution treated bar has to be determined prior to any subsequent drawing, grinding, reeling or cold straightening operations which may slightly increase the surface hardness.

NOTE 6. Properties of cold-worked bars greater than 19 mm (¾ in) diameter section shall be in accordance with table 2. Products of cold worked material have the suffix X in the grade numbers.

NOTE 7. Grade 8 nuts can be used in conjunction with B17B, MB17B and B80A, MB80A up to temperatures of 525 °C without significant stress relaxation occurring by comparison with the use of 17B and 80A nuts respectively.

NOTE 8. Cone stripping tests may be required (see **1.5.5.3**).

NOTE 9. With corrosive service conditions, whether or not high temperatures prevail, the high chromium steels or chromium-nickel steels should be considered. Final selection will depend on the precise nature of the environment.

NOTE 10. The nut grades stated are all considered suitable for use with the corresponding bolt grade. In elevated temperature service the choice of nut grade will influence the stress relaxation behaviour. Where grade 8 is recommended all austenitic stainless steel nut grades will normally be suitable and will assist in minimizing high temperature seizure on low alloy steel studbolts.

Section 2. Metric series bolting

NOTE 1. This section relates to metric series bolting for use with metric series pipe flanges, valves and fittings as referred to in BS 4504 and also for general pressure containing purposes.

Dimensional requirements are given for four designs of alloy steel studbolts, three designs of alloy steel studs and associated nuts, which use ISO metric screw threads in the following nominal diameters (see figures 1 and 2).

M10	M24	M36	M52
M12	M27	M39	M56
(M14)	M30	M42	M64
M16	M33	M45	M70
M20		M48	M72
(M22)			M76 }
			M82 }
			M90 } Studbolts only
			M95 }
			M100 }

(Sizes M14 and M22 are non-preferred.)

Metric hexagon bolts and screws (and associated nuts) may also be used for flange bolting and in such cases selection should be made from BS 3692 or BS 4190, except that the bearing area of bolts and nuts ordered to BS 4190 has to be full-faced to comply with this standard.

NOTE 2. BS 3692 specifies low and high tensile, medium carbon and alloy steel hexagon bolts and nuts whereas BS 4190 specifies low tensile 'mild steel' hexagon bolts and nuts.

2.1 Studbolts

2.1.1 General

The forms of the studbolts shall comply with those shown in figure 1(a), (b), (c) or (d). Dimensions shall be as given in **2.1.2** to **2.1.8** and tables 5 to 8.

Table 6. Tolerances on nominal length of studbolts: metric series

Nominal diameter	Length	Tolerances on length
	mm	mm
≤ M24	≤ 150	± 0.75
	> 150	± 1.00
> M24 ≤ M48	≤ 180	± 1.00
	> 180	± 1.5
> M48 ≤ M100	All	± 2.00

Table 5. Diameter of plain portion, maximum and minimum sizes of studbolts : metric series

Nominal diameter	Nominal diameter design		Reduced diameter design	
	max.	min.[1)]	max.	min.[1)]
	mm	mm	mm	mm
M10 × 1.5	10.0	9.78	7.49	7.27
M12 × 1.75	12.0	11.73	9.07	8.85
(M14 × 2)	14.0	13.73	10.64	10.37
M16 × 2	16.0	15.73	12.54	12.27
M20 × 2.5	20.0	19.67	15.71	15.44
(M22 × 2.5)	22.0	21.67	17.61	17.34
M24 × 3	24.0	23.67	18.86	18.53
M27 × 3	27.0	26.67	21.71	21.38
M30 × 3	30.0	29.67	24.56	24.23
M33 × 3	33.0	32.61	27.41	27.08
M36 × 3	36.0	35.61	30.26	29.87
M39 × 3	39.0	38.61	33.11	32.72
M42 × 3	42.0	41.61	35.96	35.57
M45 × 4	45.0	44.61	37.54	37.15
M48 × 4	48.0	47.61	40.38	39.99
M52 × 4	52.0	51.54	44.18	43.79
M56 × 4	56.0	55.54	47.98	47.59
M64 × 4	64.0	63.54	55.58	55.12
M70 × 4	70.0	69.54	61.38	60.92
M72 × 4	72.0	71.54	63.18	62.72
M76 × 4	76.0	75.54	67.08	66.62
M82 × 4	82.0	81.46	72.28	72.24
M90 × 4	90.0	89.46	80.38	79.84
M95 × 4	95.0	94.46	85.11	84.57
M100 × 4	100.0	99.46	89.86	89.32

[1)] Based on tolerance class h13 of BS 4500.

Table 7. Preferred nominal lengths of studbolts : metric series (based on flange designs as specified in BS 4504)

Nominal diameter	Preferred nominal lengths																															
	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	140	150	160	170	180	190	200	220	240	260	280	300	340	360	380
M10																																		
M12	×	×	×	×	×	×	×																											
(M14) [1)]																																		
M16						×	×	×	×	×																								
M20									×	×	×	×	×	×																				
(M22) [1)]																																		
M24													×	×	×	×	×	×	×	×														
M27														×	×	×	×	×	×	×	×	×	×											
M30										×	×	×	×		×	×	×	×	×	×	×	×	×	×	×	×								
M33															×	×	×	×	×	×	×	×	×	×	×	×	×							
M36																		×	×	×	×	×	×	×	×	×	×	×	×					
M39																				×	×	×	×	×	×	×	×	×	×	×	×			
M42 [1)]																																		
M45																						×	×	×	×	×	×	×	×	×	×	×		
M48																																×		
M52																											×	×	×	×	×		×	
M56																											×	×	×	×	×			
M64																													×	×	×	×		
M70 [1)]																																		
M72																																		×
M76 [1)]																																		
M82 [1)]																																		
M90 [1)]																																		
M95 [1)]																																		
M100 [1)]																																		

[1)] Preferred nominal lengths to be completed in a later revision of this standard.

NOTE. Choice of length.

(a) Minimum length. The minimum length of studs or studbolts has to ensure a full engagement of nut, i.e. with the point protruding above the face of the nut.

(b) Maximum length. There is no precise limit on the maximum length of thread although under normal circumstances, unnecessarily long studs and studbolts are avoided due to cost, and preventing corrosion or unintentional damage to the exposed thread making subsequent nut removal more difficult. Studs and studbolts may be chosen as the next nominal length greater than that required for the thicknesses and tolerances on the bolted components (e.g. flanges, gaskets, washers). The availability of 'stocked' lengths may also be taken into account. Unnecessary shortening of studs and studbolts should be avoided. Where studs and studbolts are shortened the original manufacturer's identification and grade marking should be retained.

Table 8. Length of point (see 2.2.6) for studbolts : metric series

Nominal diameter	Length
	mm
M10	1.17
M12	1.32
(M14)	1.48
M16	1.48
M20	1.80
(M22)	1.80
M24	2.09
M27	2.09
M30	2.09
M33	2.09
M36	2.09
M39	2.09
M42	2.09
M45	2.70
M48	2.70
M52	2.70
M56	2.70
M64	2.70
M70	2.70
M72	2.70
M76	2.70
M82	2.70
M90	2.70
M95	2.70
M100	2.70

2.1.2 Nominal length

The tolerances on nominal length shall be as given in table 6.

NOTE 1. The preferred nominal lengths are given in table 7. If lengths other than these are requested (see appendix C) the increments of length should be as given in table 9.

NOTE 2. Length of point is included in nominal length (see **1.2.2.1**).

Table 9. Increments of nominal length of studbolts: metric series

Nominal length		Increment
Over	Up to and including	
mm	mm	mm
—	65	5
65	200	10
200	300	20
300	—	25

2.1.3 Length of thread

For studbolts having plain portions as shown in figures 1(b), 1(c) and 1(d), the basic length of thread shall be the nominal diameter plus 10 mm.

For studbolts as in figures 1(b) and 1(c), the tolerances on the length of thread shall be plus 2 pitches, minus 0.

2.1.4 Length of reduced diameter portion

The basic length of the reduced diameter portion shall be 0.6 times the nominal diameter (see figure 1(d) and item (d)(5) of appendix C.

The following tolerances shall apply to this dimension:

(a) +0.75, −0 mm for lengths up to and including 28 mm;

(b) +1.50, −0 mm for lengths over 28 mm.

2.1.5 Length of thread plus length of reduced diameter portion

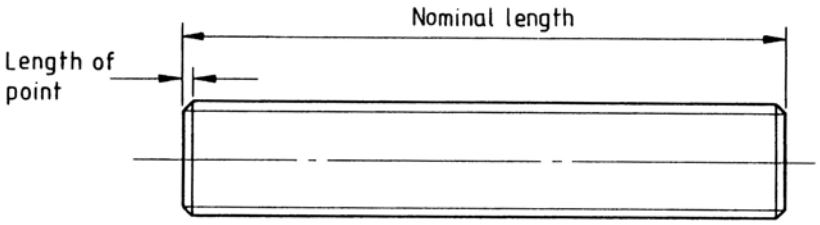
The following tolerances shall apply to this dimension:

(a) ±1.0 mm for nominal diameters up to and including M48;

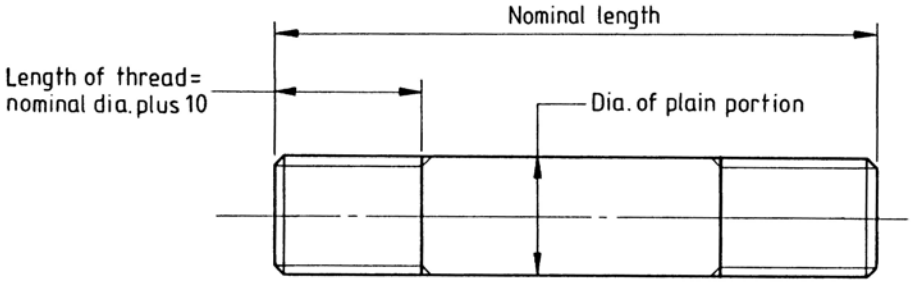
(b) ±2.00 mm for nominal diameters over M48 and up to and including M100.

2.1.6 *Ends*

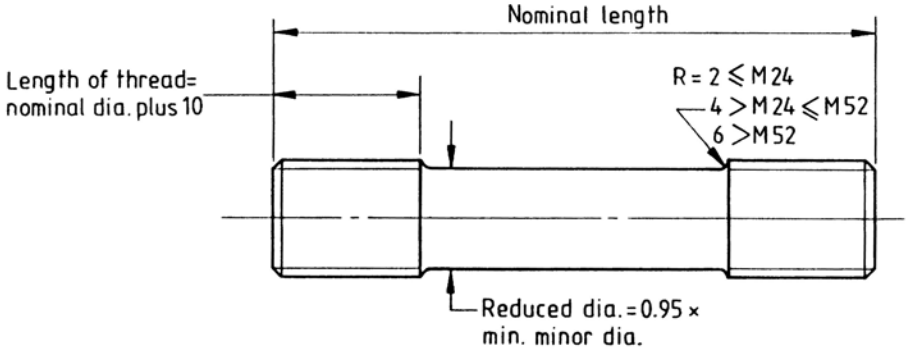
The ends of studbolts shall be finished with a point having an included angle of approximately 90 ° to a depth slightly exceeding the depth of thread. Nominal lengths of points for reference purposes shall be as given in table 8.



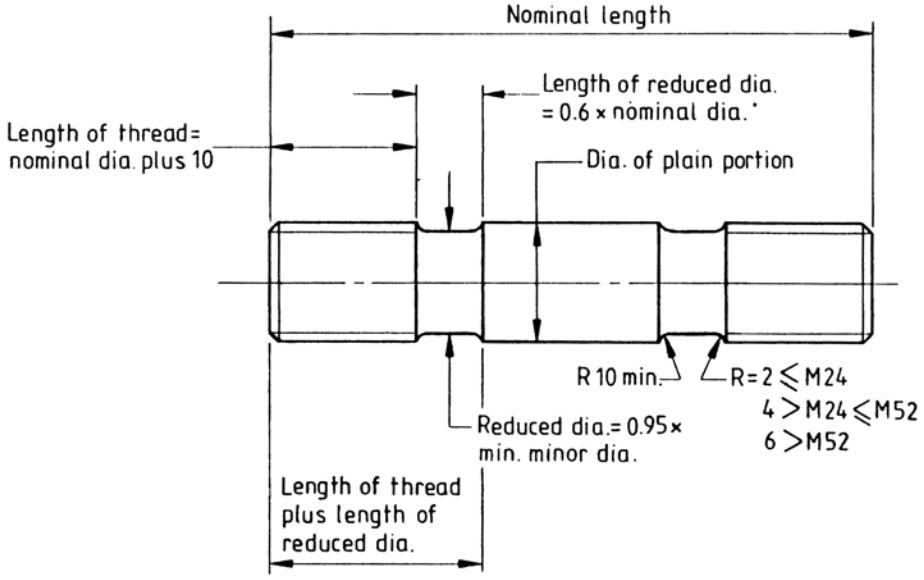
(a) Studbolt threaded full length



(b) Studbolt threaded each end with nominal diameter portion at centre



(c) Studbolt threaded each end with reduced diameter portion at centre



(d) Studbolt threaded each end with two reduced diameter portions and nominal diameter portion at centre

Dimensions are in millimetres.

NOTE 1. Dimensions at each end are the same for all designs.
Centring holes are permitted in types (c) and (d).

NOTE 2. For choice of length see note to table 7.

Figure 1. Dimensions of studbolts: metric series

2.1.7 Diameter of plain portion

The diameter of the plain portion shall not exceed the maximum values given in table 5.

NOTE. The diameter of the reduced portion should be stated by the purchaser in the order (see appendix C). Under normal conditions a minimum of 0.95 times the minor thread diameter is used, but for studs subject to particularly onerous conditions (such as high temperature service) diameters less than this may be used.

2.1.8 Screw threads

Screw threads for studbolts for all materials other than mild or carbon steel shall comply with the requirements given in table 10.

Table 10. Pitch of screw threads for studbolts: metric series

Nominal diameter	Pitch
≤ M27	ISO metric coarse (see BS 3643)
≥ M30 ≤ M43	3 mm
≥ M45 ≤ M100	4 mm

The ISO metric coarse pitch series shall be used throughout the range of sizes for mild or carbon steel.

NOTE. The tolerance class should be stated by the purchaser in the order (see appendix C), but for most conditions the following are applicable:

(a) class 6g for carbon steel and grades MB7, ML7, MB7A, MB16, MB16A, MB16B;

(b) class 6e for other materials.

2.2 Studs

2.2.1 General

The forms of the studs shall comply with those in figure 2(a), (b) or (c). Studs shown in figure 2(a) shall comply with BS 4439, covering sizes up to M39 and shall have ISO coarse pitches. Studs to figures 2(b) and 2(c) shall have pitches in accordance with **2.2.10**.

The dimensions of studs to figure 2(b) or 2(c) shall be as given in **2.2.2** to **2.2.11** and tables 5, 6 and 8 for studbolts.

2.2.2 Nominal length

The nominal lengths shall be in increments of 5 mm.

NOTE. The length of point is included in nominal length (see **1.2**). The tolerances on nominal length shall be as given in table 6.

2.2.3 Length of metal end of thread

For studs as shown in figures 2(b) and 2(c), the length of full form thread at the metal end shall equal nominal diameter except where high strength studs are used with weak flange materials, in which case the metal end threaded length shall be equal to 1.5 times the nominal diameter.

2.2.4 Length of nut end of thread

For studs as shown in figures 2(b) and 2(c), the basic length of thread shall be as given in table 11.

Table 11. Length of thread for studs: metric series

Nominal diameter	Thread length
	mm
≤ M12	Nominal dia. + 4
> M12 ≤ M20	Nominal dia. + 6
> M20 ≤ M72	Nominal dia. +10

2.2.5 Length of reduced diameter portion

The basic length of the reduced diameter portion shall be 0.6 times the nominal diameter (see figure 2(b)), and shall be rounded up to the next whole millimetre.

The following tolerances shall apply to this dimension:

(a) +0.75, −0 mm for lengths up to and including 28 mm;

(b) +1.50, −0 mm for lengths over 28 mm.

2.2.6 Lengths of thread plus length of reduced diameter portion

The following tolerances shall apply to this dimension:

(a) ± 1.0 mm for nominal diameters up to and including M48;

(b) ± 2.0 mm for nominal diameters over M48 and up to and including M72.

2.2.7 Ends

The nut ends shall be finished with a point having an included angle of approximately 90 ° to a depth slightly exceeding the depth of thread. Lengths of points shall be as given in table 8.

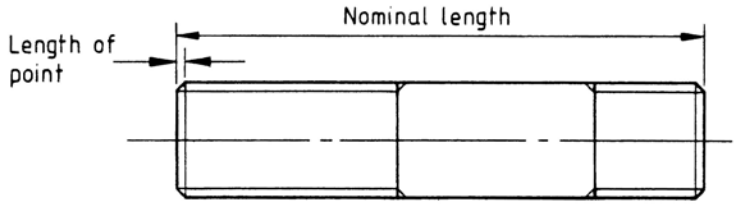
The metal ends shall be finished as follows:

(a) for studs as illustrated in figure 2(b) the corner shall be broken at 45 ° to give a smooth edge;

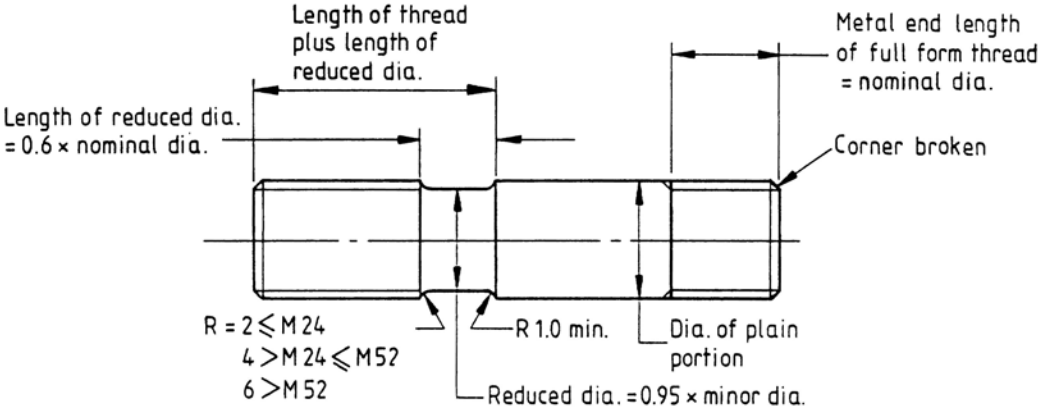
(b) for studs as illustrated in figure 2(c) the end dimensions shall comply with the scale of sizes given in table 12.

Table 12. Stud dimensions: metric series

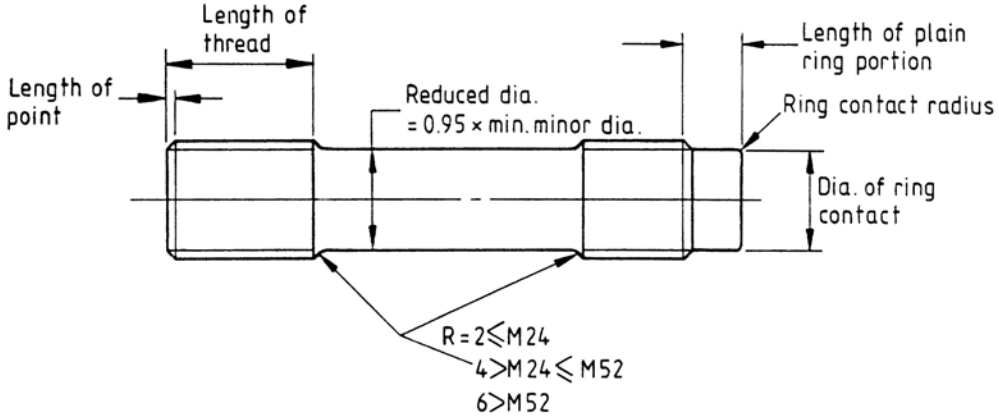
Nominal diameter	Ring contact diameter	Ring contact radius	Length of plain ring portion
	mm	mm	mm
M10 to M12	Nominal dia. −5	1	5
M14 to M27	Nominal dia. −6	1.5	6
M30 to M72	Nominal dia. −8	2	8



(a) Stud threaded each end without recess (see **2.2.1**)



(b) Stud threaded each end with recess to lock on threaded run out



(c) Stud threaded each end with recess to lock against bottom of hole

Dimensions in millimetres.

NOTE 1. Centring holes are permitted in types (b) and (c).
NOTE 2. See item (d)(4) of appendix C.

Figure 2. Dimensions of studs: metric series

2.2.8 Diameter of plain portion

The diameter of the plain portion shall be to the maximum and minimum sizes shown in table 5.

2.2.9 Diameter of reduced portion

The diameter of the reduced portion shall not exceed the maximum values given in table 5.

NOTE. The diameter of the reduced portion should be stated by the purchaser in the order (see appendix C). Under normal conditions a minimum of 0.95 times the minor thread diameter is used, but for studs subject to particularly onerous conditions (such as high temperature service) diameters less than this may be used.

2.2.10 Screw threads

Screw threads for studs of all materials other than low and medium carbon steel shall comply with the requirements given in table 13.

Table 13. Pitch of screw threads for studs: metric series

Nominal diameter	Pitch
≤ M27	ISO metric coarse (see BS 3643)
> M30 ≤ M42	3 mm
> M45 ≤ M72	4 mm

NOTE 1. For low and medium carbon steel it is permissible to use the ISO metric coarse pitch series throughout the range of sizes for low and medium carbon steel.

NOTE 2. The tolerance class (see BS 3643) should be stated by the purchaser in the order (see appendix C), but for most conditions the following are applicable:

(a) the metal end of studs should be to tolerance class 4h for all materials;

(b) the nut end of studs should be to the following classes:

(1) class 6g for carbon steel and grades MB7, ML7, MB7A, MB16, MB16A, MB16B;
(2) class 6e for other materials.

2.2.11 Tolerances on nominal length

The tolerances on nominal length shall be as shown in table 6.

2.3 Nuts for use with metric series studbolts and studs

2.3.1 Dimensions

Nuts shall comply with the dimensions and tolerances given in table 14.

Table 14. Dimensions of hexagon nuts: metric series

Nominal size and pitch	Width across flats s		Width across corners e	Thickness m		Tolerance on squareness
	max.	min.	min.	max.	min.	
	mm	mm	mm	mm	mm	mm
M10 × 1.5	16.00	15.57	17.59	8	7.42	0.29
M12 × 1.75	18.00	17.57	19.85	10	9.42	0.32
(M14 × 2)	21.00	20.16	22.78	11	10.30	0.37
M16 × 2	24.00	23.16	26.17	13	12.30	0.41
M20 × 2.5	30.00	29.16	32.95	16	15.30	0.51
(M22 × 2.5)	34.00	33.00	37.29	18	17.30	0.54
M24 × 3	36.00	35.00	39.55	19	18.16	0.61
M27 × 3	41.00	40.00	45.20	22	21.16	0.70
M30 × 3	46.00	45.00	50.85	24	23.16	0.78
M33 × 3	50.00	49.00	55.37	26	25.16	0.85
M36 × 3	55.00	53.80	60.79	29	28.16	0.94
M39 × 3	60.00	58.80	66.44	31	30.00	1.03
M42 × 3	65.00	63.80	72.09	34	33.00	1.11
M45 × 4	70.00	68.80	77.74	36	35.00	1.20
M48 × 4	75.00	73.80	83.39	38	37.00	1.29
M52 × 4	80.00	78.80	89.04	42	41.00	1.37
M56 × 4	85.00	83.60	94.47	45	44.00	1.46
M64 × 4	95.00	93.60	105.77	51	49.80	1.63
M70 × 4	100.00	98.60	114.42	56	54.80	1.76
M72 × 4	105.00	103.60	117.07	58	56.80	1.81
M76 × 4	110.00	108.60	122.72	61	59.80	1.89
M82 × 4	120.00	118.60	134.01	66	64.80	2.02
M90 × 4	130.00	128.60	145.32	72	70.80	2.20
M95 × 4	135.00	133.60	150.97	76	74.80	2.31
M100 × 4	145.00	143.60	162.27	80	78.80	2.42

NOTE. The dimensions are illustrated in figure 3.

2.3.2 Faces

Nuts shall have a chamfer of approximately 30 ° on the non-bearing face only. The bearing face shall be full faced. The bearing face shall be machined, or have a surface equal to that produced by machining.

The faces of the nut shall be square to the axis of the thread of the nut within the tolerances given in table 14 (see figure 3 and appendix E).

2.3.3 Screw threads

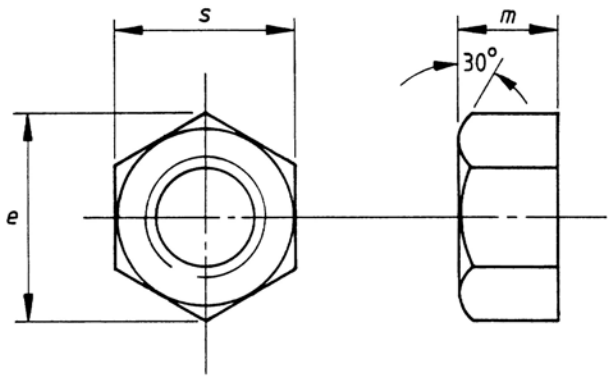
Screw threads for all materials other than low and medium carbon steel shall comply with the requirements given in table 15.

Table 15. Pitch of screw threads for nuts: metric series

Nominal dia.	Pitch	
≤ M27	ISO metric coarse (see BS 3643)	Class 6H (see item (d)(6) of appendix C)
≥ M30 ≤ M42	3 mm	
≥ M45 ≤ M100	4 mm	

The ISO metric coarse pitch series shall be used throughout the range of sizes for low and medium carbon steel.

The screw threads in nuts shall be concentric with the hexagons within a tolerance of 2 IT13, FIM (see BS 6322 : Part 1), using the width across flats as reference datum.



NOTE. See table 14.

Figure 3. Dimensions of hexagon nuts: metric series

Section 3. Inch series bolting

NOTE 1. This section of this British Standard relates to inch series bolting for use with inch series pipe flanges, valves, and fittings as specified in British Standards such as BS 10, BS 1560 and BS 3293 and also for general pressure containing purposes.

Dimensional requirements are given for four designs of studbolts, three designs of alloy steel studs and associated nuts, which use ISO inch (Unified) screw threads in the following diameters (see figures 4 and 5).

½ in	1¼ in	2 in	These sizes not specified for normal series nuts
⅝ in	1⅜ in	2¼ in	
¾ in	1½ in	2½ in	
⅞ in	1⅝ in	2¾ in	
1 in	1¾ in	3 in	
1⅛ in	1⅞ in	3½ in	
		3¾ in	
		4 in	

Inch series bolts and screws (and associated nuts) may also be used for flange bolting and in such cases selection should be made from BS 1768 or BS 1769.

NOTE 2. BS 1768 specifies low and high tensile medium carbon and alloy steel hexagon bolts and nuts, BS 1769 specifies low tensile mild steel hexagon bolts and nuts (heavy series).

3.1 Studbolts

3.1.1 General

The forms of the studbolts shall comply with those shown in figure 4(a), (b), (c) or (d). Dimensions shall be as given in **3.1.2** to **3.1.8** and tables 16 to 19.

3.1.2 Nominal length

The tolerances on nominal length shall be as given in table 17.

NOTE 1. The preferred nominal lengths are given in table 18. If lengths other than these are requested (see appendix C) the increments of nominal length should be as follows:

(a) ¼ in for lengths up to and including 12 in;

(b) ½ in for lengths over 12 in.

NOTE 2. The length of point is excluded from the nominal length (see **1.2.2.1**).

3.1.3 Length of thread

For studbolts having plain portions as shown in figures 4(b), (c) and (d), the basic length of thread shall be equal to the nominal diameter plus 0.375 in.

For studbolts in figures 4(b) and 4(c), the limits on the length of thread shall be plus 2 pitches, minus 0.

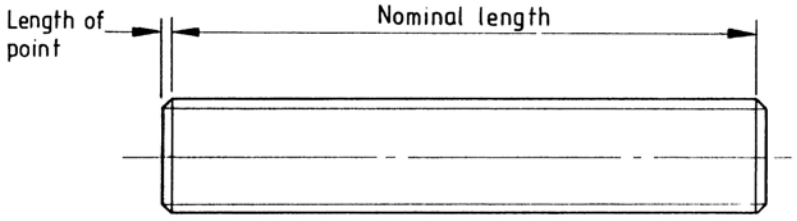
3.1.4 Length of reduced diameter portion

The basic length of the reduced diameter portion shall be equal to 0.6 times the nominal diameter (see figure 4(d) and item (d) (5) of appendix C).

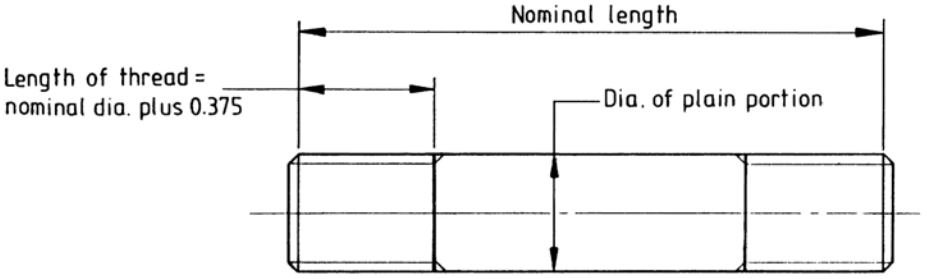
The following tolerences shall apply to this dimension:

(a) +0.030, −0 in for lengths up to and including 1.2 in;

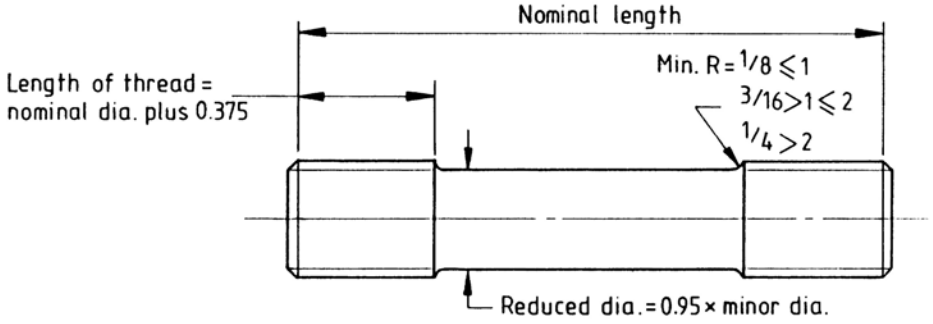
(b) +0.060, −0 in for lengths over 1.2 in and up to and including 2.1 in.



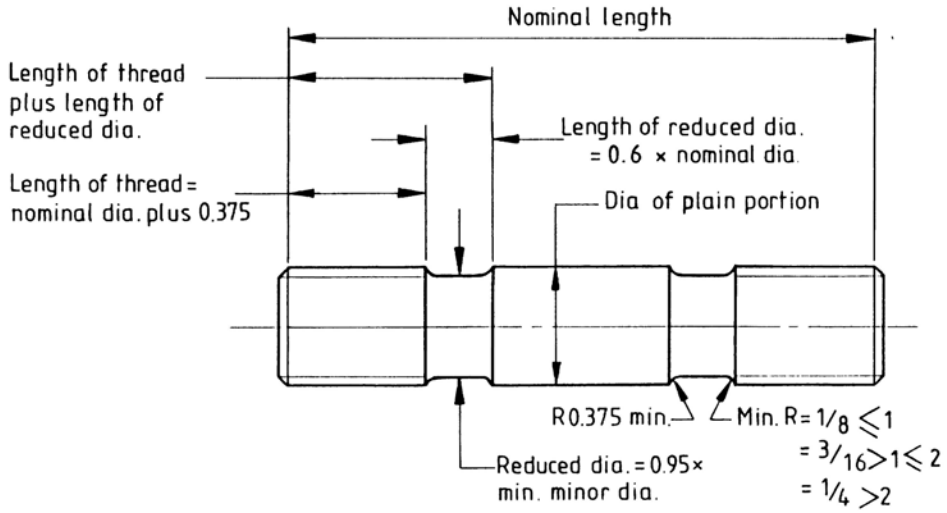
(a) Studbolt threaded full length



(b) Studbolt threaded each end with nominal diameter portion at centre



(c) Studbolt threaded each end with reduced diameter portion at centre



(d) Studbolt threaded each end with two reduced diameter portions and nominal diameter portion at centre

Dimensions are in inches.

NOTE 1. Exclusion of length of points from nominal length is in agreement with USA oil industry practice.

NOTE 2. Dimensions at each end are the same for all designs. Centring holes are permitted in types (c) and (d).

NOTE 3. For choice of length see note to table 18.

Figure 4. Dimensions of studbolts: inch series

3.1.5 Length of thread plus length of reduced diameter portion

The following tolerances shall apply to this dimension:

(a) ±0.030 in for lengths up to and including 2 in;

(b) ±0.060 in for lengths over 2 in and up to and including 6 in.

3.1.6 Ends

The ends of studbolts shall be finished with a point having an included angle of approximately 90 ° to a depth slightly exceeding the depth of thread. Nominal lengths of points for reference purposes shall be as given in table 19.

3.1.7 Diameter of plain portion

The diameter of the plain portion shall not exceed the maximum values given in table 16.

NOTE. The diameter of the reduced portion should be stated by the purchaser in the order (see appendix C). Under normal conditions a minimum of 0.95 times the minor thread diameter is used, but for studs subject to particularly onerous conditions (such as high temperature service) diameters less than this may be used.

Table 16. Diameter of plain portion, maximum and minimum sizes of studbolts : inch series

Nominal diameter	Nominal diameter design		Reduced diameter design [1]	
	max.	min.	max.	min.
in	in	in	in	in
½	0.500	0.496	0.373	0.364
⅝	0.625	0.619	0.474	0.464
¾	0.750	0.744	0.581	0.571
⅞	0.875	0.867	0.685	0.675
1	1.000	0.992	0.786	0.774
1⅛	1.125	1.117	0.905	0.893
1¼	1.250	1.242	1.022	1.010
1⅜	1.375	1.365	1.142	1.126
1½	1.500	1.490	1.260	1.244
1⅝	1.625	1.615	1.381	1.365
1¾	1.750	1.740	1.498	1.482
1⅞	1.875	1.865	1.620	1.604
2	2.000	1.990	1.732	1.716
2¼	2.250	2.240	1.968	1.952
2½	2.500	2.490	2.210	2.192
2¾	2.750	2.740	2.440	2.422
3	3.000	2.990	2.685	2.667
3½	3.500	3.485	3.160	3.138
3¾	3.750	3.735	3.397	3.375
4	4.000	3.985	3.635	3.613

[1] Based on tolerance class h 13 of BS 1916.

3.1.8 Screw threads

Screw threads shall be ISO Unified inch coarse pitch series (UNC) for sizes up to and including 1 in diameter, and 8 threads/in (8 UN series) for sizes 1⅛ in and above in accordance with BS 1580.

NOTE. The tolerance class should be stated by the purchaser in the order (see appendix C), but for most conditions the following are applicable:

(a) class 2A (see BS 1580) for grades B7, L7, B7A and B16, B16A, B16B;

(b) class 2AG for other materials.

Table 17. Tolerances on nominal length of studbolts : inch series

Nominal diameter	Length	Tolerances on length
in	in	in
≤ 1	≤ 6	± 0.030
	> 6	± 0.045
> 1 ≤ 2	≤ 7	± 0.045
	> 7	± 0.060
> 2 ≤ 4	All	± 0.075

Table 18. Preferred nominal lengths of studbolts : inch series (based on flanges as specified in BS 1560 : Section 3.1)

Nominal diameter	Preferred nominal lengths																															
	2	2¼	2½	2¾	3	3¼	3½	3¾	4	4¼	4½	4¾	5	5¼	5½	5¾	6	6¼	6½	6¾	7	7¼	7½	7¾	8	8¼	8½	8¾	9	9¼	9½	9¾
½	×	×	×	×	×	×	×	×	×	×	×																					
⅝	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×											
¾					×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×		×			
⅞							×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×				×		×	×		
1											×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
1⅛													×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
1¼															×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
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4*																																

* Preferred nominal lengths to be completed in a later revision of this standard.

NOTE. Choice of length.
(a) Minimum length. The minimum length of studs or studbolts has to ensure a full engagement of nut, i.e. with the point protruding above the face of the nut.
(b) Maximum length. There is no precise limit on the maximum length of thread although under normal circumstances, unnecessarily long studs and studbolts are avoided due to cost, and preventing corrosion or unintentional damage to the exposed thread making subsequent nut removal more difficult. Studs and studbolts may be chosen as the next nominal length greater than that required for the thicknesses and tolerances on the bolted components (e.g. flanges, gaskets, washers). The availability of 'stocked' lengths may also be taken into account. Unnecessary shortening of studs and studbolts should be avoided. Where studs and studbolts are shortened the original manufacturer's identification and grade marking should be retained.

Table 18. Preferred nominal lengths of studbolts : inch series (based on flanges as specified in BS 1560 : Section 3.1) (*continued*)

10	10¼	10½	10¾	11	11¼	11½	11¾	12	12¼	12½	13½	14	14½	15	15½	16	16½	17	17½	18	18½	19	19½	20	20½	21	21½	22	22½	23½	24	24½	25	25½
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Table 19. Length of point (see 3.2.6) for studbolts: inch series

Nominal diameter	Length
in	in
½	0.057
⅝	0.066
¾	0.071
⅞	0.078
1 and greater	0.087

3.2 Studs

3.2.1 General

The forms of the studs shall comply with those in figure 5(a) or (b) or (c). Studs to figure 5(a) shall comply with BS 2693 : Part 1, covering sizes up to 1½ in nominal diameter. Pitch details shall comply with **3.2.10**.

The dimensions of studs to figure 5(b) shall be as given in **3.2.2** to **3.2.10** and tables 16, 17 and 19 for studbolts.

3.2.2 Nominal length

The nominal lengths shall be in the following increments:

(a) increments of ⅛ in for lengths up to and including 5 in;

(b) increments of ¼ in for lengths above 5 in.

NOTE. Nominal length excludes length of point (see **1.3.3.1**).

The tolerances on nominal length shall be as given in table 17.

3.2.3 Length of metal end of thread

For studs to figure 5(b) the length of full form thread at the metal end shall be the nominal diameter except where high strength studs are used with weak flange materials in which case the metal end threaded length shall be equal to 1.5 times the nominal diameter.

3.2.4 Length of nut end of thread

For studs as shown in figure 5(b) the basic length of thread shall be as given in table 20.

Table 20. Length of thread for studs: inch series

Nominal diameter	Thread length
in	in
≤⅞	Nominal dia. + ¼
> ⅞ ≤ 2¼	Nominal dia. + 5/16
> 2¼ ≤ 4	Nominal dia. + ⅜

3.2.5 Length of reduced diameter portion

The basic length of the reduced diameter portion shall be 0.6 times the nominal diameter (see figure 5(b)), and shall be rounded up to the next 1/16 in.

The following tolerances shall apply to this dimension:

(a) +0.030, −0 in for lengths up to and including 1⅛ in;

(b) +0.060, −0 in for lengths over 1⅛ in.

3.2.6 Length of thread plus length of reduced diameter portion

The following tolerances shall apply to this dimension:

(a) ±0.030 in for lengths up to and including 2 in;

(b) ±0.060 in for lengths over 2 in and up to and including 6 in.

3.2.7 Ends

The nut ends shall be finished with a point having an included angle of approximately 90 ° to a depth slightly exceeding the depth of thread. Lengths of points shall be as given in table 19.

The metal ends shall be finished as follows:

(a) for studs as illustrated in figure 5(b) the corner shall be broken at 45 ° to give a smooth edge;

(b) for studs as illustrated in figure 5(c) the end dimensions shall comply with the scale of sizes given in table 21.

Table 21. Stud dimensions: inch series

Nominal diameter	Ring contact diameter	Length of plain ring portion
in	in	in
≤ ⅛	Nominal dia. − ¼	¼
> ⅛	Nominal dia. − 5/16	5/16

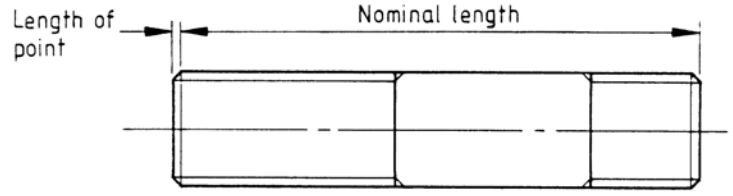
3.2.8 Diameter of plain portion

The diameter of the plain portion shall be to the maximum and minimum sizes shown in table 16.

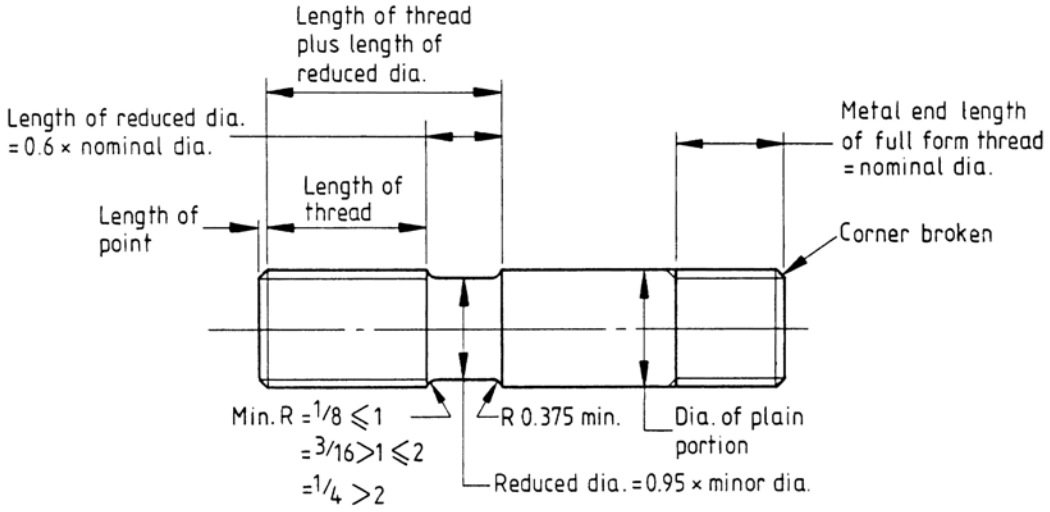
3.2.9 Diameter of reduced portion

The diameter of the reduced portion shall not exceed the maximum values given in table 16.

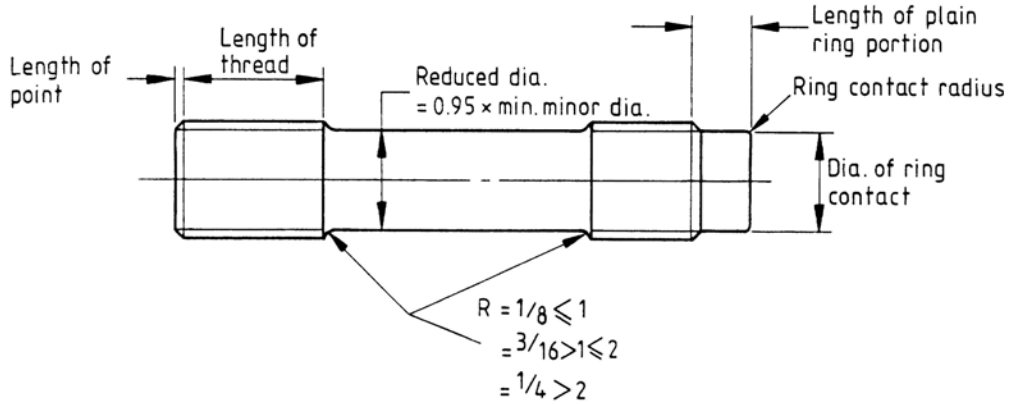
NOTE. The diameter of the reduced portion should be stated by the purchaser in the order (see appendix C). Under normal conditions a minimum of 0.95 times the minor thread diameter is used, but for studs subject to particularly onerous conditions (such as high temperature service) diameters less than this may be used.



(a) Stud threaded each end without recess (see **3.2.1**)



(b) Stud threaded each end with recess to lock on thread runout



(c) Stud threaded each end with recess to lock against bottom of hole

Dimensions are in inches.

NOTE 1. Centring holes are permitted in types (b) and (c).
NOTE 2. See item (d) (4) of appendix C.

Figure 5. Dimensions of studs: inch series

3.2.10 Screw threads

Screws threads shall be ISO Unified inch coarse pitch series (UNC) for sizes up to and including 1 in diameter, and 8 thread/in (8 UN series) for sizes 1⅛ in and above, in accordance with BS 1580.

NOTE. The tolerance class (see BS 1580) should be stated by the purchaser in the order (see appendix C), but for most conditions the following are applicable:

(a) the metal end of studs should be to the tolerance class 2A for all materials;

(b) the nut end of studs should be to the following tolerance classes:

(1) class 2A for B7, L7, B7A and B16, B16A, B16B;

(2) class 2AG for other materials.

3.2.11 Tolerances on nominal length

The tolerances on nominal length shall be as shown in table 17.

3.3 Nuts for use with inch series studbolts and studs

3.3.1 Dimensions

Nuts shall comply with the dimensions and tolerances given in table 22 or 23.

NOTE. Nuts of the following grades (see table 4) should be supplied as heavy series (see table 22) unless the purchaser requests the normal series: 2H 4 L4 7 8C 8T

3.3.2 Faces

Heavy series nuts (see table 22) and normal series nuts (see table 23) shall have a chamfer of approximately 30 ° on the non-bearing face. The bearing face shall be finished with either a washer face or a chamfer of aproximately 30°.

The bearing face shall be machined or have a surface finish equal to that produced by machining.

The faces of the nut shall be square to the axis of the thread of the nut within the tolerances given in tables 22 and 23 (see figures 6 and 7) when tested as described in appendix E.

3.3.3 Screw threads

Screw threads shall be ISO inch (UNC) for sizes up to and including 1 in diameter and 8 threads/in (8 UN series) for sizes 1⅛ in diameter and above in accordance with BS 1580 and shall conform to the tolerances for class 2B specified in that standard.

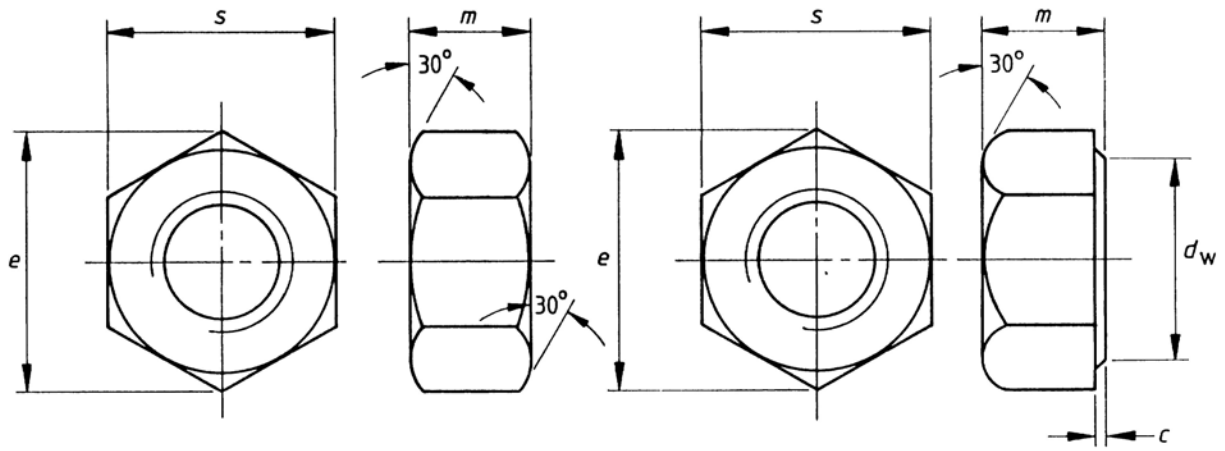
NOTE. See item (d) (6) of appendix C.

The screw threads of nuts shall be concentric with the hexagon within a tolerance of 2 IT13, FIM, using the width across the flats as the reference datum.

Table 22. Dimensions of heavy series nuts: inch series

Nominal size	Threads per inch	Width across flats s		Width across corners e	Washer face			Thickness m		Tolerance on squareness
					Diameter d_w		Thickness c			
		max.	min.	max.	max.	min.		max.	min.	
in	threads/in	in	in	in	in	in	in	in	in	in
½	13	0.875	0.85	1.01	0.836	0.808	1/64	0.504	0.464	0.015
5/8	11	1.062	1.031	1.23	1.013	0.979	1/64	0.631	0.587	0.016
3/4	10	1.250	1.212	1.44	1.189	1.150	1/64	0.758	0.710	0.019
7/8	9	1.438	1.394	1.66	1.366	1.324	1/64	0.885	0.833	0.023
1	8	1.625	1.575	1.88	1.539	1.496	1/64	1.012	0.956	0.023
1 1/8	8	1.812	1.756	2.09	1.710	1.668	1/64	1.139	1.079	0.027
1 1/4	8	2.000	1.938	2.31	1.892	1.841	1/64	1.251	1.187	0.027
1 3/8	8	2.188	2.119	2.53	2.070	2.013	1/64	1.378	1.310	0.030
1 1/2	8	2.375	2.3	2.74	2.251	2.185	1/64	1.505	1.433	0.030
1 5/8	8	2.562	2.481	2.96	2.433	2.857	1/64	1.632	1.556	0.030
1 3/4	8	2.750	2.662	3.18	2.605	2.529	1/64	1.759	1.679	0.030
1 7/8	8	2.938	2.844	3.39	2.779	2.702	1/64	1.886	1.802	0.035
2	8	3.125	3.025	3.61	2.949	2.874	1/64	2.013	1.925	0.035
2 1/4	8	3.500	3.388	4.04	3.296	3.219	1/32	2.251	2.155	0.040
2 1/2	8	3.875	3.75	4.47	3.65	3.563	1/32	2.505	2.401	0.045
2 3/4	8	4.250	4.112	4.91	4.012	3.906	1/32	2.759	2.647	0.050
3	8	4.625	4.475	5.34	4.373	4.251	1/32	3.013	3.893	0.055
3 1/2	8	5.375	5.2	6.21	5.061	4.94	1/32	3.506	3.370	0.060
3 3/4	8	5.750	5.563	6.64	5.42	5.27	1/32	3.760	3.616	0.065
4	8	6.125	5.925	7.07	5.78	5.62	1/32	4.014	3.862	0.070

NOTE. The dimensions are illustrated in figure 6.



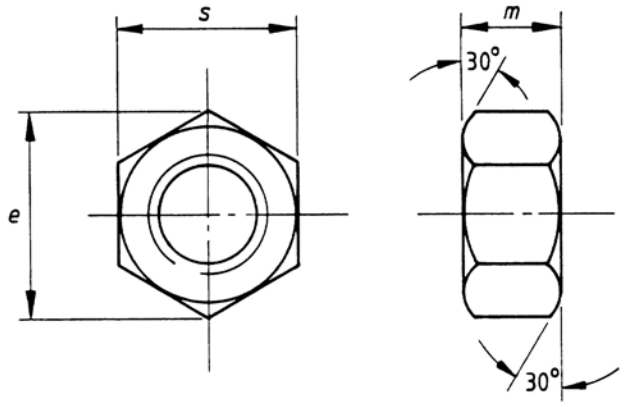
NOTE. See table 22.

Figure 6. Dimensions of heavy series nuts: inch series

Table 23. Dimensions of normal series nuts: inch series

Nominal size	Threads per inch	Width across flats s		Width across corners e	Thickness m		Tolerance on squareness
		max.	min.	max.	max.	min.	
in	threads/in	in	in	in	in	in	in
½	13	0.750	0.736	0.866	0.448	0.427	0.013
⅝	11	0.938	0.912	1.083	0.559	0.535	0.014
¾	10	1.125	1.100	1.299	0.644	0.625	0.017
⅞	9	1.312	1.282	1.516	0.754	0.724	0.020
1	8	1.500	1.470	1.732	0.871	0.831	0.020
1⅛	8	1.688	1.657	1.949	0.979	0.939	0.024
1¼	8	1.875	1.830	2.165	1.080	1.030	0.024
1⅜	8	2.062	2.017	2.382	1.188	1.138	0.026
1½	8	2.250	2.205	2.598	1.295	1.245	0.026
1⅝	8	2.438	2.378	2.808	1.406	1.353	0.028
1¾	8	2.625	2.565	3.031	1.510	1.460	0.030
1⅞	8	2.812	2.752	3.250	1.621	1.567	0.030
2	8	3.000	2.940	3.464	1.735	1.675	0.030

NOTE. The dimensions are illustrated in figure 7.



NOTE. See table 23.

Figure 7. Dimensions of normal series nuts: inch series

Appendices

Appendix A. Notes on bolting for service at elevated temperatures

A.1 Important note

This appendix is by no means comprehensive and purports only to indicate the main aspects, particularly with regard to materials, to be borne in mind by designers when selecting bolting for flanges.

It is important that its contents should not be taken as an authoritative guide on the subject of joint design or a firm criterion on bolting procedures.

For details of further information regarding flange bolting see BS 5500, BS 1506 and BS 4504.

The strength of bolting at a flange or valve joint depends on the bolting material and the bolt or studbolt dimensions.

The actual performance of a bolted assembly at elevated temperature depends upon the service temperature(s), the duration of the service, and the load induced by the assembly (tightening) operation, in addition to the particular grades of bolt(s), stud(s), nut(s), and washers used. Joint tightness requires these performance characteristics to be suitable for the particular type of joint and gasket (if any) employed.

Recognition of these interdependent factors is necessary in making a correct selection of bolting components, and in using a suitable assembly technique, in order to ensure satisfactory high temperature high pressure service.

It is essential to choose bolting that is compatible with the flange material in respect of the thermal expansion characteristics.

A.2 Allowable bolting stress

In a high temperature joint the fasteners have to provide the load required to initially seat the gasket at ambient conditions and that required during operation to clamp the joints faces and/or the gasket together with sufficient force to resist the pressure load and prevent leakage for the design retightening period. It is essential that the fastener material and initial tightening stress are selected to meet these different loading requirements, taking account of stress relaxation (see **A.3**).

The gasket seating load is usually higher than and generally independent of that imposed by the pressure. Values of the gasket loading required for initial seating and the minimum gasket loading required to maintain sealing for various types of gasket are given in the relevant flange and pressure vessel standards, e.g. BS 5500.

The values of allowable bolting stress for use at elevated temperatures given in the various valve, flange and pressure vessel standards, are those which should be used to determine the size and number of bolts required to maintain the joint seal for the typical service life between retightening. The materials listed in this bolting standard will withstand the higher stresses required for initial gasket seating without fracture or significant yielding.

Table 24, extracted from BS 5500, gives the recommended design stress values for flange bolting materials used in pressure vessels designed to BS 5500.

A.3 Stress relaxation

Relaxation of stress at constant strain occurs in all fasteners operating at temperatures above about 300 °C. The initial elastic stress applied to the fastener therefore gradually reduces until it is retightened. The stress relaxation characteristics of a fastener material dictate its performance in a particular joint assembly. Laboratory determined stress relaxation data are available for the special steels that have been developed for bolts for high temperature service.

BS 3500 : Part 6 covers standardized methods for testing and comparing stress-relaxation properties of metals and alloys.

Stress-relaxation properties of steels for bolting have been the subject of work for many years. Unlike the case of short-time tensile strength and extended time stress-rupture properties there has not been a coordinated effort to assess stress-relaxation characteristics of steels for bolting. However, individual users of bolting and steelmakers have obtained data on steels of specific interest to them, a case in point is given in tables 25, 26 and 27 for low alloy steels investigated extensively by a British steel manufacturer.

Properties for a range of steels are published in DIN 17240.

Properties for a wide range of alloys have been published in AST DS60 which was prepared for The Metal Properties Council and ASTM-ASME-MPC Joint committee on the effect of temperature on the properties of metals.

This compilation confirms that considerable effort has been expended but highlights the need for use of standard techniques (as to BS 3500 : Part 6) and the values of assessing systematically the properties of many casts of steel to provide an appropriate basis for use in designs, as the case of data given in tables 25, 26 and 27.

A.4 Properties at elevated temperatures in British Standard Specifications

It is established policy to include data on proof stress and stress-rupture in the specifications, based on

Table 24. Recommended design stress values for flange bolting materials in accordance with table 3.8.1.4 of BS 5500 : 1988

Material	BS references	Diameter (mm)	Recommended design stress (N/mm^2) for design metal temperatures (°C) not exceeding																				
			50	100	200	250	300	350	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750
Mild and carbon steel	(BS 1506-111)	≤ 152	93	89	85	76	67																
	(BS 3692 grade 8.8)	≤ 68	192	174	139	129	119																
	(BS 4190 grade 4.6)	≤ 68	120	113	92	81	71																
1 % chromium molybdenum steel	(BS 4882 grade B7, L7)	≤ 63	193	181	167	158	154	148	140														
		> 63 ≤ 100	174	163	152	145	141	134	127														
	(BS 4882 grade B7A)	≤ 100	193	181	167	165	163	158	154	146	118												
12 % chromium steel	(BS 4882 grade B6)	≤ 100	190	179	170	168	165	160	146	134													
1 % chromium molybdenum vanadium steel	(BS 4882 grade B16)	≤ 100	193	187	183	176	169	165	157	153	144	130	115	93									
1 % chromium molybdenum vanadium boron steel	(BS 4882 grade B16A)	≤ 100	174	168	163	159	152	149	143	140	135	130	115	93	61								
Austenitic chromium nickel 18/8 type steel	(BS 4882 grade B8)	All	126	106	89	83	80	77	75	72	71	70	69	68	66	64							
	(BS 4882 grade B8X)	≤ 19	200	169	142	128	117	106	94	87	80	75											
Stabilized austenitic chromium nickel 18/8 type steel	(BS 4882 grade B8T)	All	126	108	90	83	79	76	75	74	73	73	72	72	68	58							
	(BS 4882 grade B8TX)	≤ 19	201	172	144	130	119	107	96	90	84	79											
	(BS 4882 grade B8C)	All	128	118	104	97	92	90	88	88	87	87	87	86	85	74							
	(BS 4882 grade B8CX)	≤ 19	209	189	166	153	139	126	113	106	99	93											
Austenitic chromium nickel molybdenum steel	(BS 4882 grade B8M)	All	129	109	94	87	83	79	78	77	76	75	74	74	73	72							
	(BS 4882 grade B8MX)	≤ 19	207	174	148	136	124	112	100	93	87	81											
Precipitation hardening austenitic nickel chromium steel [1]	(BS 4882 grade B17B)	All	145	142	141	139	138	138	137	137	136	136	136	135	134	133	115	90	69				
Precipitation hardening nickel chromium titanium aluminium alloy [1] [2]	(BS 4882 grade B80A)	All	207	206	205	204	204	203	202	200	198	198	198	197	196	194	187	174	152	131	110	90	69

[1] For very high temperature applications the selection of materials for bolts, gaskets and flanges, as well as the design of flanges, requires special consideration and the bolt stresses may differ appreciably from the values recommended.

[2] Material liable to exhibit negative stress relaxation.

analysis of data collected by Technical Committee ISM/73/–/1, Elevated and low temperature properties of steels.

BS 1506 is the specification for steel used in this standard and it is intended that as data becomes available in a suitable form for the elevated temperature properties of the steels that data will be used for recommending values to be published in BS 1506.

Organizations obtaining data on stress-relaxation properties can assist in the work of ISM/73/–/1 by submitting results of their tests, details of the steel tested (using the recommendations given in BS 3500 : Part 6) and the size of material to the BSI offices for the attention of the secretary of ISM/73/–/1.

Table 25. Mean stress-relaxation properties of bars stressed to give a strain of 0.15 % (steel 1¼ %Cr½ %Mo, related to type 631-850 of BS 1506)

Temperature	Residual stress N/mm² (tonf/in²) at			
	1000 h	3000 h	10 000 h	30 000 h
°C				
350	211 (13.6)	208 (13.5)	205 (13.3)	201 (13.0)
400	198 (12.8)	191 (12.4)	179 (11.6)	164 (10.6)
450	157 (10.1)	142 (9.2)	118 (7.6)	96 (6.2)
500	93 (6.0)	61 (3.9)	30 (1.9)	

NOTE 1. Extract from a steel manufacturer's published data.

NOTE 2. Heat-treated condition: 840 °C to 900 °C oil-quenched, and tempered at 600 °C to 700 °C, air cooled.

Table 26. Mean stress-relaxation properties of bars stressed to give a strain of 0.15 % (steel 1¼ %CrMoV, related to type 671-850 of BS 1506)

Temperature	Residual stress N/mm² (tonf/in²) at			
	1000 h	3000 h	10 000 h	30 000 h
°C				
400	234 (15.1)	224 (14.5)	215 (13.9)	192 (12.4)
450	188 (12.2)	174 (11.2)	157 (10.2)	141 (9.1)
500	136 (8.8)	114 (7.4)	83 (5.4)	47 (3.0)

NOTE 1. Extract from a steel manufacturer's published data.

NOTE 2. Heat-treated condition: 930 °C to 970 °C oil-quenched, and tempered at 650 °C to 720 °C, air cooled.

Table 27. Mean stress-relaxation properties of bars stressed to give a strain of 0.15 % (steel 1 %CrMoVBTi, related to type 681-820 of BS 1506)

Temperature	Residual stress N/mm² (tonf/in²) at			
	1000 h	3000 h	10 000 h	30 000 h
°C				
400	247 (16.0)	237 (15.3)	224 (14.5)	212 (13.7)
450	216 (14.0)	203 (13.1)	188 (12.2)	173 (11.2)
500	180 (11.6)	163 (10.5)	141 (9.1)	118 (7.6)
550	134(8.7)	106 (6.9)	70 (4.5)	42 (2.7)
600	61 (3.9)	30 (1.9)		

NOTE 1. Extract from a steel manufacturer's published data.

NOTE 2. Heat-treated condition: 970 °C to 1010 °C oil or water quenched, and tempered at 660 °C to 730 °C for not less than 2 h, air cooled.

Appendix B. Notes on bolting for service at low temperatures

B.1 General

Design and construction codes for pressure containment equipment require that materials have adequate notch toughness to ensure freedom from risk of brittle fracture. In the case of bolting and many other components the notch toughness is determined by using the Charpy V-notch impact test. The codes and the materials specifications specify minimum energy for fracture at a given test temperature.

B.2 Application of bolting

B.2.1 BS 5500 covers the use of bolting at low temperatures in the following extract and table from BS 5500 : 1988 for vessels required to operate at low temperatures:

'**2.1.2.4** Bolts and nuts shall comply with the material specifications listed in tables 3 and 4 of BS 4882 : 1973 or table 3 of BS 1473 : 1972.

Table 2.2.2 specifies bolting material suitable for use at low temperature and the minimum design temperature for each material.'

NOTE. In table 2.2.2 the materials are taken from BS 1506 : 1958.

B.2.2 BS 2654 and BS 5387, storage tanks, also specify bolting based on use of BS 1506.

B.2.3 European, American and other design codes also require bolting to be of appropriate fracture toughness grades for service at low temperatures.

Appendix C. Information to be supplied by the purchaser

The following information should be quoted on the purchaser's enquiry and order:

(a) quantity;

(b) grade of material, identifying symbol of bolt, studbolt, stud and/or nut [1]. The material for bolts to BS 1768 and BS 3692 is limited to that specified in table 3 (see also **1.3.1**);

(c) form:

(1) whether bolts;

(2) whether studbolts;

(3) whether studs;

(4) whether nuts;

(d) dimensions:

(1) nominal diameter;

(2) nominal length (see figures 1, 2, 4 and 5);

(3) diameter of plain portion;

(4) diameter of reduced portion (see **2.2.9** and **3.2.9**);

(5) length of thread, plain portion and reduced diameter portion;

(6) special thread tolerances, e.g. high temperature and special coating applications;

(e) method of production, if significant (see **1.3.2**);

(f) if check analysis is required (see **1.3.4** and **1.4.4**);

(g) if testing of finished bolts is required (see **1.5.4** and **1.5.5.1**);

Table 2.2.2 Bolting materials for low-temperature

Material	Application requirements	Impact requirements	Min. design temperature
			°C
BS 1506-162	Nuts	Not specified	−50
BS 1506-240	Nuts	Not specified	−50
BS 1506-240 LT100	Nuts	20J at −100°C	−100
BS 1506-621 A	Bolts	Not specified	−50
BS 1506-621A LT 100	Nuts, bolts	20J at −100°C	−100
BS 1506-801 B	Nuts, bolts	Not specified	−200
BS 1506-821 Ti	Nuts, bolts	Not specified	−200
BS 1506-821 Nb	Nuts, bolts	Not specified	−200
BS 1510 LT100	Nuts, bolts	27J at −100°C	−100

[1] The manufacturer should be consulted when advice on materials is required. This is particularly relevant when considering nuts manufactured from free machining steels.

(h) if inch series, whether normal series nuts are required (see **3.3.1**);

(i) whether cone stripping tests are required on nuts (see note to tables 28 and 29 regarding size limitation for proof test, and **1.5.5.3**);

(j) whether any tests in addition to those stated in the standard are required (see note to tables 28 and 29 regarding size limitation for proof test);

(k) requirement for 100% indentation testing for bolting for sour gas application (see **1.5.6.2** and **1.5.6.3**);

(l) whether a manufacturer's test certificate is required;

(m) whether tests are to be witnessed by the purchaser's representative;

(n) whether any special marking or thread coding is required;

(o) any special packing and despatch instructions.

Appendix D. Cone stripping test

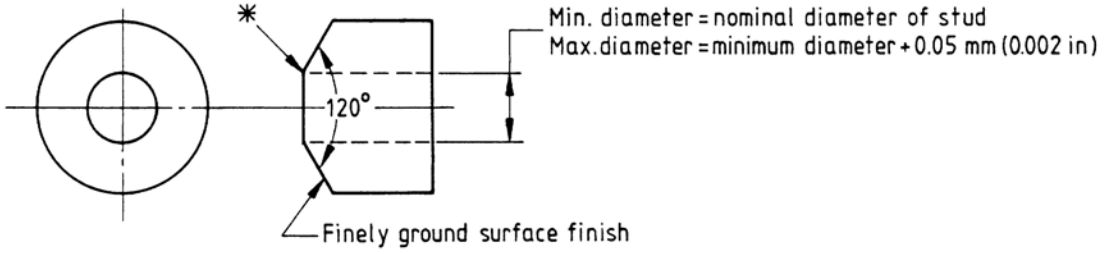
NOTE 1. The purpose of the test is to detect the presence of detrimental defects in the nut material which may produce bursting of the nut wall.

NOTE 2. The sizes of nut for which the test can be carried out are determined by the availability of a 500kN (50 ton f) capacity tensile testing machine.

For the purpose of this test a 120° hardened steel cone of the form and dimensions shown in figure 8 is used.

The nut is assembled with this cone on a hardened steel stud as shown in figure 9 and the stripping proof load specified in tables 28 and 29 shall be applied.

The nut shall be considered acceptable if the stripping load exceeds this proof load.



* Contact point of cone to be sharp for nut sizes 12 mm (½ in) and less. For sizes over 12 mm (½ in) this point to be flat and 0.381 ± 0.025 mm (0.015 ± 0.001 in) in width. Hardness 57 Rockwell C minimum. Specified tolerance for dimensions to be met for consistent results.

Figure 8. Hardened steel cone

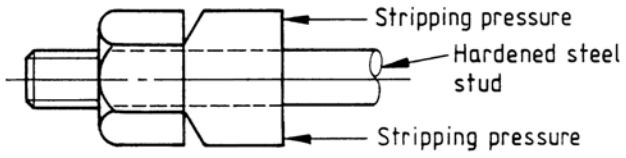


Figure 9. Application of cone to testing of nuts

Table 28. Proof load using 120° hardened steel cone (metric units for metric series nuts as in table 14)

Nominal diameter and pitch (see note)	Tensile stress area A_e	Proof load for normal series nuts[1]	
		Grades M2H, M4, M7[2]	Grades M2HM, M4M M7M, M6[3]
	mm^2	kN	kN
M10 x 1.5	58	53	46
M12 x 1.75	84.3	75	65
M14 x 2	115	99	85
M16 x 2	157	132	114
M20 x 2.5	245	194	167
M22 x 2.5	303	232	200
M24 x 3	353	261	225
M27 x 3	459	325	280
M30 x 3	581	387	333

[1] Based upon the following equation:

$C_{PL} = (1 - 0.012D) f A_e$

where

C_{PL} is the cone stripping proof load (in kN)

D is the nominal diameter of nut (in mm)

f is the proof load stress (in N/mm^2)

A_e is the tensile stress areas of nut (in mm^2) (see BS 3643 : Part 1)

[2] Based upon a proof load stress of 1040 N/mm^2.

[3] Based upon a proof load stress of 895 N/mm^2.

NOTE. Sizes above M30 to be specified by the purchaser.

Table 29. Proof load using 120° hardened steel cone (inch units for inch series nuts as in tables 22 and 23)

Size (see note)	Threads per inch	Tensile stress area	Proof load for[1]			
			Heavy series		Normal series	
			Grades 2H,4,7[2]	Grades 2HM, 4M 7M,6[3]	Grades 2H,4,7[3]	Grades 2HM, 4M, 7M,6[4]
	n	A_e				
		in^2	tonf	tonf	tonf	tonf
½ UNC	13	0.141	9.42	8.09	8.09	7.28
⅝ UNC	11	0.226	14.35	12.30	12.30	11.07
¾ UNC	10	0.334	20.22	17.35	17.35	15.60
⅞ UNC	9	0.462	26.63	22.82	22.82	20.80
1 UNC	8	0.606	33.15	28.41	28.41	25.58
1⅛ to 8 UN	8	0.790	40.89	35.00	35.00	31.54
1¼ to 8 UN	8	1.000	48.82	41.85	41.85	37.68

[1] Based upon the following equation:

$C_{PL} = (1 - 0.3D) f A_e$

where

C_{PL} is the cone stripping proof load (in tonf)

D is the nominal diameter of nut (in inches)

f is the proof load stress (in $tonf/in^2$)

A_e is the tensile stress area of nut (in in^2) $= 0.7854\ (D - 0.9743/n)^2$

where

n = is the number of threads per inch

[2] Based upon a proof load stress of 78.12 $tonf/in^2$.

[3] Based upon a proof load stress of 66.96 $tonf/in^2$.

[4] Based upon a proof load stress of 60.27 $tonf/in^2$.

NOTE. Sizes above 1¼ in to be specified by the purchaser.

Appendix E. Checking squareness of thread to face of nut (metric and inch series)

For the purpose of measurement of squareness the nut is screwed by hand on to a tapered truncated screw gauge as shown in figure 10 until the thread of the nut is tight on the thread of the screw gauge.

The gauge is provided with a sleeve having a face diameter equal to the minimum distance across flats, which slides on a parallel extension of the tapered screw gauge and is at exactly 90° to the axis of the latter.

When this sleeve is brought into contact with the leading face of the nut it should not be possible for a feeler gauge of a thickness equal to the squareness tolerance to enter between the leading face of the nut and the face of the sleeve.

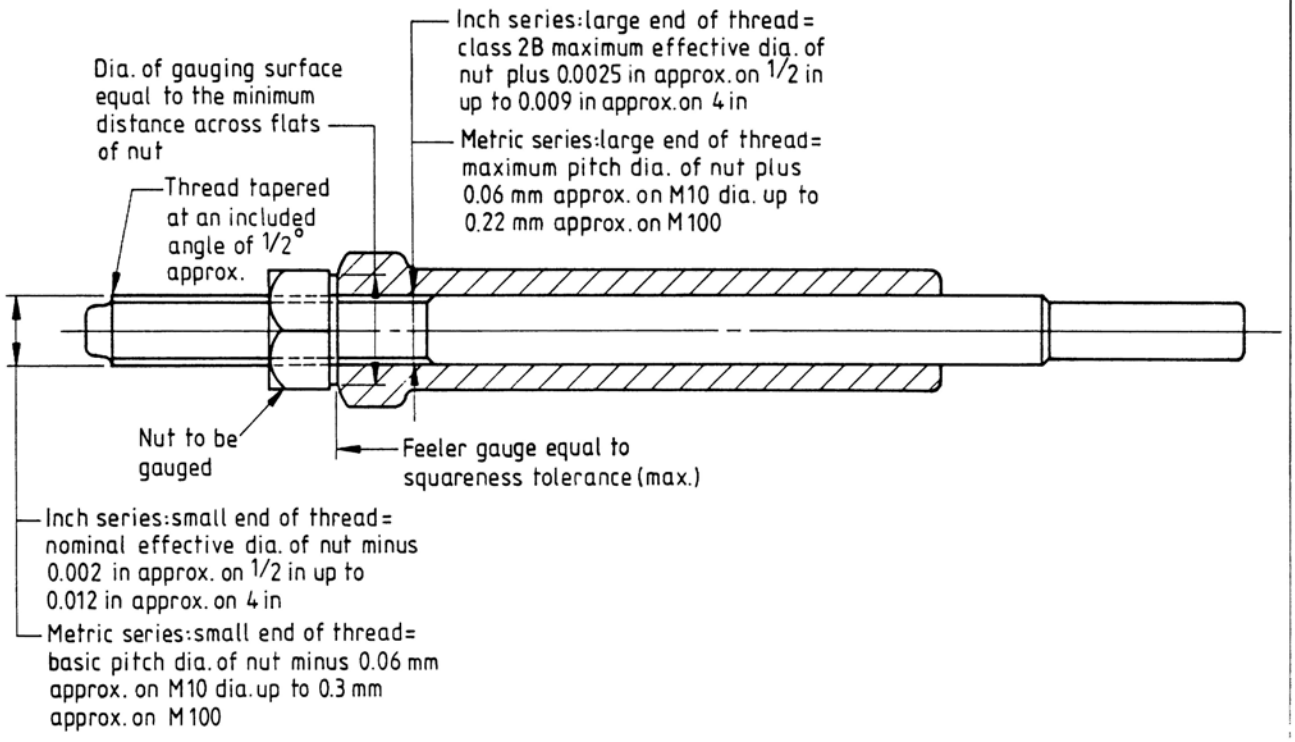


Figure 10. Recommended gauge for checking squareness of thread to face of nut: metric and inch series

Publications referred to

[1)]BS 10 Specification for flanges and bolting for pipes, valves and fittings

BS 131 Methods for notched bar tests
Part 1 The Izod impact test of metals
Part 2 The Charpy V-notch impact test on metals

BS 240 Method for Brinell hardness test and for verification of Brinell hardness testing machines

BS 427 Method for Vickers hardness test and for verification of Vickers hardness testing machines

BS 891 Method for hardness test (Rockwell method) and for verification of hardness testing machines (Rockwell method)

BS 970 Specification for wrought steels for mechanical and allied engineering purposes
Part 1 General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels

BS 1506 Specification for carbon, low alloy and stainless steel bars and billets for bolting material to be used in pressure retaining applications

BS 1560 Circular flanges for pipes, valves and fittings (Class designated)

BS 1580 Specification for Unified screw threads

[1)]BS 1768 Specification for Unified precision hexagon bolts, screws & nuts (UNC & UNF threads). Normal series

[1)]BS 1769 Specification. Unified black hexagon bolts, screws & nuts (UNC & UNF threads). Heavy series

BS 1916 Limits and fits for engineering

BS 2654 Specification for manufacture of vertical steel welded non-refrigerated storage tanks with butt-welded shells for the petroleum industry

[1)]BS 2693 Specification for screwed studs
Part 1 General purpose studs

BS 3076 Specification for nickel and nickel alloys: bar

BS 3111 Steel for cold forged fasteners and similar components
Part 1 Specification for carbon and low alloy steel wire

BS 3293 Specification for carbon steel pipe flanges (over 24 inches nominal size) for the petroleum industry

BS 3500 Methods for creep and rupture testing of metals
Part 6. Tensile stress relaxation testing

BS 3643 ISO metric screw threads
Part 1 Principles and basic data
Part 2 Specification for selected limits of size

BS 3692 Specification for ISO metric precision hexagon bolts, screws and nuts. Metric units

BS 4190 Specification for ISO metric black hexagon bolts, screws and nuts

BS 4439 Specification for screwed studs for general purposes. Metric series

BS 4500 ISO limits and fits

BS 4504 Circular flanges for pipes, valves and fittings (PN designated)

BS 5387 Specification for vertical cylindrical welded storage tanks for low-temperature service: double-wall tanks for temperatures down to −196 °C

BS 5500 Specification for unfired fusion welded pressure vessels

BS 5750 Quality systems

BS 6104 Mechanical properties of fasteners
Part 1 Specification for bolts, screws and studs

BS 6322 Tolerances for fasteners
Part 1 Specification for tolerances of bolts, screws and nuts with thread diameters ≥1.6 mm and ≤150 mm and product grades A, B and C

DIN 17240 Heat resisting and highly heat resisting materials for bolts and nuts; quality specifications

ASTDS 60 Compilation of stress-relaxation data for Engineering alloys

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[1)] Obsolescent British Standards (see foreword).

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