

Australian Standard[®]

**Bolts, studbolts and nuts for
flanges and other high and low
temperature applications**

The following scientific, industrial and governmental organizations and departments were officially represented on the committee entrusted with the preparation of this standard:

Australian Institute of Steel Construction Ltd
Bureau of Steel Manufacturers of Australia
Confederation of Australian Industry
Department of Defence
Department of Industrial Relations, N.S.W.
Electricity Supply Association of Australia
Engineering and Water Supply Department, S.A.
Fasteners Institute of Australia
Federal Chamber of Automotive Industries
Institution of Production Engineers
Metal Trades Industry Association of Australia
Metropolitan Water Sewerage & Drainage Board, Sydney
Petroleum Refinery Engineers Advisory Committee
Railways of Australia Committee
Society of Automotive Engineers—Australasia
Telecom Australia
Tractor and Machinery Association of Australia
University of New South Wales
University of Sydney

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PREFACE

This standard was prepared jointly by the Association's Committee on Fasteners and Committee on Flanges as a part of the revision of AS 2129—1978, Flanges and Bolting for Pipes, Valves and Fittings. It supersedes the corresponding portion of AS 2129—1978.

During the preparation of this standard it was noted that while AS 2129 covered quite a large proportion of Australian requirements for bolting for flanges there were major sections of industry, most notably the petroleum, chemical and petrochemical industries, which were heavily committed to the use of flanges to ANSI B16.5, Steel Pipe Flanges and Flanged Fittings, Including Ratings for Class 150, 300, 400, 600, 900, 1500 and 2500, which require an inch series of stud bolts with associated nuts. It was recognised that while the ultimate object is to establish a single series of metric pipe flanges and associated bolting to cover all requirements, nevertheless the ANSI B16.5 flanges will continue to be used for some considerable period.

It was also noted that AS 2129 was in effect a soft metric conversion of imperial flanges and bolting and included a series of metric bolting intended for use in the cryogenic and elevated temperature ranges; in reality most fasteners used in these applications were still inch series manufactured in accordance with ASTM A193, Specification for Alloy-steel and Stainless Steel Bolting Materials for High-temperature Service, ASTM A 194, Specification for Carbon and Alloy Steel Nuts for Bolts for High-pressure and High-temperature Service, and ASTM A 320, Specification for Alloy-steel Bolting Materials for Low-temperature Service. To achieve an overall rationalized system of flange bolting, and recognizing current requirements, the committee agreed that the standard would include the following sections:

- (a) A section giving a metric series of bolts, studbolts and nuts used in the temperature range -50°C to $+300^{\circ}\text{C}$, covering the bulk of requirements of AS 2129.
- (b) A section giving all inch series of studbolts and nuts covering the bolting requirement of flanges to ANSI B16.5 and other flanges and which are also suitable for bolting flanges to AS 2129 in the temperature ranges -200°C to -50°C and $+300^{\circ}\text{C}$ to $+525^{\circ}\text{C}$.

The metric series of bolting is, with respect to dimensions, materials and properties, in line with ISO standards (where applicable) and it should be noted that the physical properties are specified in such a manner as to make testing in full size possible. This follows the approach used in all Australian metric fastener standards. Conversely, for the inch series bolting, the grades have been selected from ASTM A 193, ASTM A 194 or ASTM A 320 and have been rationalized to suit Australian requirements, but owing to the manner in which the physical properties are specified in those standards it is not possible to test the fasteners in full size. This accounts for the different approach to the test requirements between the inch and the metric fasteners.

During the preparation of the standard it was also noted that the methods of defining the overall length and length of thread were different for the metric and inch series of studbolts. For metric studbolts these lengths include the chamfer on the threaded end, whereas for inch studbolts these lengths do not include the chamfer on the threaded end. The committee gave serious consideration to the rationalization of these practices, but concluded that both methods were so deeply entrenched in the different sections of industry that any change from current practices was not warranted and could cause confusion.

An appendix has been included giving notes on bolting strength and performance at elevated temperatures. The appendix represents material given in BS 4882, Bolting for Flanges and Pressure Containing Purposes, with minor editorial amendments. Acknowledgement is made to the British Standards Institution for the use of this material.

In most sectors of industry, metric conversion is now at an advanced stage and it is anticipated that this rate of conversion will increase during the next few years. As a consequence, measuring capability in imperial units will decline. To meet this situation, an appendix has been provided which gives the approximate metric equivalent of all dimensions, tolerances and mechanical properties given in Section 3 of this standard. The inch designation, however, has been retained because it is currently well entrenched in Australian industry; furthermore, the cost to industry of amending drawings, specifications, and the like to introduce a different designation could not be justified.

Although at present there are no international standards dealing specifically with bolting for flanges, account has been taken where possible of standards prepared by ISO/TC 2, Bolts, Nuts, Fasteners and Accessories, and the provision of the following ISO standards have been incorporated in this standard:

ISO 225	Bolts, Screws and Studs—Dimensioning
ISO 272	Fasteners—Hexagon Products—Widths Across Flats
ISO 885	General Purpose Bolts and Screws—Metric Series—Radii Under the Head
ISO 888	Bolts, Screws and Studs—Nominal Lengths, and Thread Lengths for General Purpose Bolts
ISO 898/1	Mechanical Properties of Fasteners Part 1—Bolts, Screws and Studs
ISO 4759/1	Tolerances for Fasteners Part 1—Bolts, Screws and Nuts with Thread Diameters Between 1.6 (inclusive) and 150 mm (inclusive) and Product Grades A, B and C

In addition, for inch bolting account was also taken of ANSI B16.5, ASTM A 193, ASTM A 194, ASTM A 320, and BS 4882.

This standard may require reference to the following Australian standards:

AS 1014	Gauging of Metric Screw Threads	AS 1544	Methods for Impact Tests on Metals Part 2—Charpy V-notch Part 3—Charpy U-notch and Keyhole Notch
AS 1110	ISO Metric Hexagon Precision Bolts and Screws	AS 1654	Limits and Fits for Engineering
AS 1111	ISO Metric Hexagon Commercial Bolts and Screws	AS 1721	General Purpose Metric Screw Threads
AS 1112	ISO Metric Hexagon Nuts, Including Thin Nuts, Slotted Nuts and Castle Nuts	AS 1815	Method for Rockwell Hardness Test Part 1—Testing of Metals
AS 1214	Hot-dip Galvanized Coatings on Threaded Fasteners (ISO Metric Coarse Thread Series)	AS 1816	Method for Brinell Hardness Test Part 1—Testing of Metals
AS 1252	General Grade High-strength Steel Bolts With Associated Nuts and Washers for Structural Engineering (ISO Metric Series)	AS 1817	Method for Vickers Hardness Test Part 1—Testing of Metals
AS 1275	Metric Screw Threads for Fasteners (Based on ISO Recommendations)	AS 1823	Suppliers Quality Control System—Level 3
AS 1391	Methods for Tensile Testing of Metals	AS 1897	Electroplated Coatings on Threaded Components (Metric Coarse Series)
AS 1442	Carbon Steels and Carbon-manganese Steels— Hot-rolled Bars and Semi-finished Products	AS 2129	Flanges and Bolting for Pipes, Valves and Fittings
AS 1443	Carbon Steels and Carbon-manganese Steels—Bright Bars	AS B133	Unified Screw Threads
AS 1444	Wrought Alloy Steels—AISI-SAE Standard, Hardenability (H) and Stainless Series	AS B193	Hot-dip Galvanized Coating on Fasteners (BSW and UNC Threads)
		AS K132	Electroplated Coatings on Threaded Components Part 1—Cadmium on Steel Part 2—Zinc on Steel

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STANDARDS ASSOCIATION OF AUSTRALIA

Australian Standard

for

**BOLTS, STUDBOLTS AND NUTS FOR FLANGES AND OTHER
HIGH AND LOW TEMPERATURE APPLICATIONS**

SECTION 1. SCOPE AND DEFINITIONS

1.1 SCOPE. This standard specifies requirements for bolts, studbolts and nuts, mainly intended for bolting for flanges and other pressure-containing purposes. It covers both a metric series and an inch series of fasteners.

Materials have been selected for use in temperature conditions from -250°C to $+575^{\circ}\text{C}$, and provision is also made for the supply of bolts, studbolts and nuts with hot-dip galvanized and other metallic coatings to provide improved corrosion resistance at essentially ambient temperatures.

The dimensional and marking requirements (except property class/strength grade marking) of this standard also apply to non-ferrous, stainless steel and weather-resistant steel fasteners.

NOTE: Appendix A gives information on bolting strength performance at elevated temperatures.

The specific requirements are given in the following Sections:

- (a) Section 2—specifies a metric series of bolts, studbolts and associated nuts for use in the temperature range -50°C to $+300^{\circ}\text{C}$.

NOTES:

1. This Section covers the bulk of the requirements of AS 2129.
 2. Bolts and studbolts of property class 4.6 and nuts of property class 5, manufactured from free cutting steel, should not be used at temperatures in excess of $+200^{\circ}\text{C}$.
- (b) Section 3—specifies an inch series of studbolts and associated nuts with unified threads covering—
 - (i) bolting for flanges to ANSI B16.5 and other flanges as used in the petroleum, chemical, petrochemical industries and other applications in the temperature range -250°C to $+575^{\circ}\text{C}$;
 - (ii) bolting suitable for flanges to AS 2129 in the cryogenic and elevated temperature ranges, i.e. -200°C to -50°C and $+300^{\circ}\text{C}$ to $+525^{\circ}\text{C}$.

1.2 DEFINITIONS. For the purpose of this standard, the following definitions apply:

1.2.1 Bolting.

1.2.1.1 Metric series—studbolts, bolts and nuts made in accordance with Section 2 of this standard.

1.2.1.2 Inch series—studbolts and nuts made in accordance with Section 3 of this standard.

1.2.2 Bolts.

1.2.2.1 Bolt—a fastener with a head integral with the shank and which is threaded at the opposite end.

1.2.2.2 Nominal length (l)—the distance from the bearing surface of the head to the extreme end of the shank including any chamfer or radius.

1.2.2.3 Thread length (b)—the difference between the nominal length of the bolt and the distance between the bearing surface of the head and the nearest face of a nut with no internal chamfer screwed as far as practicable onto the bolt by hand.

1.2.3 Studbolts.

1.2.3.1 Studbolt—a fastener intended for flanges threaded at both ends, or threaded for the whole of its length intended for use with a nut at each end.

1.2.3.2 Nominal length (l).

- (a) *Metric series*—the length of a studbolt including the chamfer at each end (see Fig. 2.1).
- (b) *Inch series*—the length of a studbolt excluding the chamfer at each end (see Fig. 3.1).

1.2.3.3 Thread length.

- (a) *Metric series*—the distance from the end of a studbolt including the chamfer, to the last full thread (see Fig. 2.1).
- (b) *Inch series*—the distance from the end of a studbolt excluding the chamfer, to the last full thread (see Fig. 3.1).

1.2.3.4 Body—the unthreaded centre portion of a studbolt.

NOTE: Type 'a' studbolts (see Clause 2.3.1) have no body.

1.2.4 Thread runout.

- (a) *All bolts and Type 'b' studbolts with rolled thread*—the distance from the top of the extrusion cone to the nearest face of a nut with no internal chamfer screwed on to the bolt as far as practicable by hand.
- (b) *All bolts and Type 'b' studbolts with cut threads (and also Type 'e' studbolts with rolled threads)*—the distance from the last witness of thread to the nearest face of a nut with no internal chamfer screwed on to the bolt as far as practicable by hand.

SECTION 2. METRIC BOLTS, STUBBOLTS AND NUTS FOR FLANGES INTENDED FOR USE IN THE TEMPERATURE RANGE -50°C TO $+300^{\circ}\text{C}$

2.1 SCOPE OF SECTION. This Section specifies the requirements for a metric series of bolts, studbolts and nuts of the diameters given in Table 2.1, mainly intended for bolting flanges to AS 2129 in the temperature range -50°C to $+300^{\circ}\text{C}$.

TABLE 2.1
NOMINAL DIAMETERS OF
METRIC BOLTS, STUBBOLTS
AND NUTS

Bolts	Studbolts	Nuts
M12	M12	M12
M16	M16	M16
M20	M20	M20
M24	M24	M24
M27*	M27	M27†
M30	M30	M30
M33*	M33	M33†
M36	M36 M39 M45 M52	M36 M39† M45† M52†

* Non-preferred bolt size.

† Indicates a 'non-preferred' size in AS 1112, but preferred for the purposes of this standard.

2.2 METRIC BOLTS. Metric hexagon bolts shall be manufactured either to AS 1111 in property class 4.6, or to AS 1110 in property classes 4.6, 8.8 and 8.8 as required by AS 2129 (see Note 2).

Test requirements for hexagon bolts shall be in accordance with AS 1110 or AS 1111 as appropriate.

NOTES:

- High strength structural bolts to AS 1252 may be substituted for property class 8.8 bolts if agreed to by the purchaser. Bolts to AS 1252 are heavy hexagon series and the selection of such bolts would be subject to space being available on the relevant flange.
- Products made of low carbon martensitic steel are to be additionally identified by underlining the symbol of the property class (see Clause 2.5.2).

2.3 METRIC STUBBOLTS.

2.3.1 Property Classes. Metric studbolts shall be manufactured in property classes 4.6, 8.8 and 8.8 as required by AS 2129.

2.3.2 Types of Studbolts. Metric studbolts for use with flanges shall be of the following types:

- Type 'a'—threaded full length.
- Type 'b'—threaded each end and a body diameter approximately equal to the nominal diameter.

- Type 'e'—threaded each end and a body diameter approximately equal to the pitch diameter.

NOTES:

- See also Fig. 2.1.
- Any one of the types indicated may be supplied unless otherwise specified by the purchaser. (See also AS 2129.)

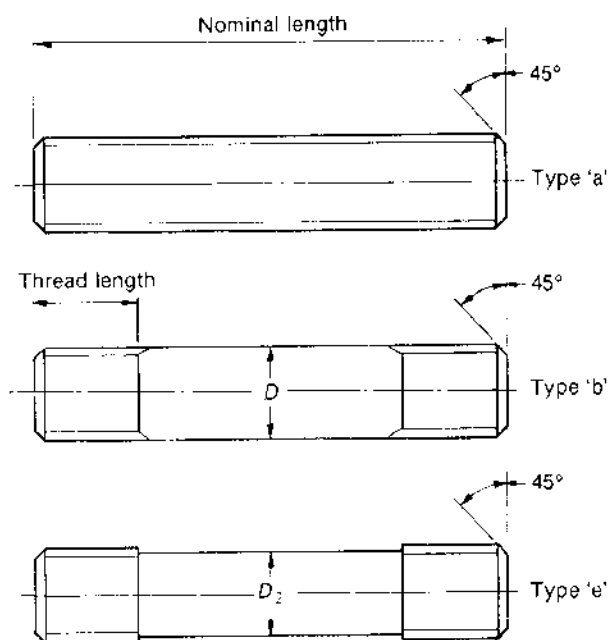


Fig. 2.1. TYPES OF METRIC STUBBOLTS

2.3.3 Shape, Dimensions and Finish.

2.3.3.1 General dimensions. The general dimensions of studbolts shall be as given in Table 2.3.

2.3.3.2 Body diameter. The body diameter (D and D_2) of studbolts, other than Type 'a', shall be as given in Table 2.3.

2.3.3.3 Length of studbolts. Nominal lengths and tolerances on nominal lengths of studbolts shall be as given in Table 2.4.

2.3.3.4 Ends of studbolts. The ends of studbolts shall be finished with 45-degree (nominal) chamfer to a depth slightly exceeding the depth of thread as shown in Fig. 2.1. The end shall be reasonably square with the shank.

Alternatively, for property class 4.6 Types 'a' and 'e' studbolts with rolled threads, one or both ends may be in the as-rolled condition. The lead formed at the end of the studbolt by the rolling operation may be regarded as providing the necessary chamfer to the end, no other machining operation being necessary.

2.3.3.5 Screw threads. The form of thread and diameters and associated pitches of studbolts shall be the ISO coarse pitch series as specified in AS 1275 or AS 1721. The screw threads shall be made to 6g tolerance as specified in the above standards.

Screw threads shall be formed by thread rolling or thread cutting. Screw threads may be formed after heat treatment (see Note 2).

NOTES:

1. Where the threads are produced by rolling, small laps are commonly present at the crests and are generally of a magnitude which is not detrimental to the performance of the studbolt.

A lap formed at the crest of the thread perpendicular to the axis of the studbolt is not considered cause for rejection if the lap does not exceed 33 percent of the depth of the thread.

2. If the purchaser requires the threads to be formed after heat treatment, this should be indicated in his enquiry or order.

2.3.3.6 Thread length. The minimum lengths of thread for Type 'b' and Type 'e' studbolts shall be as given in Table 2.3 and are based on the formulas given in Table 2.2. The tolerance on studbolt thread lengths shall be plus 2 pitches for all diameters.

The length of thread runout for Type 'b' and Type 'e' studbolts shall not exceed the values given in Table 2.3.

TABLE 2.2

THREAD LENGTH OF TYPE 'b' AND TYPE 'e' STUBBOLTS

Nominal length of studbolt	Length of thread
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

NOTE: D = nominal diameter in millimetres.

2.3.3.7 Finish. Studbolts shall be cleanly finished, sound and free from defects detrimental to their use.

Studbolts shall be normally supplied in the uncoated condition, but may be supplied with corrosion-resistant coatings (see Notes).

NOTES:

1. If the purchaser requires coated products, reference should be made to the relevant coating specification, i.e. AS 1214 or AS 1897, and this should be indicated in his enquiry or order. Unless information is given to the contrary, studbolts will be supplied in the uncoated condition.
2. For further information regarding designations of coated studbolts, see Appendix D.

2.3.4 Material.

2.3.4.1 General. The steel used for the manufacture of studbolts shall be made by an open hearth, a basic oxygen or an electric process and shall be such that the mechanical and other properties hereinafter specified for the finished studbolts can be obtained.

NOTE: For the purpose of this standard, a basic oxygen process means the process of making steel in a basic converter blown with commercially pure oxygen.

2.3.4.2 Chemical composition. The chemical composition of steel used for the manufacture of studbolts should conform to Table 2.5. Within these limits the choice of steels shall be at the discretion of the manufacturer. The steel used shall be such that the finished products possess the mechanical properties appropriate to the property class quoted.

NOTE: Materials and heat treatments other than those given in Table 2.5 may be used by special agreement between the purchaser and the supplier provided that the mechanical properties specified in Table 2.6 are maintained.

2.3.4.3 Free-cutting steels. Free-cutting steels may be used where permitted in Table 2.5. The chemical composition of such steels shall be as given in Table 2.5, and the steel grade shall be selected from AS 1442 (Table 5) or AS 1443 (Table 4) as appropriate.

2.3.4.4 Heat treatment. Studbolts of property class 8.8 shall be heat-treated under uniform conditions to give the mechanical properties specified in Table 2.6. The studbolts shall be hardened and then tempered by being uniformly reheated to the minimum temperatures given in Table 2.5.

NOTE: Other minimum tempering temperatures may be used by agreement between the purchaser and supplier provided that the latter can demonstrate that all the mechanical properties hereinafter specified are maintained.

2.3.4.5 Decarburization. Decarburization of the thread surface of studbolts of property class 8.8 shall be not greater than the amount given in Table 2.6 when tested in accordance with Clause 2.3.6 (see also Fig. 2.6). There shall be no carburization.

2.3.5 Mechanical Properties.

2.3.5.1 Property class system. The property class system for metric studbolts consists of two figures; the first is one-hundredth of the nominal tensile strength in megapascals and the second is one-tenth of the ratio between the nominal yield stress (or stress at permanent set limit $R_{p0.2}$) and the nominal tensile strength expressed as a percentage.

Example. Property class 4.6 in accordance with Table 2.6:

1/100 nominal tensile strength of 400 MPa gives the symbol '4'.

$$\frac{1}{10} \text{ ratio } \frac{\text{Nominal yield stress}}{\text{Nominal tensile strength}} = \frac{1}{10} \times \frac{240}{400} \times \frac{100}{1}$$

gives the symbol '6'.

∴ The property class designation is '4.6'

Multiplication of these two figures and the result by 10 will give the minimum yield stress in MPa, e.g. $4 \times 6 \times 10 = 240$ MPa.

NOTE: The minimum yield stress (R_{eL} or $R_{p0.2}$) and minimum tensile strength (R_m) are equal to or greater than the nominal values.

2.3.5.2 Mechanical property requirements. The mechanical properties of metric studbolts shall conform to those given in Table 2.6 as applicable.

Finished metric studbolts which are tested in full size shall conform to the values for proof load and breaking load given in Table 2.7 when tested in accordance with the test program shown in Table 2.8. The material of studbolts which are not tested in full size shall conform to the values given in Table 2.6 when tested in accordance with the test program shown in Table 2.9, and these requirements shall apply in place of all requirements for the proof loads and breaking loads given in Table 2.7. The material

TABLE 2.3
GENERAL DIMENSIONS OF METRIC STUDBOLTS

millimetres

Nom. dia. <i>D</i>	Pitch of thread <i>p</i>	Thread runout Types 'b' and 'e'	Minimum thread length for Types 'b' and 'e'			Body diameter		
			Length of studbolt			Type 'b'		Type 'e' <i>D</i> ₂
			≤125	>125 ≤200	>200	<i>D</i>		
		max.				max.	min.	
M12*	1.75	5.2	30.0	36.0	49.0	12.70	11.30	10.8
M16*	2	6.0	38.0	44.0	57.0	16.70	15.30	14.7
M20*	2.5	7.5	46.0	52.0	65.0	20.84	19.16	18.3
M24*	3	9.0	—	60.0	73.0	24.84	23.16	22.0
M27	3	9.0	—	66.0	79.0	27.84	26.16	25.0
M30*	3.5	10.5	—	72.0	85.0	30.84	29.16	27.7
M33	3.5	10.5	—	78.0	91.0	34.00	32.00	30.7
M36*	4	12.0	—	—	97.0	37.00	35.00	33.3
M39	4	12.0	—	—	103.0	40.00	38.00	36.3
M45	4.5	13.5	—	—	115.0	46.00	44.00	42.0
M52	5	15.0	—	—	129.0	53.20	50.80	48.7

* Bolts are normally used for these diameters.

TABLE 2.4
POPULAR LENGTHS OF METRIC STUDBOLTS

Length, mm			Nominal diameter <i>D</i>										
Nom.	Max.	Min.	M12	M16	M20	M24	M27	M30	M33	M36	M39	M45	M52
40	41.25	38.75	X										
45	46.25	43.75	X										
50	51.25	48.75	X										
55	56.5	53.5	X	X									
60	61.5	58.5	X	X									
65	66.5	63.5		X									
70	71.5	68.5		X	X								
80	81.5	78.5		X	X								
90	91.75	88.25			X								
100	101.75	98.25			X	X							
110	111.75	108.25				X	X						
120	121.75	118.25				X	X						
130	132.0	128.0				X	X						
140	142.0	138.0				X	X	X	X				
150	152.0	148.0				X	X	X	X				
160	164.0	156.0				X	X	X	X	X	X		
180	184.0	176.0					X	X	X	X	X		
200	204.6	195.4					X	X	X	X	X		
220	224.6	215.4						X	X	X	X		
240	244.6	235.4						X	X	X	X	X	
260	265.2	254.8						X	X	X	X	X	
280	285.2	274.8							X	X	X	X	X
300	305.2	294.8										X	X
325	330.7	319.3										X	X
350	355.7	344.3										X	X

NOTES:

1. X indicates popular diameter/length combinations.
2. The diameter/length combinations are based on the requirements of AS 2129.
3. The inclusion of dimensional data in this table is not intended to imply that all of the products described are stock production sizes. The purchaser should consult with the supplier concerning stock availability.

from which the test specimens are taken shall be of the same stock size and heat of steel as the relevant batch of studbolts and subjected to the same heat treatment (if appropriate). Where metric studbolts are too short for testing in accordance with Table 2.8, they may be accepted on the basis of a hardness test. The result of such a test shall conform to the appropriate value given in Table 2.6.

2.3.6 Testing of Mechanical Properties.

2.3.6.1 General. The requirements of this standard shall be complied with in production, and the manufacturer shall make periodic tests to ensure that the product complies with the specified requirements. Such tests shall be conducted in accordance with a sampling plan (see Notes), and the test results shall be recorded in a test report. Additional tests of individual shipments of material are not ordinarily contemplated. Individual tests or types of steel are not identified in the finished product.

NOTES:

1. A recommended sampling plan is given in Appendix C.
2. In the event of a dispute as to the results of tests in accordance with this Clause, referee testing should be carried out by an independent laboratory mutually acceptable to the purchaser and the manufacturer. A laboratory registered by

the National Association of Testing Authorities, Australia for this field and class of testing is recommended.

3. For information on test certificates or a certificate of compliance, see Appendix D.

2.3.6.2 Proof load testing of full-size metric studbolts.

- (a) **Method.** The proof load test of the studbolts shall be carried out using a straight full-size threaded specimen. The specimen shall be placed on a suitable testing machine with each threaded end in a threaded grip or in a nut. The grips of the testing machine (see Fig. 2.2) shall be self-aligning to avoid bending of the specimen during the determination of the proof load.

For Type 'a' studbolts, the length of free thread between the nuts or threaded grips shall be at least 6 pitches.

For all other types of studbolts, the length of free thread between the nuts or threaded grips and any unthreaded portion of the body shall be at least 6 pitches.

The proof load test shall be carried out by applying the proof force specified in Table 2.7, and measuring any permanent extension of the studbolt.

TABLE 2.5
CHEMICAL COMPOSITION OF METRIC STUDBOLTS

Property class	Material and treatment	Chemical composition, percent				Tempering temperature (Note 1) °C
		Carbon		Phosphorus	Sulphur	
		min.	max.	max.	max.	
4.6 (Note 2)	Low or medium carbon steel	—	0.55	0.05	0.06	—
8.8 (Note 3)	Low carbon steel with alloying elements (e.g. boron, manganese or chromium), quenched and tempered	0.15	0.35	0.05	0.05	425
8.8	Medium carbon steel, quenched and tempered	0.25	0.55	0.05	0.05	450 (Note 4)

NOTES:

1. The mean of three hardness readings on a studbolt tested before and after retempering must not differ more than 20 Vickers points when retempered at a temperature 10°C less than the specified minimum tempering temperature for 30 min.
2. Free-cutting steel may be used for property class 4.6 unless otherwise agreed between the purchaser and the manufacturer. (See also Clause 2.3.3.3)
Where free-cutting steels with sulphur and/or lead content are used, the following sulphur, phosphorus and lead contents apply:

Sulphur	0.35 percent max.
Phosphorus	0.11 percent max.
Lead	0.35 percent max.

Studbolts manufactured from free-cutting steel should not be used at temperatures in excess of +200°C.
3. Products made of low carbon martensitic steel are to be additionally identified by underlining the symbol of the property class (see Clause 2.5.2).
4. For sizes M20 and larger, a tempering temperature of 425°C may be used.

- (b) *Requirement.* The overall length of the studbolt shall be measured, at its true centreline, with a suitable instrument capable of indicating to 2.5 μm . The test is considered satisfactory if the studbolt, after the proof load has been applied and held for not less than 15 s, shows a permanent extension of not more than 12.5 μm (see Fig. 2.3).

NOTE: Variables such as straightness and thread alignment may result in an apparent elongation of the studbolt when the proof load is initially applied. In such cases the studbolt may be retested using a 3 percent greater load and shall be considered satisfactory if the length after this loading is the same as before this loading, within 12.5 μm .

2.3.6.3 Tensile strength (wedge) testing of full-size studbolts.

- (a) *Method.* The tensile strength of studbolts shall be determined with the same specimen used for the proof load test. The specimen shall be placed in the testing machine with one end assembled in a threaded adaptor or nut, and the other assembled in a hardened threaded wedge. The

wedge shall have a minimum hardness of HRC 45 and conform to the dimensions given in Table 2.10 and Fig. 2.4.

For Types 'b' and 'e' studbolts, one end of the specimen shall be screwed into the threaded adaptor or nut to the thread runout, and the other screwed into the threaded wedge such that there are 6 pitches of free thread between the thread runout and the leading face of the threaded wedge. For Type 'a' studbolts, one end of the specimen shall be screwed into the threaded adaptor or nut and the other into the threaded wedge such that the distance between the leading faces of the threaded adaptor and threaded wedge is equal to 6 pitches.

The specimen shall be subject to an axial force until fracture occurs.

- (b) *Requirements.* To comply with this test the studbolt shall conform to the values of the breaking load given in Table 2.7 before fracture occurs.

TABLE 2.6
MECHANICAL PROPERTIES OF METRIC STUDBOLTS

Mechanical property			Properties for property class (Note 1)		
			4.6	8.8 and 8.8	
				$\leq \text{M16}$	$> \text{M16}$
Tensile strength, R_m	Nom.	MPa	400	800	800
	Min.	MPa	400	800	830
Brinell hardness	Min.	HB	114	230	242
	Max.	HB	209	306	319
Vickers hardness	Min.	HV	120	242	255
	Max.	HV	220	323	336
Rockwell hardness	Min.	HRB	67	—	—
		HRC	—	21	23
	Max.	HRB	95	—	—
		HRC	—	33	34
Yield stress, R_{eL} (Note 2)	Nom.	MPa	240	—	—
	Min.	MPa	240	—	—
Stress under proof load, S_p	$S_p/R_{p0.2}$		0.94	0.91	0.91
	Min.	MPa	225	580	600
Stress at permanent set limit, $R_{p0.2}$	Nom.	MPa	—	640	640
	Min.	MPa	—	640	680
Elongation after fracture, A	Min.	%	22	12	12
Impact strength (Note 3)	Min.	J	—	30	30
Minimum height of non-decarburized thread zone, h_d			—	$0.5 h_s$	
Maximum depth of complete decarburization			—	0.015 mm	

NOTES:

1. Inclusion of the property class given in this standard does not necessarily imply that such types are stock items. The purchaser should refer to the manufacturer's listings for stock availability.
2. In a case where the yield stress, R_{eL} , cannot be determined, it is permissible to measure the stress at permanent set limit, $R_{p0.2}$ using the specified values for R_{eL} .
3. For sizes M16 and larger only.

TABLE 2.7
TENSILE AND PROOF LOADS FOR METRIC STUDBOLTS

Nominal diameter <i>D</i>	Tensile stress area <i>A_s</i> mm ²	Breaking load, kN		Proof load, kN	
		4.6	8.8 and 8.8	4.6	8.8 and 8.8
M12	84.3	33.7	67.4	19.0	48.9
M16	157	62.8	125	35.3	91.0
M20	245	98.0	203	55.1	147
M24	353	141	293	79.4	212
M27	459	184	381	103	275
M30	561	224	466	126	337
M33	694	278	576	156	416
M36	817	327	678	184	490

TABLE 2.8
ACCEPTANCE TESTS FOR FULL-SIZE METRIC STUDBOLTS

Mechanical property	Test method	Test for property class	
		4.6	8.8 and 8.8
Extension under proof load	Proof load test (Clause 2.3.6.2)	Required	Required
Breaking load	Breaking load test (Clause 2.3.6.3)	Required	Required
Decarburization	Decarburization test (Clause 2.3.6.7)	—	Required

NOTE: This test program is mandatory for studbolts up to and including M24.

TABLE 2.9
ACCEPTANCE TESTS FOR MACHINED PROPORTIONAL TEST PIECES*

Mechanical property	Test method	Test for property class	
		4.6	8.8 and 8.8
Tensile strength, <i>R_m</i>	Tensile test (Clause 2.3.6.4)	Required	Required
Yield point stress, <i>R_{eL}</i>	Tensile test (Clause 2.3.6.4)	Required	—
Stress at permanent set limit, <i>R_{p0.2}</i>	Tensile test (Clause 2.3.6.4)	—	Required
Percentage elongation after fracture, <i>A</i>	Tensile test (Clause 2.3.6.4)	Required	Required
Impact strength	Impact test (Clause 2.3.6.5)	—	Required

*For studbolts in excess of M24.