British Standard

BRITISH STANDARD

BS 4395-1: 1969

Incorporating Amendment Nos. 1 and 2

Specification for

High strength friction grip bolts and associated nuts and washers for structural engineering metric series —

Part 1: General Grade

UDC 621.882:624.014.2:693.8

Co-operating organizations

The Mechanical Engineering Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

Associated Offices' Technical Committee
Association of Consulting Engineers
Association of Mining Electrical and Mechanical Engineers
Board of Trade
British Chemical Plant Manufacturers' Association
British Compressed Air Society
British Electrical and Allied Manufacturers' Association*
British Gear Manufacturers' Association
British Internal Combustion Engine Manufacturers' Association
British Mechanical Engineering Confederation
British Pump Manufacturers' Association
British Steel Industry*
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Department of Employment and Productivity (H.M. Factory Inspectorate)
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National Physical Laboratory (Ministry of Technology
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The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

Association of Hydraulic Equipment Manufacturers
Black Bolt and Nut Association of Great Britain Britain
British Railways Board
British Constructional Steelwork Association
British Cycle and Motor Cycle Industries Association Ltd.
Council of British Manufacturers of Petroleum Equipment
Electronic Engineering Association
Fasteners and Turned Parts Institute
Institute of Iron and Steel Wire Manufacturers
Ministry of Defence, Navy Department
Post Office
Precision Bolt and Nut Institute
Rolled Thread Screw Association
Scientific Instrument Manufacturers' Association
Society of Motor Manufacturers and Traders Ltd.
Washer Manufacturers' Association of Great Britain
Individual Manufacturer

This British Standard, having been approved by the Mechanical Engineering Industry Standards Committee, was published under the authority of the Executive Board on
19 February 1969

The following BSI references relate to the work on this standard:
Committee references MEE/60, MEE/60/11
Draft for comment 67/31503

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Amendments issued since publication

Amd. No.	Date	Comments
1841	October 1975	
2198	January 1977	Indicated by a sideline in the margin

Contents

Foreword

A complete list of British Standards, numbering over 9,000, fully indexed and with a note of the contents of each, will be found in the BSI Catalogue which may be purchased from BSI Sales Department. The Catalogue may be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

BS 18, *Methods for tensile testing of metals.*

BS 21, *Pipe threads.*

BS 240, *Method for Brinell hardness test.*

BS 240-1, *Testing of metals.*

BS 427, *Method for Vickers hardness test.*

BS 427-1, *Testing of metals.*

BS 891, *Method for Rockwell hardness test.*

BS 891-1, *Testing of metals.*

BS 1580, *Unified screw threads.*

BS 1916, *Limits and fits for engineering.*

BS 3643, *ISO metric screw threads.*

BS 3643-1, *Thread data and standard thread series.*

BS 3643-2, *Limits and tolerances for coarse pitch series threads.*

BS....[1)], *The use of high strength friction grip bolts in structural engineering.*

BS-1, *General grade metric series.*

This British Standard has been prepared under the authority of the Mechanical Engineering Industry Standards Committee as a result of the decision taken to adopt the ISO metric screw thread system in the United Kingdom (see Appendix A), and requests received from industry for the provision of a specification for high strength friction grip bolts to basic metric dimensions.

Although at present there are no ISO Recommendations, dealt recommendations or draft proposals relating specifically to high strength friction grip bolts, account has been taken of current documentation prepared by ISO Committee ISO/TC 2 "Bolts, nuts and accessories", and where possible the provisions of the following ISO Recommendation and draft recommendations have been incorporated in the text of this standard:

ISO Recommendation R 272, *"Hexagon bolts and nuts, metric series, widths across flats, heights of heads, thicknesses of nuts".*

ISO Draft Recommendation DR 950, *"Nominal lengths for bolts, screws and studs, thread lengths for general purpose bolts".*

ISO Draft Recommendation DR 952, *"Hexagon bolts and nuts, metric series, tolerances on widths across flats, widths across corners".*

ISO Draft Recommendation DR 987, *"Bolts and screws, radii under the head of general purpose bolts and screws, metric series".*

Although the basic hexagon sizes for the bolts and nuts are in accordance with ISO Recommendation R 272, the next larger width across flats for any given diameter, as shown in the normal metric series, have been selected in order to provide greater bearing areas for both bolts and nuts.

[1)] In course of preparation.

The diametral dimension for the flat washers given in this standard have been based on the "large diameter series" detailed in draft ISO Recommendation No. 940 "Washers for hexagon bolts — metric series". The thicknesses for the flat washers have been based on those currently given in BS 3139[2)], and the American Standard ASTM A 325[3)], since it was felt that these thicknesses were more compatible with the function for which these washers are used, the washer thicknesses quoted in ISO/DR 940 being more applicable to ordinary hexagon bolts and nuts.

The dimensions of square taper washers given in this standard have been based on the inch sizes at present given in BS 3139, since it seems unlikely that BS 4 "Structural steel sections", will be revised to provide rational metric sizes for sections in the near future. It also seems unlikely that a metric version of BS 4 would in any way change the flange angles, and there appears to be justification for retaining them as at present, since ISO is currently considering the adoption of structural steel sections covered by BS 4.

On the question of the material to be utilized for general grade bolts to Part 1 of this standard, the BSI committee responsible were unable to reconcile the different practices adopted on the continent, as detailed in ISO Draft Recommendation No. 911[4)] and BS 3692[5)] and the American practice as detailed in ASTM A 325. It is continental practice to maintain a constant tensile strength throughout the diameter range of threaded products, thus necessitating a change in chemical composition because of the increase in ruling section, whereas it is the American practice to maintain a generally constant chemical composition, which in practice leads to a reduction in the tensile strength over the diameter range.

It was originally intended to specify ISO strength Grade 8.8 for general grade metric high strength friction grip bolts to Part 1 of this standard, and ISO strength Grade 10.9 for high grade bolts in the envisaged Part 2 (see BS 3692). However, it was pointed out in committee that if ISO strength Grade 8.8 was specified in Part 1, an alloy steel rather than a carbon steel would need to be used for diameters greater than 24 mm. It was felt by the committee that economic considerations were important in this respect and might prove paramount for users intending to change over to metric products. Accordingly this Part 1 has been prepared with the material requirements based on the American Grade 5 material used in ASTM A 325 and BS 3139-1 (see notes to Table 1).

NOTE 1 Although the minimum radii under the head specified for bolts in this standard are in accordance with ISO/DR 987, the transition diameter (d_a max.) quoted in Table 5 falls between the values quoted for finished and semi-finished products in the draft recommendation. This minor deviation was justified by the committee on the grounds that these products were not general purpose bolts and as such, it was felt desirable to specify a maximum transition diameter consistent with their specialized function.

NOTE 2 Although the mechanical requirements specified in this standard are in metric technical units (i.e. kgf/mm^2) in accordance with present ISO agreements (ISO/DR 911), comparable SI units have been included in anticipation of future international agreement in this respect. 1 kgf = 9.806 65 newtons. For further information about SI units see PD 5686. "The use of SI units", and Supplement No. 1 (1967) to BS 350-2, "Additional tables for SI conversions".

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2) BS 3139, "High strength friction grip bolts for structural engineering", Part 1, "General grade bolts".

3) ASTM A 325, "High-strength carbon steel bolts for structural joints, including the suitable nuts and plain hardened washers".

4) ISO Draft Recommendation No. 911, "Mechanical properties of fasteners", Part 1, "Bolts, screws and studs".

5) BS 3692, "ISO metric precision hexagon bolts, screws and nuts".

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i to vi, pages 1 to 19 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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1 General

1.1 Scope

Part 1 of this British Standard specifies requirements for one (general) grade of quenched and tempered high strength friction grip hexagon head bolts and their associated nuts and washers for use in structural engineering.

Dimensions are given for a range of nominal sizes from 12 mm (M 12) to 36 mm (M 36) inclusive and mechanical properties are specified. Full details of tests, inspection procedure and provisions for marking are also included.

NOTE Attention is drawn to the importance of ensuring that these bolts are correctly used if satisfactory results are to be obtained. Recommendations giving guidance in the use of this form of fastener are given in BS ...., "The use of high strength friction grip bolts in structural engineering", Part 1, "General grade metric series" (in course of preparation).
Any alternative method of use should be left to the responsibility of the engineer and should be noted on the appropriate drawings or documents, or both.

1.2 Terminology

The term "high strength friction grip bolts" relates to bolts of high tensile steel, used in conjunction with high tensile steel nuts and quenched and tempered steel washers, which are tightened to a predetermined shank tension in order that the clamping force thus provided will transfer loads in the connected members by friction between the parts and not by shear in or bearing on the bolts or plies of connected members.

2 Bolts

2.1 Material

Steel used in the manufacture shall be that produced by the open-hearth, electric or any of the oxygen processes[6)]. The maximum content of sulphur and phosphorus shall not exceed 0.06 % each. In the case of the oxygen processes the maximum content of nitrogen shall not exceed 0.008 %.

2.2 Heat treatment

Bolts shall be heat-treated under uniform conditions. They shall be hardened by quenching in oil or water and shall then be tempered.

2.3 Mechanical properties

Bolts shall meet the requirements set out in Table 4 for all properties selected for the test programme (see **2.4**).

NOTE The figures given in Columns 4 to 10 inclusive of Table 4 are minimum values.

The manner in which tests are to be carried out is specified in Appendix B.

2.4 Test programme

Appendix D consists of a list of mechanical properties for bolts and indicates by the symbol "●" the tests to be carried out by the supplier for all bolts. The tests indicated by the symbol "⊕" may be carried out at the special request of the purchaser. If these tests are required, this should be clearly stated in the enquiry, order or contract.

2.5 General test requirements

2.5.1 Number of tests. Each test selected from Appendix D shall be carried out three times per batch of bolts. A batch shall consist of the number of pieces shown in Table 1.

Table 1 — Number of pieces comprising a batch of bolts

Diameter of bolt d	Number of pieces in batch
Up to and including 16 mm	15 000 or fraction thereof
Over 16 mm up to and including 24 mm	5 000 or fraction thereof
Over 24 mm	2 500 or fraction thereof

2.5.2 Retests. Should any specimen fail to meet the requirements of a specified test, an additional sample of double the number of specimens from the same batch at the time of manufacture shall be tested and if all the additional specimens satisfy the requirements of the test the batch shall be deemed to comply with this standard.

2.6 Dimensions and finish

The dimensions, tolerances and general finish of the bolts shall be in accordance with the requirements specified in **2.6.1** to **2.7** inclusive and in Table 5 (Figure 2).

2.6.1 Length of bolts

2.6.1.1 *Nominal length.* The nominal length of the bolt shall be the distance from the underside of the head to the extreme end of the shank, including any chamfer or radius. The standard nominal lengths are given in Appendix F, together with preferred size combinations of diameter and length.

2.6.1.2 *Tolerance.* The tolerance on the nominal length shall be as given in Table 2.

[6)] This term includes both top and bottom blown oxygen processes.

Table 2 — Tolerance on nominal length

Nominal length		Tolerance on length
Over	Up to and including	
mm	mm	mm
30	50	± 1.25
50	80	± 1.50
80	120	± 1.75
120	180	± 2.00
180	250	± 2.30
250	315	± 2.60
315	400	± 2.85
400	500	± 3.15

2.6.2 Ends of bolts. The ends of bolts may, at the option of the manufacturer, be finished with either a 45° chamfer to a depth slightly exceeding the depth of the thread or with a radius approximately equal to 1¼ times the nominal diameter of the shank.

2.6.3 Screw threads

2.6.3.1 *General.* The form of thread, and diameters and associated pitches of general grade metric high strength friction grip bolts shall be in accordance with BS 3643-1[7)].

2.6.3.2 *Tolerances.* The screw threads shall be made to the tolerances for the "medium" class of fit (6 g) as specified in BS 3643-2[7)].

2.6.4 Length of thread. The length of thread on bolts shall be the distance from the end of the bolt (including any chamfer or radius) to the leading face of a screw ring gauge which has been screwed as far as possible on to the bolt by hand.

The length of thread run out shall not exceed 2.5 times the pitch of the thread.

The standard thread lengths are based on the formulae set out in Table 3.

Table 3 — Thread lengths

Nominal length of bolt	Length of thread[a]
Up to and including 125 mm	$2d$ + 6 mm
Over 125 mm up to and including 200 mm	$2d$ + 12 mm
Over 200 mm	$2d$ + 25 mm

[a] d = thread diameter (see Table 4).

2.6.4.1 *Tolerances.* The tolerances on bolt thread lengths shall be plus two pitches for all diameters. Bolts that are too short for minimum thread length shall be threaded as near to the head as possible, providing the radius specified in Table 5 is maintained.

2.6.5 *Chamfering and facing.* The heads shall be chamfered at an angle of approximately 30° on their upper faces. The diameter of the ring formed by the chamfer on the upper face of the bolt shall not be smaller than 90 % of the minimum across-flats dimension (see Figure 1).

The lower or bearing face shall be washer-faced. The bearing face shall be machined or have a surface equal to that produced by machining.

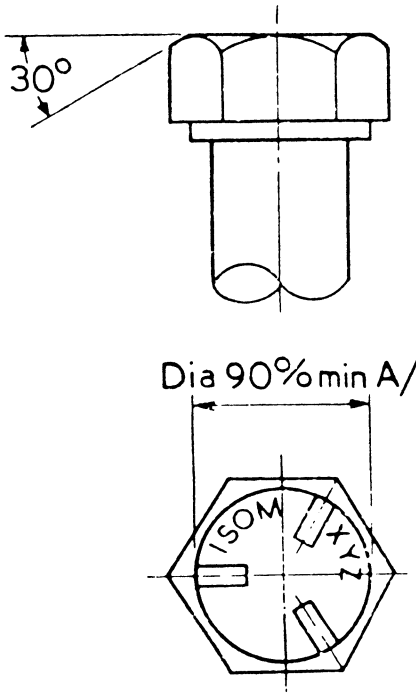
2.6.6 Diameter of shank. The maximum and minimum diameters of the unthreaded portion of the shank of the bolt shall be in accordance with dimensions given in Table 5, Columns 2 and 3. The shank diameter shall be capable of acceptance by a ring gauge having an internal diameter equal to the maximum shank diameter as specified in Column 2, Table 5 and subject to a tolerance of plus 0.025 mm to plus 0.050 mm.

A suitable design of gauge for this test would be a plain ring gauge having a maximum thickness equal to the nominal diameter of the bolt, a minimum fillet radius in the bore equal to the maximum radius under the bolt head and an internal diameter as specified above.

2.7 Marking

Bolts shall be identified as general grade high strength friction grip bolts by being marked with three radial lines 120° apart. They shall also bear the manufacturer's identification mark and in addition shall be marked "ISOM" or "M" to signify ISO metric thread (see Figure 1).

7) BS 3643, "ISO metric screw threads", Part 1, "Thread data and standard thread series", Part 2, "Limits and tolerances for coarse pitch series threads".



'ISOM' or 'M' = ISO metric identification
'XYZ' = manufacturer's (trade) marking

Figure 1 — Chamfering, facing and marking of bolts

Table 4 — Mechanical properties of bolts

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Nominal size and thread diameter	**Pitch of thread (coarse pitch series)**	**Tensile stress area (see Note 1)**	**Ultimate load (see Note 2) min.**		**Yield load or load permanent set at limit $R_{0.2\ min}$ (see Note 3) min.**		**Proof load (see Note 4) min.**		**Elongation after fracture**	**Hardness (see Note 5)**					
										Brinell HB		**Rockwell HRC**		**Vickers HV 30**	
d mm	p mm	A_s mm^2	**tonne-force (1 000 kgf)**	**kilo-newtons**	**tonne-force (1 000 kgf)**	**kilo-newtons**	**tonne-force (1 000 kgf)**	**kilo-newtons**	**percent** min.	Max.	Min.	Max.	Min.	Max.	Min.
M 12[a]	1.75	84.3	7.1	69.6	5.45	53.5	5.04	49.4	12	321	255	34	25	330	260
M 16	2.0	157	13.25	130	10.16	99.7	9.39	92.1	12	321	255	34	25	330	260
M 20	2.5	245	20.71	203	15.85	155	14.64	144	12	321	255	34	25	330	260
M 22	2.5	303	25.57	250	19.60	192	18.1	177	12	321	255	34	25	330	260
M 24	3.0	353	29.79	292	22.94	225	21.10	207	12	321	255	34	25	330	260
M 27	3.0	459	33.89	333	26.04	259	23.88	234	12	295	223	30	19	292	225
M 30	3.5	561	41.42	406	31.82	313	29.19	286	12	295	223	30	19	292	225
M 36	4.0	817	60.32	591	46.35	445	42.51	418	12	295	223	30	19	292	225

NOTE 1 The tensile stress area is calculated from the following formula:

$$A_s = \frac{\pi}{4}(\text{mean of effective and minor diameters})^2 = \frac{\pi}{16}(\text{effective diameter} + \text{minor diameter})^2$$

NOTE 2 Based on 84.38 kgf/mm^2 (827 N/mm^2) for sizes M 12 to M 24 inclusive and 73.83 kgf/mm^2 (725 N/mm^2) for sizes M 27 to M 36 inclusive.

NOTE 3 Based on 64.7 kgf/mm^2 (635 N/mm^2) for sizes M 12 to M 24 inclusive and 56.73 kgf/mm^2 (558 N/mm^2) for sizes M 27 to M 36 inclusive.
Equivalent to stress at permanent set limit $R_{0.2\ min}$.

NOTE 4 Based on 59.77 kgf/mm^2 (587 N/mm^2) for sizes M 12 to M 24 inclusive and 52.04 kgf/mm^2 (512 N/mm^2) for sizes M 27 to M 36 inclusive.

NOTE 5 Hardness values are given for guidance only.

NOTE 6 See Appendix B for method of carrying out: 1) ultimate load test;
2) yield load (or load at permanent set limit $R_{0.2\ min}$), proof load and elongation tests;
3) hardness tests.

[a] Non-preferred. Only to be used for the lighter type of construction where practical conditions, such as material thickness, do not warrant the usage of a larger size bolt than M 12.

Table 5 — Dimensions of hexagon head bolts

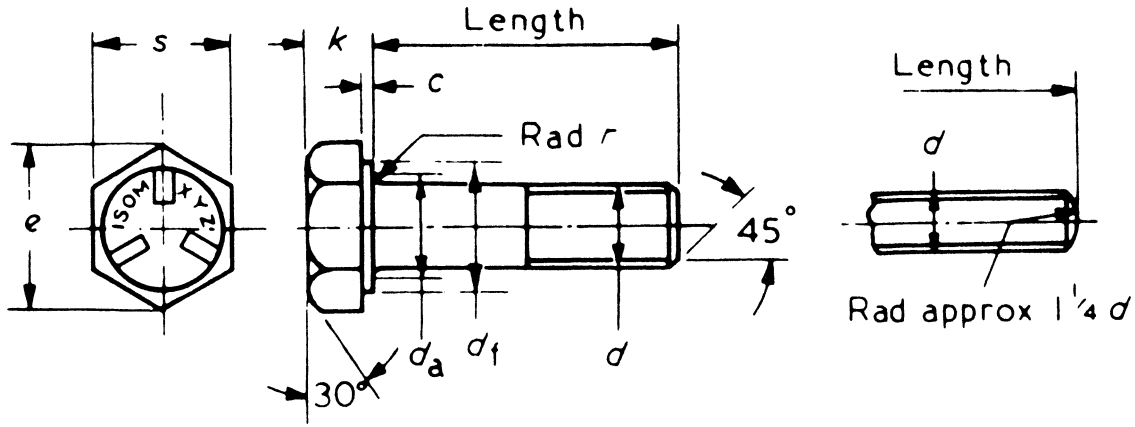


Figure 2 — Hexagon bolts

Dimensions in millimetres

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Nominal size and thread diameter *d*	**Pitch of thread** *p*	**Diameter of unthreaded shank** *d*		**Width across flats** *s*		**Width across corners** *e*		**Diameter of washer face** d_f		**Depth of washer face** *c*	**Radius under head** *r*		**Transition diameter** d_a	**Thickness of head** *k*	
	(coarse pitch series)	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Max.	Min.	Max.	Max.	Min.
M 12[a]	1.75	12.70	11.30	22	21.16	25.4	23.70	22	19.91	0.4	1.00	0.6	14.7	8.45	7.55
M 16	2.0	16.70	15.30	27	26.16	31.2	29.30	27	24.91	0.4	1.00	0.6	18.7	10.45	9.55
M 20	2.5	20.84	19.16	32	31.00	36.9	35.03	32	29.75	0.4	1.2	0.8	23.24	13.90	12.10
M 22	2.5	22.84	21.16	36	35.00	41.6	39.55	36	33.75	0.4	1.2	0.8	25.24	14.90	13.10
M 24	3.0	24.84	23.16	41	40.00	47.3	45.20	41	38.75	0.5	1.2	0.8	27.24	15.90	14.10
M 27	3.0	27.84	26.16	46	45.00	53.1	50.85	46	43.75	0.5	1.5	1.0	30.84	17.90	16.10
M 30	3.5	30.84	29.16	50	49.00	57.7	55.37	50	47.75	0.5	1.5	1.0	33.84	20.05	17.95
M 36	4.0	37.0	35.0	60	58.80	69.3	66.44	60	57.75	0.5	1.5	1.0	40.00	24.05	21.95

[a] Non-preferred. Only to be used for the lighter type of construction where practical conditions, such as material thickness, do not warrant the usage of a larger size bolt than M 12.

3 Nuts

3.1 Material

Steel used in the manufacture of nuts shall be that produced by the open-hearth, electric furnace, oxygen or acid Bessemer processes. Free cutting steel shall not be used.

3.2 Heat treatment

Nuts shall be heat-treated under uniform conditions. They shall be hardened by quenching in oil and shall then be tempered.

3.3 Mechanical properties

Nuts shall meet the requirements set out in Table 7.

3.3.1 Hardness test on nuts. If nuts of 30 mm diameter or over cannot be subjected to the proof load test, due to lack of suitable equipment, they shall be subject to a hardness test and their hardness shall not be outside the following ranges.

	Min.	Max.
Brinell	HB 166	HB 302
Rockwell	HRB 88	HRC 30
Vickers	HV 175	HV 310

3.4 General test requirements

3.4.1 Number of tests. Three nuts shall be selected for the proof load or hardness test, as appropriate, from each batch of nuts at the time of manufacture. A batch shall consist of the number of pieces shown in Table 6.

Table 6 — Number of pieces comprising a batch of nuts

Diameter of nut	Number of pieces in batch
Up to and including 16 mm	15 000 or fraction thereof
Over 16 mm up to and including 24 mm	5 000 or fraction thereof
Over 24 mm	2 500 or fraction thereof

3.4.2 Retests. Should any specimen fail to meet the requirements of a specified test, an additional sample of double the number of specimens from the same batch at the time of manufacture shall be tested and if all the additional specimens satisfy the requirements of the test the batch shall be deemed to comply with this standard.

3.5 Dimensions and finish

The dimensions, tolerances and general finish of the nuts shall be in accordance with the requirements specified in **3.5.1** to **3.6** inclusive and in Table 8 (Figure 4).

3.5.1 Screw threads

3.5.1.1 *General.* The form of thread and diameters and associated pitches for general grade metric high strength nuts shall be in accordance with BS 3643-1[8)].

3.5.1.2 *Tolerances.* The screw threads shall be made to the tolerances for medium class of fit (6H) as specified in BS 3643-2[8)].

3.5.2 Chamfering and facing. Nuts shall be chamfered at an angle of approximately 30° on their upper faces and they shall have a washer face on the bearing surface. The diameter of the ring formed by the chamfer on the nut shall not be smaller than 90 % of the minimum across-flats dimension. The bearing surface of the nut shall be machined or have a surface equal to that produced by machining.

3.5.3 Squareness of threads to face. The bearing surface of the nut shall be square to the axis of the thread of the nut within the tolerances given in Column 11, Table 8.

A gauge recommended for carrying out this test together with the manner in which the test is to be undertaken is shown in Appendix E.

3.6 Marking

Nuts for use with standard grade high strength friction grip bolts shall be identified by being marked on the chamfered face with three similar circumferential arcs 120 degrees apart. They shall also be marked with the letter "M" (see Figure 3).

Markings may be either embossed or indented at the option of the manufacturer, who may also use additional marking for his own purposes.

8) BS 3643, "ISO metric screw threads", Part 1, "Thread data and standard thread series", Part 2, "Limit sand tolerances for coarse pitch series threads".

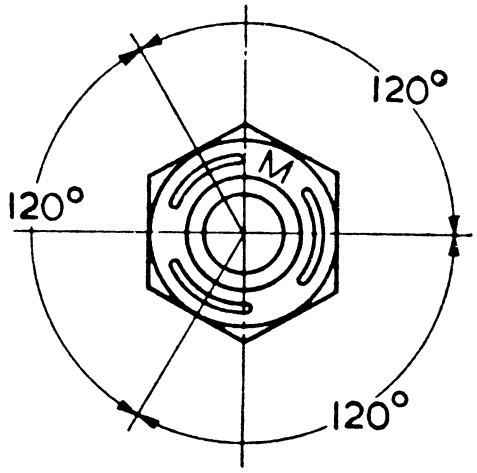


Figure 3 — Marking of nuts

Table 7 — Proof loads for nuts (coarse pitch series)

1	2	3
Nominal size and thread diameter *d*	**Proof load**	
	tonne-force (1 000 kgf)	**kilo-newtons**
M 12	8.6	84.3
M 16	16.0	157
M 20	25.0	245
M 22	30.9	303
M 24	36.0	353
M 27	46.8	459
M 30	57.2	561
M 36	83.3	817

NOTE 1 Based on 102 kgf/mm^2 (1 000 N/mm^2) on the equivalent stress area of the corresponding bolt (see Table 4).
NOTE 2 For method of carrying out test, see Appendix C.

Table 8 — Dimensions of hexagon nuts

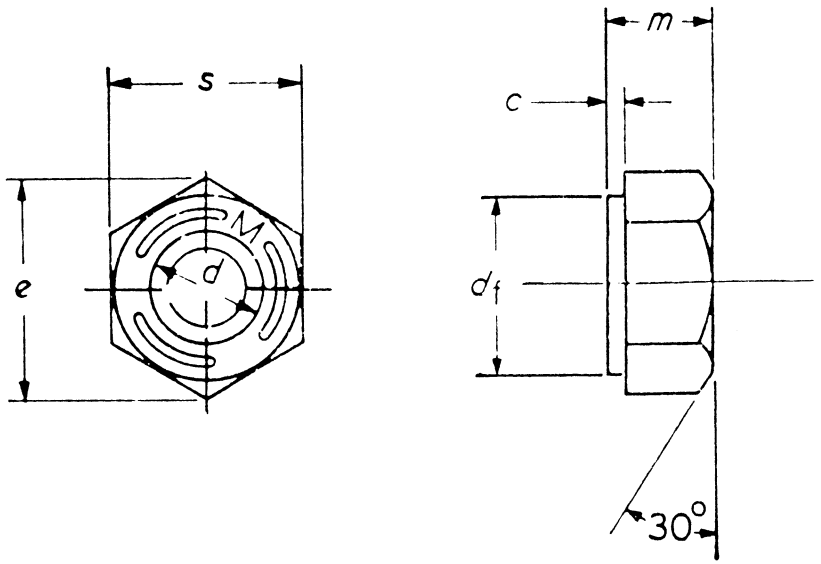


Figure 4 — Hexagon nut

Dimensions in millimetres

1	2	3	4	5	6	7	8	9	10	11	12
Nominal size and thread diameter *d*	**Pitch of thread** *p*	**Width across flats** *s*		**Width across corners** *e*		**Diameter of washer** *df*		**Depth of washer face** *c*	**Thickness of nut** *m*		**Tolerance on squareness (see 3.5.3)**
	(coarse pitch series)	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Max.	Min.	Max.
M 12[a]	1.75	22.00	21.16	25.40	23.82	22.00	19.91	0.4	11.55	10.45	0.37
M 16	2.0	27.00	26.16	31.20	29.30	27.00	24.91	0.4	15.55	14.45	0.46
M 20	2.5	32.00	31.00	36.90	35.03	32.00	29.75	0.4	18.55	17.45	0.54
M 22	2.5	36.00	35.00	41.60	39.55	36.00	33.75	0.4	19.65	18.35	0.61
M 24	3.0	41.00	40.00	47.30	45.20	41.00	38.75	0.5	22.65	21.35	0.70
M 27	3.0	46.00	45.00	53.10	50.85	46.00	43.75	0.5	24.65	23.35	0.78
M 30	3.5	50.00	49.00	57.70	55.37	50.00	47.75	0.5	26.65	25.35	0.85
M 36	4.0	60.00	58.80	69.30	66.44	60.00	57.75	0.5	31.80	30.20	1.03

[a] Non-preferred. Only to be used for the lighter type of construction where practical conditions such as material thickness do not warrant the usage of a larger size bolt than M 12.

4 Washers

4.1 Material

Steel used in the manufacture of washers shall be that produced by the open-hearth, electric furnace, oxygen or acid Bessemer process.

4.2 Heat treatment

Washers shall be quenched and tempered.

4.3 Hardness tests

4.3.1 Washers shall be subjected to a hardness test. The hardness shall be as follows:

Rockwell C. Scale 38 to 45 HRC.

4.3.2 When the Rockwell method is used, the preparation of test specimens and the method of testing shall be in accordance with BS 891[9] and the hardness values shall be determined in accordance with Rockwell C scale. Tapered washers shall be tested on the sheared edge to obtain a flat surface as specified in BS 891.

4.3.3 Alternatively the Diamond Pyramid method in accordance with BS 427[10] may be used. In this case a load of 30 kg shall be applied and the washers shall have a hardness of 362 to 440 HV 30.

4.4 General test requirements

4.4.1 Number of tests. Three washers shall be selected for the hardness test from each batch of washers at the time of manufacture. A batch shall consist of the number of pieces shown in Table 9.

Table 9 — Number of pieces comprising a batch of washers

Washers for bolt sizes	Number of pieces in batch
up to and including 16 mm	15 000 or fraction thereof
over 16 mm up to and including 24 mm	5 000 or fraction thereof
over 24 mm	2 500 or fraction thereof

4.4.2 Retests. Should any specimen fail to meet the requirements of a specified test, an additional sample of double the number of specimens from the same batch at the time of manufacture shall be tested and if all the additional specimens satisfy the requirements of the test the batch shall be deemed to comply with this standard.

4.5 Dimensions and tolerances

4.5.1 Plain washers. The dimensions of plain washers shall be in accordance with Table 10 (Figure 5).

4.5.2 Taper washers. The dimensions of square taper washers shall be in accordance with Table 11 (Figure 6). Standard angles of taper are 3°, 5° and 8° and the purchaser shall specify which of these angles are required.

4.5.3 Clipped washers. When clearance makes it necessary, plain washers may be clipped on one side at a point not closer than seven-eighths of the bolt diameter from the centre of the washer.

4.6 Finish

The surfaces of the washers shall be flat and smooth.

4.7 Marking

4.7.1 Plain washers. Flat round washers for use with high strength friction grip bolts shall be identified by the provision of three nibs and an indented letter "M" as shown in Figure 5.

4.7.2 Taper washers. 3°, 5° and 8° taper washers for use with high strength friction grip bolts shall be identified with an indented letter "M" and the angle of taper indicated by the following features:

3° taper washers shall have a projection as shown in Figure 6*a*. This projection shall be rounded to avoid sharp edges.

5° taper washers shall be chamfered on one corner as shown in Figure 6*b*.

8° taper washers shall be chamfered on two corners as shown in Figure 6*c*.

[9] BS 891, "Method for Rockwell hardness test".

[10] BS 427, "Method for Vickers hardness test".

Table 10 — Dimensions of flat round washers

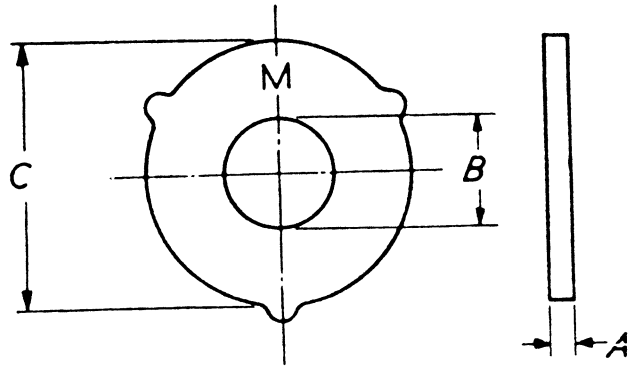


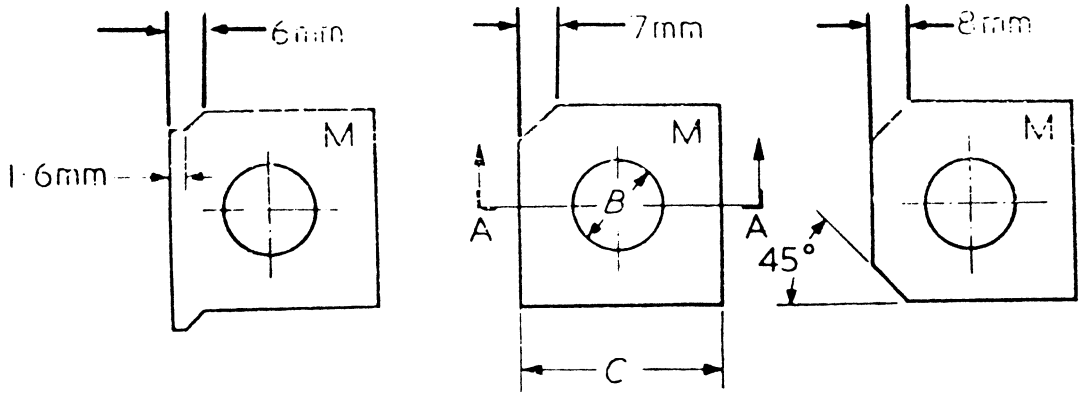
Figure 5 — Flat round washer

Dimensions in millimetres

1	2	3	4	5	6	7
Nominal size and thread diameter *d*	**Inside diameter** *B*		**Outside diameter** *C*		**Thickness** *A*	
	Max.	Min.	Max.	Min.	Max.	Min.
M 12[a]	13.8	13.4	30	29	2.8	2.4
M 16	17.8	17.4	37	36	3.4	3.0
M 20	21.5	21.1	44	43	3.7	3.3
M 22	23.4	23.0	50	48.5	4.2	3.8
M 24	26.4	26.0	56	54.5	4.2	3.8
M 27	29.4	29.0	60	58.5	4.2	3.8
M 30	32.8	32.4	66	64.5	4.2	3.8
M 36	38.8	38.4	85	83.5	4.6	4.2

[a] Non-preferred

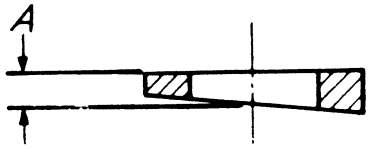
Table 11 — Dimensions of square taper washers



3°
Fig. 6*a*

5°
Fig. 6*b*

8°
Fig. 6*c*



Section AA
All chamfers 45°

Figure 6 — Square taper washers

1	2	3	4	5	6
Nominal size and thread diameter	**Inside diameter *B***		**Overall size *C***	**Mean thickness *A***	
	Max.	Min.		**3° and 5° Taper**	**8° Taper**
M 12[a]	14.2	13.4	31.75	4.76	6.35
M 16	18.2	17.4	38.10	4.76	6.35
M 20	21.9	21.1	38.10	4.76	6.35
M 22	23.8	23.0	44.45	4.76	6.35
M 24	26.8	26.0	57.15	4.76	6.35
M 27	29.8	29.0	57.15	4.76	6.35
M 30	33.2	32.4	57.15	4.76	6.35
M 36	39.2	38.4	57.15	4.76	6.35

[a] Non-preferred

5 Inspection

5.1 General inspection procedures

5.1.1 General. The manufacturer shall take the necessary steps to ensure that the conditions relating to dimensions and tests laid down in this standard are fulfilled. If, in addition, the purchaser desires to make his own inspection, he shall state so in his enquiry and contract or order. Such inspection shall be carried out in accordance with the terms stated in **5.1.2**.

5.1.2 Purchaser's inspection. The inspector representing the purchaser shall have access, at all reasonable times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works concerned with the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities, without charge, to satisfy him that the material is being furnished in accordance with the requirements of this standard. Unless otherwise specified, all tests and inspection shall be carried out at the place of manufacture prior to the despatch of the finished material from the works and shall be so conducted as not to interfere unnecessarily with the operation of the works.

6 Purchasing information

6.1 Information to be supplied with enquiry or order

In all cases when making enquiries or orders for products in accordance with this standard the standard number shall be given (i.e. BS 4395-1).

6.1.1 Bolts. For bolts the nominal diameter and length of bolt in millimetres shall also be given, e.g.:

"Bolts M 20 × 120 to BS 4395-1".

6.1.2 Nuts. For nuts it is only necessary to specify the nominal diameter and standard number, e.g.:

"Nuts M 20 to BS 4395-1".

6.1.3 Washers. For washers the nominal diameter and type of washer (e.g. flat round or taper 3°, 5° or 8°) shall also be given, e.g.:

"Washers M 20 × 5° taper to BS 4395-1".

Appendix A BSI policy statement on screw threads and the metric system

The major sectors of British industry were represented at a conference organized by the BSI on 23rd November, 1965. They gave their approval to a policy statement which urged British firms to regard the traditional screw thread systems, Whitworth, BA and BSF, as obsolescent, and to make the internationally agreed ISO metric thread their first choice (with the ISO Unified thread as second choice) for all future designs.

Prior to the conference the statement had been endorsed by the Mechanical Engineering Industry Standards Committee, the Engineering Divisional Council and the General Council of BSI.

The following is the text of the policy statement:

On 24th May, 1965 the Right Hon. Douglas Jay, the President of the Board of Trade, announced in Parliament that it would be desirable for this country to change to the metric system. An extract from his statement is given below:

> "... British industries on a broadening front should adopt metric units sector by sector, until that system can become in time the primary system of weights and measures for the country as a whole ... the Government hope that within ten years the greater part of the country's industry will have effected the change ...."

The national need for increased exports coupled with maximum efficiency and economy of production lies behind the above statement and makes it essential to give urgent and serious consideration to the screw thread situation in the United Kingdom.

After many years' work the International Organization for Standardization (ISO) has reached agreement on ISO Recommendations for general purpose screw threads. This agreement will enable the industries of the world to align the usage of screw threads and to minimize the present diversities of practice.

The ISO Recommendations comprise a system of ISO metric threads[11)] and a system of ISO inch threads[12)]. The ISO inch threads are the same as the existing Unified threads.

In view of the world trend towards the metric system, and having particular regard to the declared UK national policy for its adoption, it is strongly recommended that British industry should adopt the ISO metric screw thread system.

Although it is appreciated that some of those sections of industry already using ISO inch (Unified) screw threads may find it necessary, for various reasons, to continue with their use for some time, Whitworth and BA threads should be superseded by ISO metric threads in preference to an intermediate change to ISO inch threads.

NOTE Threads on pipes will continue to be BSP (to BS 21 "Pipe threads") which have been adopted as the ISO pipe thread and which are covered in ISO Recommendation R7, "Pipe threads for gas list tubes and screwed fittings where pressure-tight joints are made on the threads (⅛ in to 6 in)".

Appendix B Testing of mechanical properties of steel bolts (See **2.3**)

B.1 Tensile testing of machined test pieces. Perform the tests in accordance with the requirements of BS 18[13)] to determine the following:

1) Tensile strength.

2) Yield stress or stress at permanent set limit of 0.2 %.

3) Percentage elongation after fracture, gauge length $5.65\sqrt{\text{area}}$.

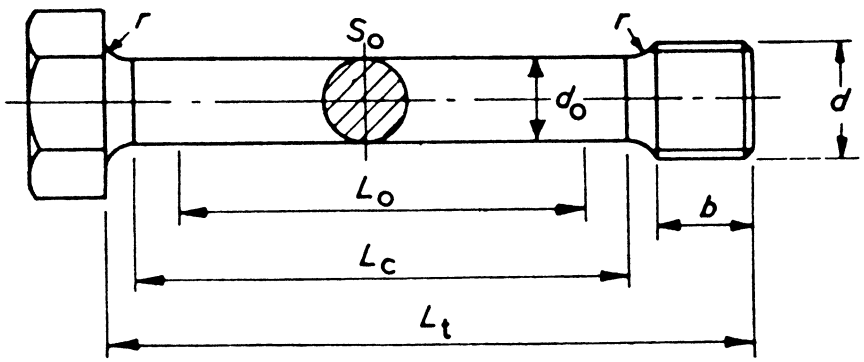
Machine the test piece as illustrated in Figure 7 from an actual bolt or bolt blank.

When machining the test specimen the reduction of the shank diameter of heat-treated bolts over 16 mm thread diameter shall not exceed 25 % of the original diameter (about 44 % of the cross-sectional area) of the test specimen.

B.2 Brinell hardness test. The Brinell hardness test shall be performed in accordance with the requirements of BS 240-1[14)]. The impression should be applied either on the top of the head or to the centre position of the end of the bolt, after approximately 0.4 mm has been removed by grinding.

B.3 Rockwell hardness test. The Rockwell hardness test shall be performed in accordance with the requirements of BS 891-1[15)]. The impression of the ball or cone shall be applied either on the top of the head or to the centre position of the end of the bolt, after approximately 0.4 mm has been removed by grinding.

11) BS 3643, "ISO metric screw threads".
12) BS 1580, "Unified screw threads".
13) BS 18, "Methods for tensile testing of metals".
14) BS 240, "Method for Brinell hardness test", Part 1, "Testing of metals".
15) BS 891, "Method for Rockwell hardness test", Part 1, "Testing of metals".



d = nom. thread diameter
d_o = diameter of test section (less than minor diameter of thread) (see Note)
b = length of thread (d min.)
L_o = gauge length $5{\cdot}65\sqrt{S_o}$
L_c = length of straight ($L_o + d_o$)
L_t = length of specimen ($L_o + 2r + b$)
S_o = area of test section
r = radius (4 mm min.)

NOTE The head of the test piece may be manufactured either with or without the original washer face of the bolt.

Figure 7 — Test piece

B.4 Vickers hardness test. The Vickers hardness test shall be performed in accordance with the requirements of BS 427-1[16]. The impression of the indenter shall be applied either on the top of the head or to the centre position of the end of the bolt, after approximately 0.4 mm has been removed by grinding.

B.5 Proof load testing for full size bolts. The proof load test consists of applying the proof load, specified in Table 1, which is obtained from the proof stress and measuring any permanent extension of the bolt. The proof load is applied axially to the bolt in a normal tensile testing machine (see Figure 8). The length of free thread above the nut or adaptor (between nut or adaptor and head of bolt) shall be between half and one diameter.

The extension of the bolt shall be measured, at its true centre line, with a suitable instrument. The instrument shall be such that the total of inaccuracies due to measurement does not exceed ± 5 micrometres. The test is considered satisfactory if the measurement, after the proof load has been applied for not less than 10 seconds, shows an extension of not more than 12.5 micrometres.

[16] BS 427, "Method for Vickers hardness test", Part 1, "Testing of metals".

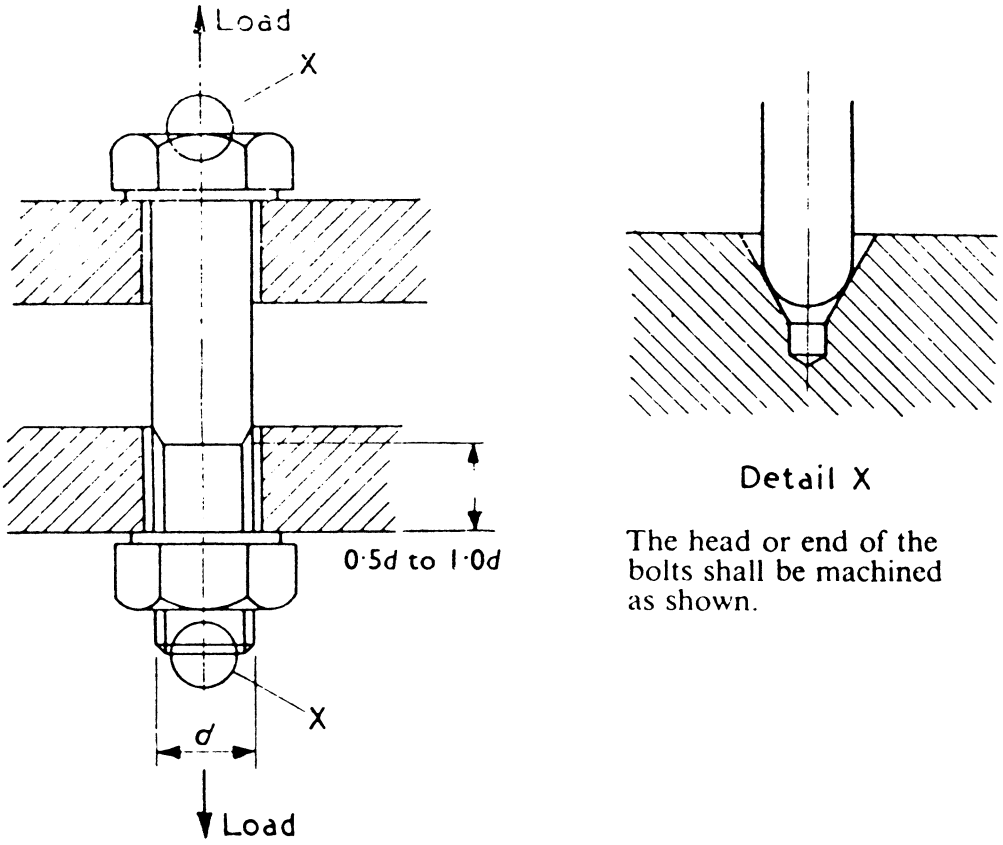


Figure 8 — Application of proof load to full size bolt

B.6 Test for strength under wedge loading for full size bolts

B.6.1 Screw the bolt into a threaded adaptor or nut, the distance from the thread runout of the bolt to the face of the nut or adaptor being one nominal diameter, with a hardened wedge (in accordance with Table 12) placed under the head. Position the bolt so that no corner of the hexagon takes bearing load (see Figure 9). Subject the bolt to an axial load at a testing machine crosshead speed (free running) not greater than 26 mm per minute, until fracture occurs.

B.6.2 To meet the requirements of this test it is necessary for the fracture to occur in the shank or thread and not between the head and the shank. The bolt should meet the minimum tensile strength given in Table 4 before fracture occurs.

This test is passed if the fracture originates in the threaded part even if the fracture extends into the fillet or head before separation. If failure occurs due to the stripping of the thread, the individual test shall be discarded and another specimen substituted.

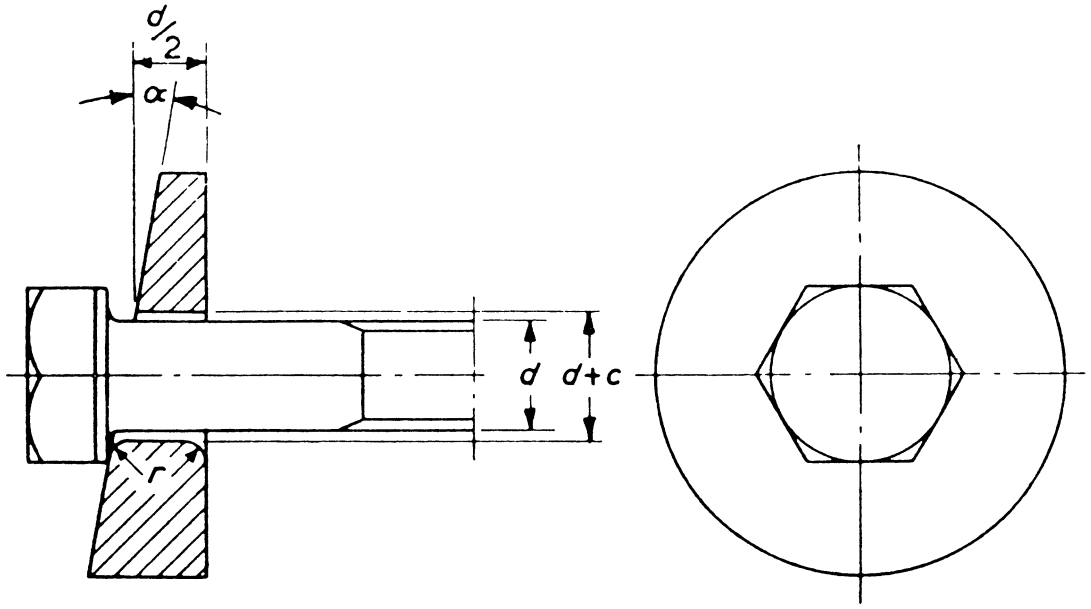


Figure 9 — Wedge loading of full size bolt

Table 12 — Dimensions for wedge loading test

Nominal size and thread diameter		r	c	Angle $\alpha \pm 30$	
Above	Up to and including			For bolts with plain shank length $2d$ or above	For bolts with plain shank length less than $2d$
		mm	mm		
—	20	1.6	1.3	10°	6°
20	30	3.2	1.6	6°	4°

Appendix C Testing of mechanical properties of steel nuts (See 3.3)

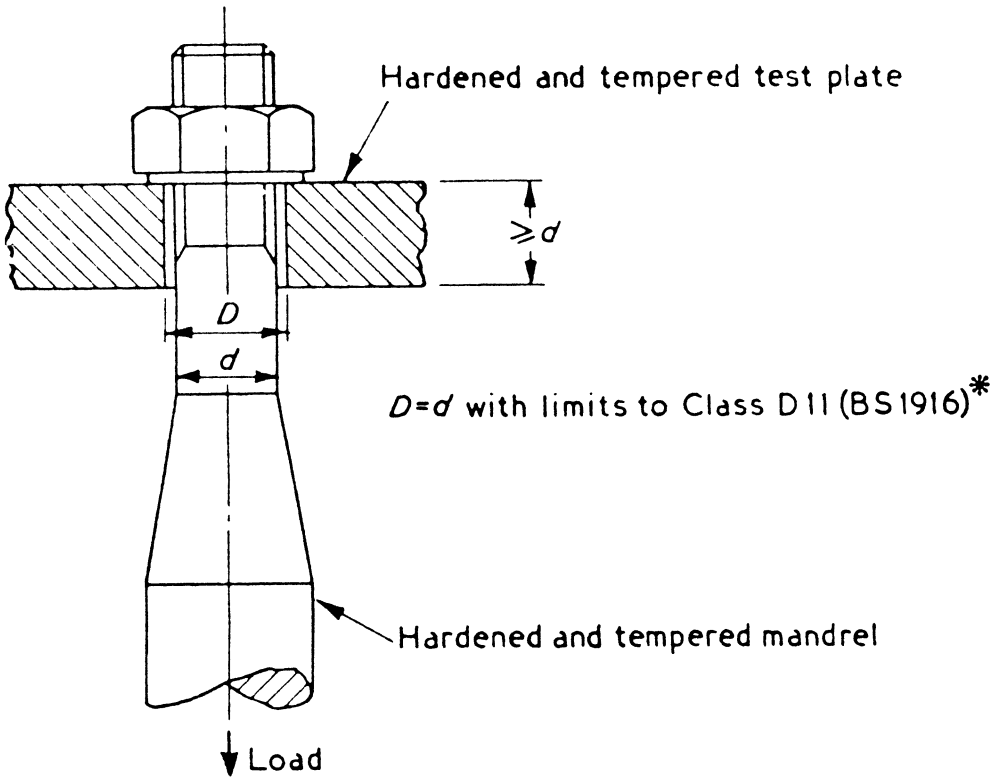
C.1 Proof load test. The proof load test consists of applying the relevant proof load given in Table 7 which was obtained from the proof load stress given in Note 1 to Table 7.

C.1.1 Assemble the nut to be tested on a hardened and tempered mandrel as shown in Figure 10 and apply the specified load in an axial direction.

C.1.2 The nut shall withstand this load without failure by stripping or rupture, and should be removable by the fingers after the load is released. If the threads of the mandrel are damaged during the test, the test shall be discarded.

C.1.3 It may he necessary to use a manual wrench to start the nut in motion. Such wrenching is permissible providing it is restricted to a half turn and the nut is then removable by the fingers following initial loosening.

C.2 Hardened mandrel. The mandrel shall have a hardness of not less than Rockwell C45. The thread shall be tolerance class 4 h except that the major diameter shall be equal to the minimum major diameter for class 4 h with a plus tolerance of one quarter of the 6 g major diameter tolerance.



* BS 1916, ' Limits and fits for engineering '.

Figure 10 — Proof load test for nut

C.3 Hardened test plate. The test plate shall have a hardness of not less than Rockwell C38.

C.3 Hardness tests on nuts. Brinell, Rockwell or Vickers hardness may be determined. Apply the impression to the top or bottom face of the nut, otherwise on the side of the nut.

C.4.1 Perform a Brinell hardness test in accordance with the requirements of BS 240-1[17].

C.4.2 Perform a Rockwell hardness test in accordance with the requirements of BS 891-1[18].

C.4.3 Perform a Vickers hardness test in accordance with the requirements of BS 427-1[19].

[17] BS 240, "Method for Brinell hardness test", Part 1, "Testing of metals".
[18] BS 891, "Method for Rockwell hardness test", Part 1, "Testing of metals".
[19] BS 427, "Method for Vickers hardness test", Part 1, "Testing of metals".

Appendix D Test programme

Test No.	Mechanical property	Test method	Obligatory ●
			By arrangement between manufacturer and purchaser ⊕
1.	Tensile strength	Tensile test using test piece without wedge	●
2.	Yield stress or stress at permanent set limit of 0.2 %	Tensile test using test piece	⊕
3.	Percentage elongation after fracture	Tensile test using test piece	●
4.	Stress under proof load	Proof load test on bolt without wedge	●
5.	Strength under wedge loading	Wedge loading test on bolt	● Bolts M 30 and under only[a]
6.	Hardness	Rockwell or Vickers test on bolt	⊕

NOTE If all tests are required, and each test is carried out once, two bolts are sufficient for this purpose.

[a] Based on the availability of a 51 tonnes testing machine.

Appendix E Recommended gauge for checking squareness of thread to face of nut (See **3.5.3**)

Figure 11 shows the recommended gauge for checking the squareness of the thread to the face of the nut.

The nut shall be screwed by hand onto the mandrel of the gauge until the thread of the nut is tight on the thread of the mandrel. The face of the sleeve shall be brought into contact with the leading face of the nut. With the sleeve in this position it shall not be possible for a feeler gauge of thickness equal to the squareness tolerance to enter anywhere between the leading face of the nut and the face of the sleeve.

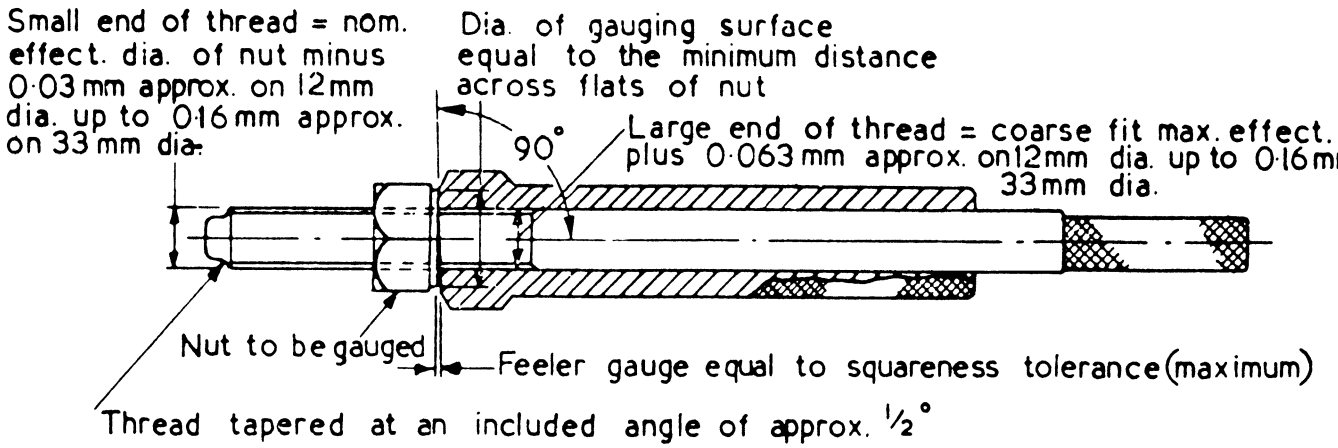


Figure 11 — Nut squareness gauge

Appendix F Standard nominal lengths and preferred sizes of ISO metric high strength friction grip bolts (general grade)

Nominal size and thread diameter *d*	Standard nominal lengths																																		
	40	45	50	55	60	65	70	75	80	85	90	100	110	120	130	140	150	160	170	180	190	200	220	240	260	280	300	325	350	375	400	425	450	475	500
M 12[a]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
M 16			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
M 20					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
M 22						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
M 24							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
M 27								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
M 30										X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
M 36												X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

NOTE The inclusion of dimensional data in this standard is not intended to imply that all of the products described are stock production sizes. The purchaser is requested to consult with the manufacturer concerning lists of stock production sizes.

[a] Non-preferred. Only to be used for the lighter type of construction where practical conditions such as material thickness do not warrant the usage of a larger size bolt than M 12.

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