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**SPECIFICATION FOR
HIGH STRENGTH
FRICTION GRIP BOLTS
AND ASSOCIATED NUTS AND WASHERS
FOR STRUCTURAL ENGINEERING
METRIC SERIES**

**Part 2. Higher grade bolts and nuts
and general grade washers**

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THIS BRITISH STANDARD, having been approved by the Mechanical Engineering Industry Standards Committee, was published under the authority of the Executive Board on 31 July, 1969.

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The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

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 240. Method for Brinell hardness test.
Part 1. Testing of metals.
- BS 427. Method for Vickers hardness test.
Part 1. Testing of metals.
- BS 891. Method for Rockwell hardness test.
Part 1. Testing of metals.
- BS 1916. Limits and fits for engineering.
- BS 3643. ISO metric screw threads.
Part 1. Thread data and standard thread series.
Part 2. Limits and tolerances for coarse pitch series threads.
- BS The use of high strength friction grip bolts in structural steelwork. Metric series.
Part 2. Higher grade*.

* In course of preparation

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

The following BSI references relate to the work on this standard:
Committee references MEE/60, MEE/60/11
Draft for comment 69/2366

CONTENTS

Co-operating organizations	Page 5
Foreword	6

SPECIFICATION**1. GENERAL**

1.1 Scope	8
1.2 Terminology	8

2. BOLTS

2.1 Material	8
2.2 Heat treatment	9
2.3 Mechanical properties	9
2.4 Test programme	9
2.5 General test requirements	9
2.6 Dimensions and finish	9
2.7 Marking	12

3. NUTS

3.1 Material	15
3.2 Heat treatment	15
3.3 Mechanical properties	15
3.4 General test requirements	15
3.5 Dimensions and finish	16
3.6 Marking	16

4. WASHERS

4.1 Material	19
4.2 Heat treatment	19
4.3 Hardness tests	19
4.4 General test requirements	19
4.5 Dimensions and tolerances	20
4.6 Finish	20
4.7 Marking	20

5. INSPECTION

5.1 General inspection procedures	23
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6. PURCHASING INFORMATION

6.1 Information to be supplied with enquiry or order	23
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APPENDICES

	Page
A. BSI policy statement on screw threads and the metric system	24
B. Testing of mechanical properties of steel bolts	25
C. Testing of mechanical properties of steel nuts	28
D. Test programme	30
E. Recommended gauge for checking squareness of thread to face of nut	31
F. Standard nominal lengths and preferred sizes of ISO metric high strength friction grip bolts (higher grade)	33

TABLES

1. Number of pieces comprising a batch of bolts	9
2. Tolerance on nominal length	10
3. Thread lengths	11
4. Mechanical properties of bolts	13
5. Dimensions of hexagon head bolts	14
6. Number of pieces comprising a batch of nuts	15
7. Mechanical properties of nuts (coarse pitch series)	17
8. Dimensions of hexagon nuts	18
9. Number of pieces comprising a batch of washers	19
10. Dimensions of flat round washers	21
11. Dimensions of square taper washers	22
12. Dimensions for wedge loading test	27

FIGURES

1. Chamfering, facing and marking of bolts	11
2. Hexagon bolts	14
3. Marking of nuts	17
4. Hexagon nut	18
5. Flat round washer	21
6. Square taper washers	22
7. Test piece	25
8. Application of proof load to full size bolt	26
9. Wedge loading of full size bolt	27
10. Proof load test for nut	29
11. Nut squareness gauge	32

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 Federation
 British Pump Manufacturers' Association
 *British Steel Industry
 Crown Agents for Oversea Governments and Administrations
 Department of Employment and Productivity
 *Electricity Council, the Central Electricity Generating Board and the Area Boards in England and Wales
 *Engineering Equipment Users' Association
 Gas Council
 Institute of Marine Engineers
 Institution of Civil Engineers
 Institution of Gas Engineers
 Institution of Heating and Ventilating Engineers
 Institution of Mechanical Engineers
 Institution of Mechanical Engineers (Automobile Division)
 *Institution of Production Engineers
 *Locomotive and Allied Manufacturers' Association of Great Britain
 London Transport Board
 *Machine Tool Trades Association
 Ministry of Defence
 *Ministry of Defence, Army Department
 Ministry of Power
 *Ministry of Public Building and Works
 Ministry of Technology
 *Ministry of Technology—National Engineering Laboratory
 Ministry of Transport
 *National Coal Board
 National Physical Laboratory (Ministry of Technology)
 Radio Industry Council
 Royal Institute of British Architects

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
 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

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FOREWORD

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, draft 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 appropriate the provisions of the following ISO Recommendations have been incorporated in the text of this standard:

- | | |
|------------------------------|--|
| ISO Recommendation R 225. | 'Bolts, screws and nuts, dimensions'. |
| ISO Recommendation R 272. | 'Hexagon bolts and nuts, metric series, widths across flats, heights of heads, thicknesses of nuts'. |
| ISO Recommendation R 733. | 'Hexagon bolts and nuts, metric series, tolerances on widths across flats, widths across corners'. |
| ISO Recommendation R 885. | 'Bolts and screws. Radii under the head for general purpose bolts and screws. Metric series'. |
| ISO Recommendation R 888. | 'Nominal lengths for bolts, screws and studs, thread lengths for general purpose bolts'. |
| ISO Recommendation R 898/I. | 'Mechanical properties of fasteners'.
Part I, 'Bolts, screws and studs'. |
| ISO Recommendation R 898/II. | 'Mechanical properties of fasteners'.
Part II, 'Nuts with specified proof load values'. |

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.

The diametral dimension for the flat washers given in this specification have been based on the 'large diameter series' detailed in ISO Recommendation R 887, 'Washers for hexagon bolts, metric series'. The thicknesses for the flat washers have been based on those currently given in BS 3139*, and the American Standard ASTM A 325†, 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/R 887 being more applicable to ordinary hexagon bolts and nuts.

The dimensions of square taper washers given in this British 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.

Part 1 of this standard provides for a general grade of parallel shank high strength friction grip bolts and their associated nuts and washers. The mechanical properties of the bolts conform to metric equivalents of USA standard SAE grade 5 material used in BS 3139: Part 1* and ASTM A 325†.

This publication (Part 2), gives requirements for a higher grade of parallel shank bolt with mechanical properties conforming to ISO/R 898/I‡, strength grade 10.9. The requirements for the nuts in this part of the standard are in accordance with ISO/R 898/II§, strength grade 12.

The envisaged Part 3 of this standard will deal with the higher grade of waisted shank high strength friction grip bolts.

NOTE 1. The standard thread lengths for the higher grade bolts specified in this Part of the standard have been increased slightly compared with those quoted in ISO/R 888 and Part 1 of this standard. This increase in thread length has been incorporated to align with current UK/USA practice concerning higher grade parallel shank bolts.

* BS 3139, 'High strength friction grip bolts for structural engineering', Part 1, 'General grade bolts'.

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

‡ ISO Recommendation R 898/I, 'Mechanical properties of fasteners', Part I, 'Bolts, screws and studs'.

§ ISO Recommendation R 898/II, 'Mechanical properties of fasteners', Part II, 'Nuts with specified proof load values'.

NOTE 2. Although the minimum radii under the head specified for bolts in this standard are in accordance with ISO/R 885, the transition diameter (d_a max.) quoted in Table 2 falls between the values quoted for finished and semi-finished products in the 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 3. Although the mechanical requirements specified in this standard are in metric technical units (i.e. kgf/mm²), in accordance with present ISO agreements (ISO/R 898/I), 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 to BS 350: Part 2, 'Additional tables for SI conversions'.

SPECIFICATION

1. GENERAL

1.1 SCOPE

Part 2 of this British Standard relates to the higher grade (10.9) of quenched and tempered high strength friction grip hexagon head bolts and their associated nuts (Grade 12) and washers for use in structural engineering.

Dimensions are given for a range of nominal sizes from 16 mm (M 16) to 33 mm (M 33) 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 steelwork. Metric series', Part 2, 'Higher grade' (in course of preparation).

Any alternative method of use shall be the responsibility of the engineer and shall be noted on the appropriate drawings and/or documents.

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*. 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%.

* This term includes both top and bottom blown oxygen processes.

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 of 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 is 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 <i>d</i>	Number of pieces in batch
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 unless all the additional specimens satisfy the requirements of the test the batch shall be rejected.

2.6 DIMENSIONS AND FINISH

The dimensions, tolerances and general finish of the bolts shall be in accordance with 2.6.1 to 2.6.6 inclusive and with Table 5.

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 shown in Table 2.

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 $1\frac{1}{4}$ 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 higher grade metric high strength friction grip bolts shall be in accordance with BS 3643 Part 1*.

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

2.6.4 Length of thread

2.6.4.1 General. 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.

* BS 3643, 'ISO Metric screw threads', Part 1, 'Thread data and standard thread series', Part 2, 'Limits and tolerances for coarse pitch series threads'.

The length of thread runout 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.

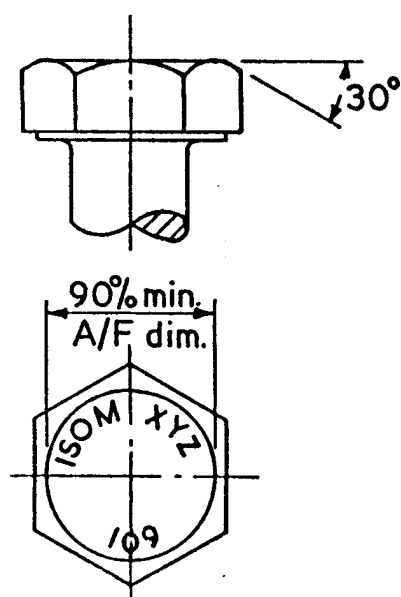
TABLE 3. THREAD LENGTHS

Nominal length of bolt	Length of thread
Up to and including 125 mm	$2d + 12$ mm
Over 125 mm up to and including 200 mm	$2d + 18$ mm
Over 200 mm	$2d + 30$ mm

2.6.4.2 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 of head. 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 Fig. 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.



'ISOM' or 'M' = ISO metric identification
 'XYZ' = manufacturer's (trade, marking)
 '10.9' = strength grade 10.9

Fig. 1. Chamfering, facing and marking of bolts