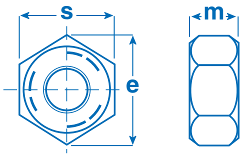
# Fastener Handbook Bolt Products

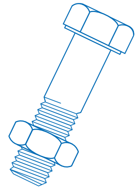
NEW EDITION

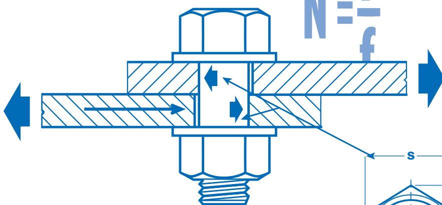


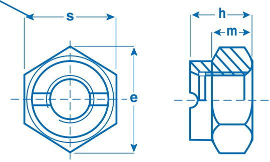

Nut

AJAX FASTENERS

$$N = \frac{F}{f}$$





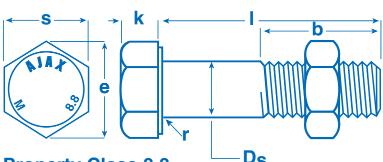



$$F = Q + \frac{100}{100}$$

$$W = Q + F$$

$$(V^*_{sf}/\emptyset V_{sf})^2 + (N^*_{tf}/\emptyset N_{tf})^2 \leq 1.0$$

$$N = \frac{W}{YA_s}$$




Property Class 8.8

**Don't risk it!**

**SPECIFY AJAX**

BOLT PRODUCTS


## THIS HANDBOOK

This handbook has been universally accepted as a benchmark publication. It has now been republished to include all the original data plus new charts, diagrams and product information.
The new index will assist you with its comprehensive reference to product, page and new section numbering.

## ATAC (Ajax Technical Advice Centre)

This innovative service is provided to assist you with technical advice on the correct choice of Ajax Fasteners products for specific applications. Call: 1300 301 982

## TRACEABILITY

Ajax Fasteners' quality assurance procedure conforms to Australian Standard Suppliers Quality System, AS/NZS ISO 9002-1994 & QS 9000-1998. This assures the user that the product is made under controlled manufacturing conditions and provides total traceability of all stages of the manufacturing process. Product supplied into the market can be traced to the manufacturing process using the "Quality Assurance Number" from the packet label.

## QUALITY POLICY

Ajax Fasteners' policy is to design and market manufactured or procured products of superior quality, durability and reliability. The quality standards of the Ajax range have been set to meet or exceed our customers' requirements.

**Don't risk it!**
**SPECIFY AJAX**

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# Commitment to Customer Service

**AJAX has established CUSTOMER SERVICE CENTRES in most states throughout Australia with these states having on-line access to all Ajax warehouses and manufacturing centres.**
**Each CUSTOMER SERVICE CENTRE provides the following services:**

- Stock Enquiries
- Order Placement
- Technical Assistance
- Special Product Quotations
- Delivery Advice
- Invoicing and Account Queries
- Test Certificate and Compliance Detail

## CUSTOMER SERVICE NUMBERS

**FREE PHONE : 1800 501 800**
**FREE FAX : 1800 501 820**

A file containing the products and list prices of the Ajax stocked range is available from the Ajax web site **www.ajaxfast.com.au**, navigate to the price list page to download.

| | | | |
|---|---|---|---|
| **VICTORIA** | 76-88 Mills Road, Braeside 3195 | Ph: (03) 9586 6666 | Fax: (03) 9586 6637 |
| **TASMANIA** | 21 Pitcairn Street, Glenorchy 7010 | Mb: 0417 050 616 | Fax: (03) 6227 1146 |
| **NEW SOUTH WALES** | 1B Sydney Steel Road, Marrickville 2204 | Ph: (02) 9562 5965 | Fax: (02) 9519 2393 |
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## Published by Ajax Fasteners
## A Division of Ajax Cooke Pty Ltd (Inc. in Victoria) A.C.N. 006 926 656



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Designed and produced by R.W.Graphics Pty Ltd.




**Note:** Due to research and development, products are continually improved. This may lead to the specifications being changed without notice.

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# Foreword

**Ajax Fasteners is Australia's largest manufacturer and distributor of quality industrial fasteners. When specifying Ajax products you are protected, not only by the appropriate headmarks that conform to Australian standards, but by the unique Tracelink® system which covers the Ajax Fasteners High Tensile and Structural range.**

This Handbook has been prepared by Ajax Fasteners to provide users of fasteners with dimensional and technical details of standard products which are in regular production. General technical information relating to bolt and thread specifications, breaking loads, finishes, bolted joint design and tightening practices are also included.

While the items shown in table 1 are those in regular production at the publication date and the commonly used sizes are normally stocked, this Handbook is not a stock list. An inquiry should be made as to stock availability on specific products when planning a new project, from your Ajax Fasteners Accredited Distributor.

Ajax bolts and nuts are, in most cases manufactured to meet the requirements of the appropriate Australian Standard. American DIN or British Standards are adopted for some products not covered by an Australian Standard. The Ajax Standard for products not covered by any of these National Standards adopts/sets the dimensions and properties in common usage in the Australian Engineering Industry.

In many cases, products made to different nations standards are identical or such differences as exist do not affect functional interchangeability.

The range of fasteners listed in this Handbook will be found to satisfy the majority of applications, but where a special part is required Ajax Fasteners Technical Staff are available to advise on selection and design of the most suitable product. A large number of special fasteners are produced regularly for a wide range of applications.

Ajax Fasteners is also equipped to produce small

# Foreword

cold headed and cold formed products of a variety of shapes and sizes, many of which bear little resemblance to regular bolts and nuts.

Specific inquiries should be directed to your Ajax Fasteners Accredited Distributor.

## Metric Conversion.

Australian Standards for bolts and nuts are aligned with International Standards Organisation (ISO) Standards and should in time have world wide interchangeability.

For this reason and because design improvement in the nuts makes ISO metric coarse pitch fastener assemblies functionally superior, they should be specified in all new design and be considered in maintenance replacement whenever applicable.

## Ajax Fasteners' Quality Policy

Ajax Fasteners' policy is to design, manufacture and market products of predictable quality, durability and reliability, suited to the needs of our customers.

Using the T.Q.C. tools, concepts and principles, our commitment is to achieve a quality performance in every aspect of our operation.

Quality consciousness is the responsibility of each employee. Pride in individual performance ensures conformance to specification and operating procedures result in satisfied customers.

## Ajax Fasteners' Quality – Complete Traceability

Ajax Fasteners' quality assurance procedures conform to the Australian Standard Suppliers Quality System, AS/NZS ISO 9002-1994 & QS 9000-1998. This assures the user that the product is made under controlled manufacturing conditions and provides total traceability of all stages of the manufacturing process. Product supplied into the market can be traced to the manufacturing process using the "Quality Assurance Number" from the packet Label.

A manufacturer's brand, usually a letter or symbol on the head of each fastener is mandatory for compliance with the relevant Australian Standard.

The Ajax Fasteners name is your guarantee of fastener performance to Australian Standards.

# Marking

The following Table indicates the Ajax Fasteners Range of stocked bolt products which comply to Australian Standards.

- Some imported items will not carry Ajax head marking, but the marking of the original manufacturer.

- Mechanical properties.
- Chemical composition.
- Source of manufacture – "Manufacturer's Identication".

| Head Marking | Bolt Type | Australian Standard |
|---|---|---|
|  | Hexagon Head<br>Metric Commercial | AS 1111-1996 |
|  | Hexagon Head<br>BSW Mild Steel | AS 2451-1998 |
|  | Hexagon Head Precision<br>Metric High Tensile | AS 1110-1995 |
|  | Hexagon Head<br>Unified High Tensile<br>(UNC/UNF) | AS 2465-1999<br>(SAE) Grade 5 |

AJAX FASTENERS

# Marking

| Head Marking | Bolt Type | Australian Standard |
|---|---|---|
|  | Hexagon Head<br>Unified High Tensile<br>(UNC/UNF) | AS 2465-1999<br>(SAE) Grade 8 |
|  | Hexagon Head High Strength<br>Structural | AS 1252-1983 |
|  | Cup Head Metric<br>Square Neck | AS 1390-1997 |
|  | Cup Head BSW<br>Square Neck<br>Cup Head Oval Neck Fishbolts | AS B108-1952<br><br>(AS E25) |
|  | Hexagon Head<br>Metric Coach Screws | AS 1393-1996 |
|  | Metric Hexagon Head<br>Tower Bolts | AS 1559-1986 |

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# Nut Marking

| Nut Marking | Nut Type | Australian Standard |
|---|---|---|
|  ALTERNATIVE | Hexagon<br>Metric Property Class 8 | AS 1112-1996 |
|  | Hexagon<br>Metric Property Class 8 | AS 1112-1996 |
|  ALTERNATIVE | Hexagon High Tensile<br>Metric Property Class 10 | AS 1112-1996 |
|  | Hexagon High Tensile<br>Metric Property Class 10 | AS 1112-1996 |
|  ALTERNATIVE | Hexagon<br>Unified High Tensile | AS 2465-1999<br>(SAE) Grade 8 |
|  | Hexagon<br>Unified High Tensile | AS 2465-1999<br>(SAE) Grade 8 |
|  | Hexagon High Strength<br>Structural | AS 1252-1983 |

For Nyloc nuts our stock product is as follows:
Metric 'P' type conform to Din 6924 P.C.8. Metric 'T' type conform to Din 985.
Inch sizes, BSW are manufactured to our specification sheets for which no international standard is applicable. UNC/UNF dimensions comply to ESNA NM-NE light series.

AJAX FASTENERS

# Standard Bolt Product Ranges

**Table 1**

| Product | Standard Range Bolt & Nut | Standard Range Bolt only | AS: Australian Standard |
|---|---|---|---|
| **ISO Metric Threads** | | | |
| Commercial Hexagon Head Bolts | B G Z | | AS 1111-1996 |
| Commercial Hexagon Head Set Screws | | B G Z | AS 1111-1996 |
| Cup Head | B G Z | | AS 1390-1997 |
| Cup Head Oval Neck Fishbolts | B | | AS 1085.4-1998 |
| Precision Hexagon Head High Tensile Bolt Property Class 8.8 | B Z | B | AS 1110-1995 |
| Precision Hexagon Head High Tensile Set Screws Property Class 8.8 | | B Z | AS 1110-1995 |
| Precision Hexagon Head High Tensile Fine Thread Bolts | B | BZ | AS 1110-1995 /DIN 960 |
| Precision Hexagon Head High Tensile Fine Thread Set Screws | B | BZ | AS 1110-1995 /DIN 961 |
| High Strength Structural Bolts Property Class 8.8 | G | | AS 1252-1983 |
| Hexagon Head Coach Screws | | G Z | AS 1393-1996 |
| **BSW Threads** | | | |
| Mild Steel Hexagon Head Bolts | B G Z | | AS 2451-1998 |
| Mild Steel Hexagon Head Set Screws | | B G Z | AS 2451-1998 |
| Cup Head | BZ | | AS B108-1952 |
| Cup Head Oval Neck – Fish Bolt | B | | (AS E25) |
| Four Peg – Elevator Bolts | B | | |

AJAX FASTENERS

# Standard Bolt Product Ranges

**Table 1 continued**

| Product | Standard Range Bolt & Nut | Standard Range Bolt only | AS: Australian Standard |
|---|---|---|---|
| **UNC Threads** | | | |
| High Tensile Hexagon Head Bolts Grade 5 | B Z | B | AS 2465-1999 |
| High Tensile Hexagon Head Set Screws Grade 5 | | B Z | AS 2465-1999 |
| High Tensile Hexagon Head Bolts Grade 8 | B Z | B | AS 2465-1999 |
| High Tensile Hexagon Head Set Screws Grade 8 | | B Z | AS 2465-1999 |
| **UNF Threads** | | | |
| High Tensile Hexagon Head Bolts Grade 5 | B Z | B | AS 2465-1999 |
| High Tensile Hexagon Head Set Screws Grade 5 | | B Z | AS 2465-1999 |
| High Tensile Hexagon Head Bolts Grade 8 | B Z | B | AS 2465-1999 |
| High Tensile Hexagon Head Set Screws Grade 8 | | B Z | AS 2465-1999 |

NOTES:

1. Restricted range for some products. Check availability of particular sizes.
2. B = Plain finish
3. G = Galvanised finish to AS 1214
4. Z = Zinc Plated finish to AS 1897.

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# Thread Forms and Fits

All standard Ajax screw threads are made in accordance with the latest issues of the thread specifications shown in Table 2. Other dimensional features conform with the specifications listed in Table 1.

Standard products unless specifically requested are manufactured to the Australian Standard (AS) specifications which are designed to ensure interchangeability with corresponding International (ISO) American (ANSI/ASME) and British (BS) standards.

## Table 2 Thread Specifications

| Screw thread system | Specification | Title |
|---|---|---|
| British Standard Whitworth B.S.W. | AS 3501-1987 | Parallel Screw Threads of Whitworth Form |
| Unified National Fine UNF | AS 3635 -1990 | Unified Screw Threads |
| Unified National Coarse UNC | AS 3635 -1990 | Unified Screw Threads |
| ISO Metric Coarse Pitch Series | AS 1275 -1985 | Metric Screw Threads for Fasteners |
| ISO Metric Fine Pitch Series | AS 1721-1985 | General Purpose Metric Screw Threads |

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# Thread Forms and Fits

## Screw Thread Terminology

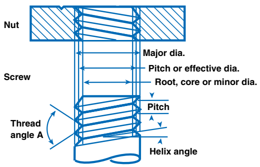



**FIGURE 1**

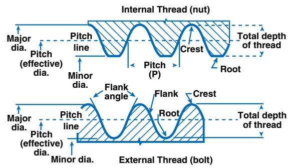
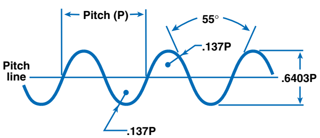


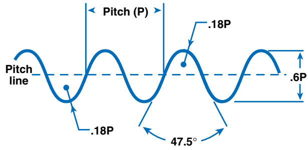

**FIGURE 2**

## Standard Thread Forms



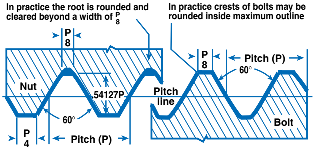

Whitworth form (B.S.W., B.S.F.)

**FIGURE 3**



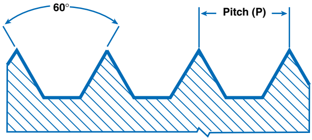

British Association (B.A.)

**FIGURE 4**




I.S.O. Metric and Unified (UNC, UNF, UNEF)

**FIGURE 5**




Coach screw thread

**FIGURE 6**

Don't RISK it! ... specify AJAX

# Thread Forms and Fits

## Thread Fits

Screw thread standards provide for various classes of fit using a hole basis tolerancing system (i.e. the maximum metal limit of the internal thread is basic size), allowances for fit being applied to the external (bolt) thread.

Exception is made for galvanized fasteners where an additional allowance is made in the nut (which is tapped after galvanizing) to accommodate the thick coating on the male thread. Only Free/1A/8g and Medium/2A/6g threads should be galvanized.

Table 3 lists the three thread class combinations which apply to the majority of commercial applications.

## Table 3

| | Thread class | | | Application |
|---|---|---|---|---|
| | Whitworth (B.S.W. & B.S.F.) | Unified (UNC & UNF) | ISO Metric | |
| Bolt<br>Nut | Free<br>Normal | 1A<br>1B | 8g<br>7H | Applies to the majority of nuts and bolts of ordinary commercial quality. The clearance permits rapid assembly without excessive play. |
| Bolt<br>Nut | Medium<br>Normal | 2A<br>2B | 6g<br>6H | Represents a precision quality screw thread product. |
| Bolt<br>Nut | Close<br>Medium | 3A<br>3B | 4h<br>5H | An exceptionally high grade threaded product, recommended only for applications where a close snug fit is essential. (See note). |

Note: These higher classes do not make any allowance for fit (i.e. maximum bolts and minimum nuts have a common size) and under some circumstances selective assembly may be necessary.

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# Testing of Bolts and Nuts

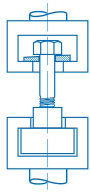


FIGURE 7

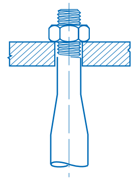


FIGURE 8

The normal mechanical properties of metals; tensile strength, proof stress, 0.2% yield stress, elongation, reduction of area; are determined on reduced section (proportional) test pieces. While these properties and testing methods can be applied to bolt materials, it is the usual practice to test bolts in their full size to more adequately reproduce the conditions under which they will be used in service.

This procedure of tensile testing bolts in their full size is recognised and adopted by many standardizing bodies, including the International Organization for Standardization **(ISO),** British Standards Institution, Standards Association of Australia, American Society for Testing and Materials **(ASTM)** and Society of Automotive Engineers **(SAE).**

The bolt is screwed into a tapped attachment (Figure 7) with six full threads exposed between the face of the attachment and the unthreaded shank. The bolt head is initially supported on a parallel collar for the proof load test, and a tapered or wedge collar for the second stage when it is broken in tension.

In this test, the bolt load is calculated from the tensile strength of the material, and the Tensile Stress Area of the thread. The Tensile Stress Area is the area calculated is based on the mean of the minor and pitch diameters of the thread. Tensile Stress Areas for common sizes and thread forms will be found in Tables 5-14.

The test, as indicated above, is carried out in two stages:

## (1) Proof Load Test.

This consists of applying a proof load (derived from a "proof load" stress) with the bolt head supported on a parallel collar. The bolt length is measured accurately before and after application of the proof load. It is required that the bolt shall not have permanently extended. A 0.0005" or 12.5 micrometers allowance is made for errors of measurements. This test provides a guide to the load to which the bolt will behave elastically.

## (2) Wedge Tensile Test.

The bolt is assembled as described previously but with the head supported on a tapered wedge collar. The angle of the wedge is varied for bolt diameter and grade, and for bolts with short or no plain shank length, but in most cases for bolts up to 1" or 20mm diameter it is 10°. The bolt is loaded

# Testing of Bolts and Nuts

until it fractures, and the breaking load must be above the specified minimum. The load is calculated from the tensile strength of the material and the Tensile Stress Area of the thread.

The test requires that, in addition to meeting the specified minimum breaking load, fracture must occur in the thread or plain shank with no fracture of the head shank junction. The bolt head must, therefore, be capable of conforming with the required wedge taper angle without fracturing at its junction with the shank. This latter requirement provides a very practical test for ductility.

Where the capacity of available testing equipment does not permit testing of bolts in full size, a hardness test is carried out. This is performed on a cross section through the bolt thread at a distance of 1 x diameter from the end.

## (3) Proof Load Test for Nuts.

The preferred method of testing nuts follows that of bolts in adoption of a test in full size to measure the load which the nut will carry without its thread stripping. This is also referred to as a Proof Load Test and it was traditional for the nut "Proof Load Stress" to be the same as the specified minimum tensile strength of the mating bolt. This "rule of thumb" still applies for products to the older standards such as BSW commercial and unified high tensile precision nuts. Metric nuts to AS 1112 – 1980 were designed with greater knowledge of bolt/nut assembly behaviour to satisfy the functional requirement that they could be used to tighten (by torque), a mating bolt of the same strength class up to its actual (not specification minimum) yield stress without the assembly failing by thread stripping. To satisfy this design requirement both the thickness/diameter ratio and proof load stress were increased and now vary with diameter.

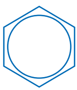
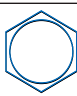
The nut is assembled on a hardened, threaded mandrel (Figure 8) and the proof load applied in an axial direction. The nut must withstand this load without failure by stripping or rupture, and be removable from the mandrel after the load is released.

Again, where nut proof loads exceed the capacity of available testing equipment, it is usual to carry out hardness tests on the top or bottom face of the nut.

FASTENERS

# Strength-Grade Designations for American Standard Fasteners

**Table 4 American SAE Standard** (AS 2465 is identical for Grades 2, 5, 8 only).

| SAE Grade | Head Marking | Diameter | Tensile Strength lbf/in² (min.) | "Proof Load" Stress lbf/in² | Rockwell Hardness |
|---|---|---|---|---|---|
| 1 (Note 6) |  | 1/4" to 1.1/2" | 60,000 | 33,000 | B70-B100 |
| 2 (Note 6) |  | 1/4" to 3/4"<br>Over 3/4" to 1.1/2" | 74,000<br>60,000 | 55,000<br>33,000 | B80-B100<br>B70-B100 |
| 4 (Note 6) | None (studs only) | 1/4" to 1.1/2" | 115,000 | 65,000 | C22-C32 |
| 5 (Note 1) |  | 1/4" to 1"<br>Over 1" to 1.1/2" | 120,000<br>105,000 | 85,000<br>74,000 | C25-C34<br>C19-C30 |
| 5.1 (Note 2 & 6) |  | No.6 to 5/8" | 120,000 | 85,000 | C25-C40 |
| 5.2 (Note 3 & 6) |  | 1/4" to 1" | 120,000 | 85,000 | C26-C36 |

AJAX FASTENERS

# Strength-Grade Designations for American Standard Fasteners

**Table 4 Continued, American SAE Standard** (AS 2465 is identical for Grades 2, 5, 8 only).

| SAE Grade | Head Marking | Diameter | Tensile Strength lbf/in² (min.) | "Proof Load" Stress lbf/in² | Rockwell Hardness |
|---|---|---|---|---|---|
| 7 (Note 4 & 6) |  | 1/4" to 1.1/2" | 133,000 | 105,000 | C28-C34 |
| 8 (Note 5) |  | 1/4" to 1.1/2" | 150,000 | 120,000 | C33-C39 |
| 8.1 (Note 6) | None (studs only) | 1/4" to 1.1/2" | 150,000 | 120,000 | C32-C38 |
| 8.2 (Note 6) |  | 1/4" to 1" | 150,000 | 120,000 | C33-C39 |

## Notes:

1. Medium carbon steel, quenched and tempered.
2. Sems (captive washer) assemblies. These are of low or medium carbon steel, quenched and tempered.
3. Low carbon boron steel, quenched and tempered.
4. Medium carbon alloy steel, quenched and tempered. Thread rolled after heat treatment.
5. Medim carbon alloy steel, quenched and tempered.
6. Not available from stock.

AJAX FASTENERS

# Breaking and Yield Loads of Ajax Bolts

When bolts are broken in tension, breaking will normally occur in the threaded section, and it might be expected that the breaking load could be calculated on the basis of the material strength and the area at the root of the thread.

Tests have proved, however, that the actual tensile breaking load of a bolt is higher than the figure calculated in this manner, and the most accurate estimate is based on the mean of the pitch and minor diameters of the thread. This calculation gives a figure which is known as the “Stress Area”, and this is now generally accepted as the basis for computing the strength in tension of an externally threaded part. Stress Area is adopted for strength calculations in **I.S.O.** recommendations and in specifications issued by the Standards Association of Australia, British Standards Institution, American Society of Automotive Engineers **(SAE).**

The following tables list tensile breaking and yield loads of Ajax bolts calculated from tensile or yield stress and “Stress Area” of the thread.

AJAX FASTENERS

# Breaking and Yield Loads of Ajax Bolts

Ajax BSW Bolts AS 2451 – 1998

## Table 5

Based on:

Tensile Strength = 28 tonf/in$^2$ min.
Yield Stress = 16 tonf/in$^2$ min.

| Size (in.) | Stress Area of Thread* | Yield Load of Bolt (Min.) | | | Breaking Load of Bolt (Min.) | | |
|---|---|---|---|---|---|---|---|
| | Sq. In. | Tonf | lbf | Kn | Tonf | lbf | Kn |
| (3/16 BSW) | 0.0171 | 0.27 | 600 | 2.73 | 0.48 | 1070 | 4.77 |
| 1/4 BSW | 0.0321 | 0.51 | 1140 | 5.12 | 0.90 | 2010 | 8.97 |
| 5/16 BSW | 0.0527 | 0.84 | 1880 | 8.40 | 1.47 | 3290 | 14.6 |
| 3/8 BSW | 0.0779 | 1.25 | 2800 | 12.4 | 2.18 | 4880 | 21.7 |
| 7/16 BSW | 0.1069 | 1.71 | 3830 | 17.0 | 2.99 | 6700 | 29.8 |
| 1/2 BSW | 0.1385 | 2.22 | 4970 | 22.1 | 3.88 | 8690 | 38.7 |
| 5/8 BSW | 0.227 | 3.63 | 8130 | 36.2 | 6.35 | 14220 | 63.3 |
| 3/4 BSW | 0.336 | 5.38 | 12050 | 53.6 | 9.41 | 21080 | 93.8 |
| 7/8 BSW | 0.464 | 7.42 | 16620 | 73.9 | 13.00 | 29120 | 129 |
| 1 BSW | 0.608 | 9.73 | 21800 | 96.9 | 17.05 | 38190 | 170 |
| 1.1/8 BSW | 0.766 | 12.26 | 27460 | 122.1 | 21.42 | 47980 | 213 |
| 1.1/4 BSW | 0.980 | 15.68 | 35120 | 156.2 | 27.44 | 61480 | 273 |
| 1.1/2 BSW | 1.410 | 22.56 | 50530 | 224.8 | 39.48 | 88370 | 393 |
| (1.3/4 BSW) | 1.907 | 30.51 | 68340 | 304.0 | 53.39 | 119590 | 532 |
| (2 BSW) | 2.508 | 40.13 | 89890 | 399.8 | 70.21 | 157270 | 700 |

* See introductory paragraph to this section for definition of "Stress Area".
(   ) Sizes not covered in standard. Data above is given for information only.

AJAX FASTENERS

# Breaking and Yield Loads of Ajax Bolts

Ajax Cup Head BSW Bolts AS B108 – 1952

## Table 6

Based on:

Tensile Strength = 26 tonf/in$^2$ min.
Yield Stress = 13 tonf/in$^2$ min.

| Size (in.) | Stress Area of Thread* | Yield Load of Bolt (Min.) | | | Breaking Load of Bolt (Min.) | | |
|---|---|---|---|---|---|---|---|
| | Sq. In. | Tonf | lbf | Kn | Tonf | lbf | Kn |
| (3/16 BSW) | 0.0171 | 0.22 | 500 | 2.22 | 0.44 | 1000 | 4.43 |
| 1/4 BSW | 0.0321 | 0.41 | 940 | 4.16 | 0.84 | 1880 | 8.32 |
| 5/16 BSW | 0.0527 | 0.69 | 1540 | 6.83 | 1.37 | 3070 | 13.7 |
| 3/8 BSW | 0.0779 | 1.01 | 2270 | 10.1 | 2.03 | 4540 | 20.2 |
| 7/16 BSW | 0.1069 | 1.39 | 3110 | 13.8 | 2.78 | 6230 | 27.7 |
| 1/2 BSW | 0.1385 | 1.80 | 4030 | 17.9 | 3.60 | 8070 | 35.9 |
| 5/8 BSW | 0.227 | 2.95 | 6610 | 29.4 | 5.90 | 13220 | 58.8 |
| 3/4 BSW | 0.336 | 4.37 | 9780 | 43.5 | 8.74 | 19570 | 87.0 |

* See introductory paragraph to this section for definition of "Stress Area".
( ) Sizes not covered in standard. Data above is given for information only.

AJAX FASTENERS

# Breaking and Yield Loads of Ajax Bolts and Set Screws

Ajax Unified High Tensile Hexagon Head
Bolts and Set Screws
(AS 2465-1999/SAE J429 Grade 5

## Table 7

Based on:

| | | | | |
|---|---|---|---|---|
| Tensile Strength | = | 120000 lbf/in² min. | (827 MPa) | Sizes 1/4" – 1"incl. |
| | = | 105000 lbf/in² min. | (724 MPa) | Sizes 1.1/8" – 1.1/2" incl. |
| Yield Stress | = | 92000 lbf/in² min. | (634 MPa) | Sizes 1/4" – 1" incl. |
| | = | 81000 lbf/in² min. | (558 MPa) | Sizes 1.1/8" – 1.1/2" incl. |
| Proof Load Stress | = | 85000 lbf/in² | (586 MPa) | Sizes 1/4" – 1" incl. |
| | = | 74000 lbf/in² | (510 MPa) | Sizes 1.1/8" – 1.1/2" incl. |

| Size | | Stress Area of Thread* | Proof Load of Bolt | | Breaking Load of Bolt (Min.) | |
|---|---|---|---|---|---|---|
| | | Sq. In. | lbf | kN | lbf | kN |
| 1/4 | UNF | 0.0364 | 3100 | 13.8 | 4350 | 19.3 |
| 5/16 | UNF | 0.0580 | 4900 | 21.8 | 6950 | 30.9 |
| 3/8 | UNF | 0.0878 | 7450 | 33.1 | 10500 | 46.7 |
| 7/16 | UNF | 0.1187 | 10100 | 44.9 | 14200 | 63.2 |
| 1/2 | UNF | 0.1599 | 13600 | 60.5 | 19200 | 85.4 |
| 5/8 | UNF | 0.256 | 21800 | 97.0 | 30700 | 137 |
| 3/4 | UNF | 0.373 | 31700 | 141 | 44800 | 199 |
| 7/8 | UNF | 0.509 | 43300 | 193 | 61100 | 272 |
| 1 | UNS | 0.679 | 57715 | 254 | 81480 | 358 |
| 1.1/8 | UNF | 0.856 | 63300 | 282 | 89900 | 400 |
| 1.1/4 | UNF | 1.073 | 79400 | 353 | 112700 | 501 |
| 1.1/2 | UNF | 1.581 | 117000 | 520 | 166000 | 738 |

*See introductory paragraph to this section for definition of "Stress Area".

AJAX FASTENERS

# Breaking and Yield Loads of Ajax Bolts and Set Screws

## Ajax Unified High Tensile Hexagon Head Bolts and Set Screws (AS 2465-1999/SAE J429 Grade 5)

**Table 8** Based on:

| | | | | |
|---|---|---|---|---|
| Tensile Strength | = | 120000 lbf/in² min. | (827 MPa) | Sizes 1/4" – 1" incl. |
| | = | 105000 lbf/in² min. | (724 MPa) | Sizes 1.1/8" – 1.1/2" incl. |
| Yield Stress | = | 92000 lbf/in² min. | (634 MPa) | Sizes 1/4" – 1" incl. |
| | = | 81000 lbf/in² min. | (558 MPa) | Sizes 1.1/8" – 1.1/2" incl. |
| Proof Load Stress | = | 85000 lbf/in² | (586 MPa) | Sizes 1/4" – 1" incl. |
| | = | 74000 lbf/in² | (510 MPa) | Sizes 1.1/8" – 1.1/2" incl. |

| Size | | Stress Area of Thread* | Proof Load of Bolt | | Breaking Load of Bolt (Min.) | |
|---|---|---|---|---|---|---|
| | | Sq. In. | lbf | kN | lbf | kN |
| 1/4 | UNC | 0.0318 | 2700 | 12.0 | 3800 | 16.9 |
| 5/16 | UNC | 0.0524 | 4450 | 19.8 | 6300 | 28.0 |
| 3/8 | UNC | 0.0775 | 6600 | 29.4 | 9300 | 41.4 |
| 7/16 | UNC | 0.1063 | 9050 | 40.3 | 12800 | 56.9 |
| 1/2 | UNC | 0.1419 | 12100 | 53.8 | 17000 | 75.6 |
| 5/8 | UNC | 0.226 | 19200 | 85.4 | 27100 | 121 |
| 3/4 | UNC | 0.334 | 28400 | 126 | 40100 | 178 |
| 7/8 | UNC | 0.462 | 39300 | 175 | 55400 | 246 |
| 1 | UNC | 0.606 | 51500 | 229 | 72700 | 323 |
| 1.1/8 | UNC | 0.763 | 56500 | 251 | 80100 | 356 |
| 1.1/4 | UNC | 0.969 | 71700 | 319 | 101700 | 452 |
| 1.1/2 | UNC | 1.405 | 104000 | 463 | 147500 | 656 |

* See introductory paragraph to this section for definition of “Stress Area”.

AJAX FASTENERS

# Breaking and Yield Loads of Ajax Bolts and Set Screws

Ajax Unified High Tensile Hexagon Head
Bolts and Set Screws
(AS 2465-1999/SAE J429 Grade 8)

**Table 9** Based on:

| | | | | |
|---|---|---|---|---|
| Tensile Strength | = | 150000 lbf/in² min. | (1034 MPa) | Sizes 1/4" – 1.1/2" incl. |
| Yield Stress | = | 130000 lbf/in² min. | (896 MPa) | |
| Proof Load Stress | = | 120000 lbf/in² | (827 MPa) | |

| Size | | Stress Area of Thread* | Proof Load of Bolt | | Breaking Load of Bolt (Min.) | |
|---|---|---|---|---|---|---|
| | | Sq. In. | lbf | kN | lbf | kN |
| 1/4 | UNF | 0.0364 | 4350 | 19.3 | 5450 | 24.2 |
| 5/16 | UNF | 0.0580 | 6950 | 30.9 | 8700 | 38.7 |
| 3/8 | UNF | 0.0878 | 10500 | 46.7 | 13200 | 58.7 |
| 7/16 | UNF | 0.1187 | 14200 | 63.2 | 17800 | 79.2 |
| 1/2 | UNF | 0.1599 | 19200 | 85.4 | 24000 | 107 |
| 5/8 | UNF | 0.256 | 30700 | 137 | 38400 | 171 |
| 3/4 | UNF | 0.373 | 44800 | 199 | 56000 | 249 |
| 7/8 | UNF | 0.509 | 61100 | 272 | 76400 | 340 |
| 1 | UNF | 0.663 | 79600 | 354 | 99400 | 442 |
| 1 | UNS | 0.679 | 81480 | 359 | 101850 | 448 |
| 1.1/8 | UNF | 0.856 | 102700 | 457 | 128400 | 571 |
| 1.1/4 | UNF | 1.073 | 128800 | 573 | 161000 | 716 |
| 1.1/2 | UNF | 1.581 | 189700 | 844 | 237200 | 1055 |

* See introductory paragraph to this section for definition of “Stress Area”.

AJAX FASTENERS

# Breaking and Yield Loads of Ajax Bolts and Set Screws

Ajax Unified High Tensile Hexagon Head
Bolts and Set Screws
(AS 2465-1999/SAE J429 Grade 8) continued

## Table 9 continued

| Size | | Stress Area of Thread* | Proof Load of Bolt | | Breaking Load of Bolt (Min.) | |
|---|---|---|---|---|---|---|
| | | Sq. In. | lbf | kN | lbf | kN |
| 1/4 | UNC | 0.0318 | 3800 | 16.9 | 4750 | 19.3 |
| 5/16 | UNC | 0.0524 | 6300 | 28.0 | 7850 | 30.9 |
| 3/8 | UNC | 0.0775 | 9300 | 41.4 | 11600 | 46.7 |
| 7/16 | UNC | 0.1063 | 12800 | 56.9 | 15900 | 63.2 |
| 1/2 | UNC | 0.1419 | 17000 | 75.6 | 21300 | 85.4 |
| 5/8 | UNC | 0.226 | 27100 | 121 | 33900 | 137 |
| 3/4 | UNC | 0.334 | 40100 | 178 | 50100 | 199 |
| 7/8 | UNC | 0.462 | 55400 | 246 | 69300 | 272 |
| 1 | UNC | 0.606 | 72700 | 323 | 90900 | 354 |
| 1.1/8 | UNC | 0.763 | 91600 | 407 | 114400 | 457 |
| 1.1/4 | UNC | 0.969 | 116300 | 517 | 145400 | 573 |
| 1.1/2 | UNC | 1.405 | 168600 | 750 | 210800 | 844 |

* See introductory paragraph to this section for definition of "Stress Area".

AJAX FASTENERS

# Breaking and Yield Loads of Ajax Bolts and Set Screws

Ajax Metric Hexagon Commercial
Bolts and Set Screws
(AS 1111-1996/AS 4291.1-1995 Property Class 4.6)

## Table 10

Based on:

| | | | |
|---|---|---|---|
| Tensile Strength | = | 400 MPa min | (58015 lbf/in²) |
| Yield Stress | = | 240 MPa min | (34810 lbf/in²) |
| Proof Load Stress | = | 225 MPa | (32635 lbf/in²) |

| Size | Tensile Stress Area of Thread* | Proof Load of Bolt | | Breaking Load of Bolt (Min.) | |
|---|---|---|---|---|---|
| | $mm^2$ | kN | lbf | kN | lbf |
| M5 | 14.2 | 3.20 | 719 | 5.68 | 1275 |
| M6 | 20.1 | 4.52 | 1015 | 8.04 | 1805 |
| M8 | 36.6 | 8.24 | 1850 | 14.6 | 3280 |
| M10 | 58.0 | 13.0 | 2920 | 23.2 | 5215 |
| M12 | 84.3 | 19.0 | 4270 | 33.7 | 7575 |
| M14 | 115 | 25.9 | 5820 | 46.0 | 10300 |
| M16 | 157 | 35.3 | 7940 | 62.8 | 14120 |
| M18 | 192 | 43.2 | 9710 | 76.8 | 17250 |
| M20 | 245 | 55.1 | 12390 | 98.0 | 22030 |
| M22 | 303 | 68.2 | 15450 | 121 | 27200 |
| M24 | 353 | 79.4 | 17850 | 141 | 31700 |
| M27 | 459 | 103 | 23200 | 184 | 41400 |
| M30 | 561 | 126 | 28330 | 224 | 50360 |
| M33 | 694 | 156 | 35100 | 278 | 62500 |

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# Breaking and Yield Loads of Ajax Bolts and Set Screws

Ajax Metric Hexagon Commercial
Bolts and Set Screws
(AS 1111-1996/AS 4291.1-1995 Property Class 4.6) continued

## Table 10 continued

| Size | Tensile Stress Area of Thread* | Proof Load of Bolt | | Breaking Load of Bolt (Min.) | |
|---|---|---|---|---|---|
| | mm² | kN | lbf | kN | lbf |
| M36 | 817 | 184 | 41370 | 327 | 73510 |
| M39 | 976 | 220 | 49500 | 390 | 87700 |
| M42 | 1120 | 252 | 56650 | 448 | 100710 |
| M48 | 1470 | 331 | 74410 | 588 | 132190 |
| M56 | 2030 | 458 | 102960 | 812 | 182550 |
| M64 | 2680 | 605 | 136000 | 1072 | 241000 |

* See introductory paragraph to this section for definition of "Stress Area".

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# Breaking and Yield Loads of Ajax Bolts and Set Screws

Ajax Metric Hexagon Precision
Bolts and Set Screws
(AS 1110-1995/ AS 4291.1-1995 Property Class 8.8)

## Table 11

| | | | | |
|---|---|---|---|---|
| | | Based on: | | |
| Tensile Strength | = | 800 MPa min | (116030 lbf/in$^2$ ) | Sizes M5 – M16 incl. |
| | = | 830 MPa min | (120380 lbf/in$^2$ ) | Sizes M18 – M39 incl. |
| Yield Stress | = | 640 MPa min | (92825 lbf/in$^2$ ) | Sizes M5 – M16 incl. |
| | = | 660 MPa min | (95725 lbf/in$^2$ ) | Sizes M18 – M39 incl. |
| Proof Load Stress | = | 580 MPa | (84120 lbf/in$^2$ ) | Sizes M5 – M16 incl. |
| | = | 600 MPa | (87025 lbf/in$^2$ ) | Sizes M18 – M39 incl. |

| Size | Tensile Stress Area of Thread* | Proof Load of Bolt | | Breaking Load of Bolt (Min.) | |
|---|---|---|---|---|---|
| | mm$^2$ | kN | lbf | kN | lbf |
| M5 | 14.2 | 8.23 | 1850 | 11.35 | 2550 |
| M6 | 20.1 | 11.6 | 2610 | 16.1 | 3620 |
| M8 | 36.6 | 21.2 | 4770 | 29.2 | 6560 |
| M10 | 58.0 | 33.7 | 7580 | 46.4 | 10430 |
| M12 | 84.3 | 48.9 | 10990 | 67.4 | 15150 |
| M14 | 115 | 66.7 | 14995 | 92 | 20680 |
| M16 | 57 | 91.0 | 20460 | 125 | 28100 |
| M18 | 192 | 115 | 25850 | 159 | 35745 |
| M20 | 245 | 147 | 33050 | 203 | 45640 |
| M22 | 303 | 182 | 40915 | 252 | 56650 |
| M24 | 353 | 212 | 47660 | 293 | 65870 |
| M27 | 459 | 275 | 61820 | 381 | 85650 |

# Breaking and Yield Loads of Ajax Bolts and Set Screws

Ajax Metric Hexagon Precision
Bolts and Set Screws
(AS 1110-1995/ AS 4291.1-1995 Property Class 8.8) continued

### Table 11 continued

| Size | Tensile Stress Area of Thread* | Proof Load of Bolt | | Breaking Load of Bolt (Min.) | |
|---|---|---|---|---|---|
| | $mm^2$ | kN | lbf | kN | lbf |
| M30 | 561 | 337 | 75760 | 466 | 104760 |
| M33 | 694 | 416 | 93520 | 576 | 129490 |
| M36 | 817 | 490 | 110160 | 678 | 152420 |
| M39 | 976 | 586 | 131740 | 810 | 182100 |

* See introductory paragraph to this section for definition of "Stress Area".

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# Breaking and Yield Loads of Ajax Bolts and Set Screws

Ajax Metric Hexagon Precision
Bolts and Set Screws
(AS 1110-1995 / AS 4291.1-1995 Property Class 10.9)

## Table 12

Based on:

| | | | | |
|---|---|---|---|---|
| Tensile Strength | = | 1040 MPa min | (150340 lbf/in$^2$) | Sizes M5 – M39 incl. |
| Yield Stress | = | 940 MPa min | (136340 lbf/in$^2$) | Sizes M5 – M39 incl. |
| Proof Load Stress | = | 830 MPa | (120330 lbf/in$^2$) | Sizes M5 – M39 incl. |

| Size | Tensile Stress Area of Thread* | Proof Load of Bolt | | Breaking Load of Bolt (Min.) | |
|---|---|---|---|---|---|
| | mm$^2$ | kN | lbf | kN | lbf |
| M5 | 14.2 | 11.8 | 2655 | 14.8 | 3325 |
| M6 | 20.1 | 16.7 | 3755 | 20.9 | 4700 |
| M8 | 36.6 | 30.4 | 6835 | 38.1 | 8565 |
| M10 | 58.0 | 48.1 | 10810 | 60.3 | 13555 |
| M12 | 84.3 | 70 | 15750 | 87.7 | 19720 |
| M14 | 115 | 95.5 | 21470 | 120 | 26970 |
| M16 | 157 | 130 | 29225 | 163 | 36650 |
| M18 | 192 | 159 | 35750 | 200 | 44960 |
| M20 | 245 | 203 | 45650 | 255 | 57330 |
| M22 | 303 | 252 | 56650 | 315 | 70820 |
| M24 | 353 | 293 | 65870 | 367 | 82510 |
| M27 | 459 | 381 | 85650 | 477 | 107230 |
| M30 | 561 | 466 | 104760 | 583 | 131060 |
| M33 | 694 | 570 | 128140 | 722 | 162310 |
| M36 | 817 | 678 | 152420 | 850 | 191090 |
| M39 | 976 | 810 | 182100 | 1020 | 229310 |

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# Breaking and Yield Loads of Ajax Bolts and Set Screws

Ajax Metric Hexagon Precision
Bolts and Set Screws, Property Class 8.8
Fine Pitch Threads
Bolts DIN 960, Set Screws DIN 961

## Table 13

| | | Based on: | | |
|---|---|---|---|---|
| Tensile Strength | = | 800 MPa min | (116030 lbf/in² ) | Sizes M8 – M16 incl. |
| | = | 830 MPa min | (120380 lbf/in² ) | Sizes M18 – M39 incl. |
| Yield Stress | = | 640 MPa min | (92825 lbf/in² ) | Sizes M8 – M16 incl. |
| | = | 660 MPa min | (95725 lbf/in² ) | Sizes M18 – M39 incl. |
| Proof Load Stress | = | 580 MPa | (84120 lbf/in² ) | Sizes M5 – M16 incl. |
| | = | 600 MPa | (87025 lbf/in² ) | Sizes M18 – M39 incl. |

| Size | Thread Pitch | Tensile Stress Area of Thread* | Proof Load of Bolt | | Breaking Load of Bolt (Min.) | |
|---|---|---|---|---|---|---|
| | | mm² | kN | lbf | kN | lbf |
| M8 | 1.0p | 39.2 | 22.7 | 5102 | 31.3 | 7036 |
| M10 | 1.25p | 61.0 | 39.0 | 8767 | 48.8 | 10970 |
| M12 | 1.25p | 92.0 | 59.0 | 13263 | 73.6 | 16545 |
| M14 | 1.5p | 125.0 | 72.5 | 16298 | 100.0 | 22480 |
| M16 | 1.5p | 167.0 | 96.9 | 21783 | 134.0 | 30123 |
| M18 | 1.5p | 216.0 | 130.0 | 29224 | 179.0 | 40239 |
| M20 | 1.5p | 272.0 | 163.0 | 36642 | 226.0 | 50804 |
| M22 | 1.5p | 333.0 | 200.0 | 44960 | 276.0 | 62044 |
| M24 | 2.0p | 384.0 | 230.0 | 51704 | 319.0 | 71711 |

* See introductory paragraph to this section for definition of “Stress Area”.

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# Breaking and Yield Loads of Ajax Bolts

Ajax Metric Hexagon
Tower Bolts
(AS 1559 - 1986 Property Class 5.8)

## Table 14

Based on:

| | | | |
|---|---|---|---|
| Tensile Strength | = | 480 MPa min | (69600 lbf/in$^2$) |
| Yeild Stress | = | 340 MPa min | (49300 lbf/in$^2$) |
| Proof Stress Load | = | 320 MPa min | (46400 lbf/in$^2$) |
| Shear Stress | = | 320 MPa min | (46400 lbf/in$^2$) |

| Size | Area of Root of Thread | Tensile Stress Area of Thread* | Proof Load of Bolt | | Breaking Load of Bolt (Min.) | |
|---|---|---|---|---|---|---|
| | mm$^2$ | mm$^2$ | kN | lbf | kN | lbf |
| M12* | 76.2 | 84.3 | 27.0 | 6070 | 40.5 | 9104 |
| M16 | 144 | 157 | 50.2 | 11285 | 75.4 | 16950 |
| M20 | 225 | 245 | 78.0 | 17534 | 118.0 | 26526 |
| M24 | 324 | 353 | 113.0 | 25402 | 169.0 | 37991 |
| M30 | 519 | 561 | 180.0 | 40464 | 269.0 | 60471 |

## Table 14A

Based on: 320 Mpa (46400 lbf/in$^2$)

| Size | Nominal Shank Area | Double Shear Loads (min) | |
|---|---|---|---|
| | mm$^2$ | kN | lbf |
| M12* | 113 | 72.3 | 16253 |
| M16 | 201 | 129 | 29000 |
| M20 | 314 | 201 | 45185 |
| M24 | 452 | 289 | 64967 |
| M30 | 707 | 452 | 101609 |

*M12 is a non-preferred diameter by AS 1559-1986

* See introductory paragraph to this section for definition of “Stress Area”.

# Bolt Shear Capacity of Ajax Bolts and Set Screws

## Table 15

| Specification | AS 1111 AS 2451 | | AS 1110 Prop. Cl. 8.8 AS 2465 Grade 5 | | | AS 1110 Prop. Cl. 10.9 AS 2465 Grade 8 | | |
|---|---|---|---|---|---|---|---|---|
| Size | Minimum Breaking Load in Single Shear – kN [1,2] | | | | | | | |
| | Shank[3] | Thread | Shank[3] | Thread | | Shank[3] | Thread | |
| | | | | Coarse | Fine | | Coarse | Fine |
| M6 | 7 | 4 | 14 | 9 | | 18 | 12 | |
| 1/4" | 9 | 5 | 16 | 9 | 11 | 20 | 11 | 14 |
| M8 | 13 | 8 | 25 | 16 | 19 | 33 | 21 | |
| 5/16" | 13 | 8 | 26 | 15 | 17 | 32 | 19 | 22 |
| 3/8" | 19 | 12 | 37 | 23 | 27 | 46 | 28 | 34 |
| M10 | 20 | 13 | 39 | 26 | 30 | 51 | 34 | |
| 7/16" | 26 | 16 | 50 | 31 | 36 | 63 | 39 | 45 |
| M12 | 28 | 19 | 57 | 38 | 45 | 74 | 50 | |
| 1/2" | 34 | 21 | 65 | 42 | 50 | 82 | 52 | 62 |
| M14 | 38 | 29 | 79 | 59 | 62 | 99 | 74 | |
| M16 | 50 | 36 | 101 | 72 | 83 | 131 | 94 | |
| 5/8" | 53 | 35 | 102 | 67 | 80 | 128 | 84 | 100 |
| M18 | 63 | 48 | 131 | 99 | 110 | 164 | 124 | |
| 3/4" | 77 | 53 | 147 | 101 | 117 | 184 | 126 | 146 |
| M20 | 79 | 56 | 163 | 117 | 140 | 204 | 146 | |
| M22 | 94 | 75 | 196 | 160 | 171 | 245 | 195 | |
| 7/8" | 105 | 73 | 201 | 140 | 160 | 251 | 175 | 200 |

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# Bolt Shear Capacity of Ajax Bolts and Set Screws

## Table 15 Continued

| Specification | AS 1111 AS 2451 | | AS 1110 Prop. Cl. 8.8 AS 2465 Grade 5 | | | AS 1110 Prop. Cl. 10.9 AS 2465 Grade 8 | | |
|---|---|---|---|---|---|---|---|---|
| | Minimum Breaking Load in Single Shear – kN [1 2] | | | | | | | |
| Size | Shank[3] | Thread | Shank[3] | Thread | | Shank[3] | Thread | |
| | | | | Coarse | Fine | | Coarse | Fine |
| M24 | 113 | 81 | 235 | 168 | 197 | 294 | 211 | |
| 1" | 137 | 97 | 262 | 184 | 208 | 327 | 230 | 260 |
| M27 | 142 | 114 | 295 | 236 | | 369 | 296 | |
| 1.1/8" | 173 | 121 | 332 | 202 | 237 | 414 | 289 | 338 |
| M30 | 177 | 130 | 368 | 270 | | 459 | 337 | |
| M33 | 212 | 172 | 440 | 357 | | 552 | 447 | |
| M36 | 254 | 190 | 529 | 395 | | 662 | 493 | |
| 1.1/2" | 308 | 226 | 589 | 377 | 444 | 736 | 539 | 634 |
| M39 | 296 | 242 | 615 | 502 | | 770 | 629 | |

## Notes:

1. Tabulated values are for failure. Refer to applicable Code for permissible Design Stress. Table 16 gives guidance for AS 1250 and AS 4100 values
2. The values shown are for a single shear plane and may be compounded for multiple shear planes. Multiple bolt joints are subject to an "unbuttoning effect". AS 1250 states that this should be considered when more than 5 bolts are aligned in the direction of the force. AS 1511 reduces design shear capacity, 14% for joints 500-1200mm length, 43% for joints over 1200mm. AS 4100 progressively reduces design shear capacity by 25% for joints 300-1300mm length and longer.
3. Based on nominal diameter of shank.

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# Bolt Shear Capacity of Ajax Bolts and Set Screws

## Table 16

| Bolt Type | Shear Stress at failure[1] (Mpa) | | Ratio[2] | AS 1250-1981 Maximum Permissible Design Shear Stress (MPa)[4] | AS 4100-1990 Maximum "Design Capacity Shear Stress" [5] (MPa) |
|---|---|---|---|---|---|
| | Min | Max[3] | | | |
| AS 1111 Property Class 4.6 | 248.0 | 431.5 | 1.74 | 79.2 | 198.4 |
| AS 2451 BSW Low Tensile 1/4" – 3/4" | 267.8 | 452.6 | 1.69 | (81.5)[6] | 214.3 |
| 7/8" – 1" | 267.8 | 452.6 | 1.69 | (76.6)[6] | 214.3 |
| AS 1559 Tower Bolt | 320.0[7] | — | — | 112.2[8] | 238.1[9] |
| As 1110 Property Class 5.8 | 322.4 | 431.5 | 1.34 | 130.0 | 257.9 |
| AS 1110 Property Class 8.8 M1.6 – M16 | 496.0 | 636.1 | 1.28 | 200.0 | 396.8 |
| M18 – M36 | 514.6 | 654.1 | 1.27 | 207.5 | 411.7 |
| AS 2465 Unified Grade 5 1/4" – 1" | 512.7 | 654.1 | 1.28 | 206.8 | 410.2 |
| 1.1/8" – 1.1/2" | 448.9 | 589.6 | 1.31 | 181.0 | 359.1 |
| AS2465 Unified Grade 8 | 641.0 | 752.1 | 1.17 | 258.5 | 512.9 |
| AS 1110 Property Class 10.9 | 644.8 | 752.1 | 1.17 | 260.0 | 515.8 |

AJAX FASTENERS

# Bolt Shear Capacity of Ajax Bolts and Set Screws

## NOTES

1. Basis is ultimate shear stress equals 62% of ultimate tensile strength. Reference AS 4100-1990. This ratio was established on tension loaded lap joints. Geometric effects on compression loading similar joint configuration can give apparent bolt shear capacity 9% higher.
2. For overload protection application, check that both maximum and minimum are suitable. Maximum equals minimum (Table 15) value times ratio
3. Maximum shear stress at failure is based on imputed maximum tensile strength, estimated from specified maximum hardness. Reference SAE J417.
4. Maximum Permissible Shear Stress in design is the lesser of .33Fyf and 0.25Fuf.
5. AS 4100 does not express stress values but extends the data to a "Design Resistance Capacity" taking account of the length of the joint (see Table 15 Note 2), the available bolt shear area (threads or shanks) and a "Capacity Factor" which is 0.8 for the Strength Limit State Criterion. Thus the "Design Capacity Shear Stress" shown here to facilitate comparison with the previous rule is 80% of the minimum shear stress at failure shown in column 2, and represents the stress value which the factored actions (loads) acting on the bolts may not exceed – not the actual shear stress which may be applied to the bolts. With Load Factors of 1.25 on dead loads and 1.5 on live loads it can be seen that bolt loading is still conservative compared to their ultimate capacity. Other load factors apply for other actions eg. earthquake, wind .
6. For mild steel bolts the relevant criterion (see Note 4 above) is generally .33Fyf. AS 2451 does not specify Fyf so the values shown are from Ajax Fasteners data.
7. On the basis of Note 1, the value here would be 297.6 MPa but 320 MPa is shown as it is a specified requirement of AS 1559 - 1986.
8. Some Design Authorities have for over 5 years, used a value 290 MPa (= 91% of the specified minimum value) which would be experienced by the fastener under the 80 year mean return wind, in lattice tower design. They previously used the 30 year mean return wind and had some towers blow down.
9. Factoring the specification minimum shear stress would give a value of 256 MPa.

AJAX FASTENERS

# Design of Bolted Joints for General Engineering

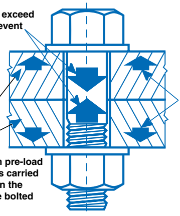



FIGURE 9

## Selection of Tensile Strength of Bolts

Bolted joints in which strength is the main design consideration, can, in most cases, be more economically designed when a high tensile bolt is used rather than a mild steel bolt. Fewer bolts can be used to carry the same total load, giving rise to savings not only from the cost of a smaller number of bolts, but also machining where less holes are drilled and tapped, and assembly where less time is taken.

## Selection of Coarse and Fine Threads

In practically all cases the coarse thread is a better choice. The course threads provide adequate strength and great advantages in assembly over fine threads. The former are less liable to become cross threaded, start more easily, particularly in awkward positions, and require less time to tighten.

In cases where fine adjustment is needed, the fine thread should be used. Providing bolts are tightened to the torque specified in tables 21-26 there should be no tendency to loosen under conditions of vibration with either coarse or fine threads.

## Types of Loading on Joints

Examine the forces being applied to the joint to decide which of the following types fits the conditions.

a) Joints carrying direct tensile loads (See Fig. 9).

b) Joints carrying loads in shear (See Fig. 10-11). Types 1 and 2.

c) Flexible gasket joints for sealing liquids or gases under pressure (See Fig. 12).

## Joints Carrying Direct Tensile Loads

**(1) Safety Factor.** Apply a safety factor according to the nature of the loading. Except in the case of the flexible gasket joint, the safety factor on a bolt differs from most other applications in that it does not affect the stress of the bolt, but refers to the factor by which the sum of the preload on all the bolts comprising the joint exceeds the design load applied. Regardless of the nature of the load, the bolts should still be preloaded to 65% of their yield stress using the recommended torque values as set out in table 21-26.

# Design of Bolted Joints for General Engineering

$$\text{Safety Factor} = \frac{\text{Sum of preload on all the bolts comprising the joint}}{\text{Design applied load}}$$

For design purposes, the preload on each bolt should be taken according to the bolt size and bolt material as shown in Tables 21 to 26 and the safety factor selected from the following table:–

### Table 17

| Nature of Loading | Safety Factors* |
|---|---|
| Steady Stress | 1.5 – 2 |
| Repeated Stress gradually applied | 2 – 3.5 |
| shock | 4.5 – 6 |

**Applies to joints with direct tensile loads only, and assumes all bolts are tightened to 65% of the yield stress.*

## (2) Total Required Preload†.

Determine this from safety factor (S) and applied load (L).

Total required preload F = S x L

## (3) Selection of Bolt Material, Bolt Size, Number of Bolts.

By selecting a suitable bolt size and bolt material, the required number of bolts can be determined from –

$$N = \frac{F}{f}$$

Where N is the number of bolts, F is the total required preload and f is the recommended preload (see Tables 21-26) on the bolt for the particular size and material selected.

## (4) Specify Tightening Torque.

Ensure that the bolts are fully tightened to the torque recommended in Tables 21-26 for the particular bolt size and material.

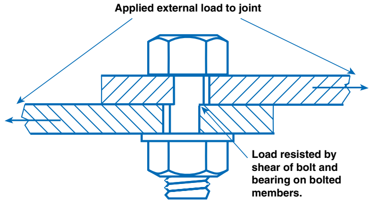
## (5) Positioning of the Bolts.

The bolts should be placed as near as possible to the line of direct tensile load. By doing this, secondary bending stresses in the bolts and bolted members are reduced to a minimum.

†**Note:** At time of publication there are no "Allowable Stress" code provisions for general mechanical engineering design of bolted joints. This information is provided for guidance only.

AJAX FASTENERS

# Design of Bolted Joints for General Engineering




TYPE 1

FIGURE 10

## Joints Carrying Loads in Shear

The design procedure for mechanical joints carrying this type of loading can be based on the well established practice laid down for structural joints carrying static loads, provided the design loads are increased by adequate factors to allow for cyclic loads, shock and other identifiable loads. These factors will vary considerably according to the application, and must be based on the designer's experience. Bolted joints carrying loads in shear fall into two types:–

1. Joints in which the load is transferred through the bolted members by bearing of the member on the shank of the bolt and shear in the bolt.
2. Friction type joints, where the load is transferred by the friction developed between the members by the clamping action of the bolts.

## Load Transfer by Bearing and Shear.

Such joints may be designed using allowable values for shear in the bolts and bearing on the joint members such as those given under the limit states provisions of AS4100. Guidance on bolt shear capacity is given on page 37-40. The lowest strength, whether it be in shear or bearing, is used to compute the required number of bolts to carry the design load.

The allowable values for shear and bearing depend not only on bolt size, but also on the tensile strength of the bolt, and whether the bolt is in a close fitting machined hole (not greater than 0.25mm clearance) or is fitted in a clearance hole (up to 2-3mm clearance).

Careful consideration should be given to the properties of the material in the bolted members to ensure they are capable of withstanding bearing loads. Tensile strength and yield stress of Ajax bolts can be obtained from Tables 5-14. Care must be taken that the pitch of the bolt spacing is sufficient to ensure that the bolted members are not weakened by the bolt holes to the extent that they cannot safely carry the load. To achieve this it may be necessary to use more than one row of bolts. Staggering of bolt holes can minimise reduction of member capacity. If more than two members are bolted together slightly higher values are permitted in bearing on the central member, and the area considered for calculating strength in shear is increased by two or four times for bolts in double or quadruple shear.

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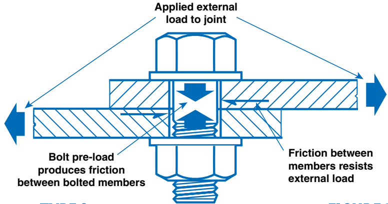
# Design of Bolted Joints for General Engineering




TYPE 2

FIGURE 11

## Friction Type Joints.

These joints are made up using high strength bolts fitted in clearance holes and tightened under careful control to develop a preload equivalent or greater than the bolt yield load.

The mechanism of carrying load is by friction developed between the mating faces, and it is well established that this type of joint is considerably stronger than a riveted joint. Refer to Australian Standard 4100.

## General Rules to Reduce Possibility of Bolt Failure Due to Fatigue

The following general rules should be observed to minimise possibility of fatigue failure of bolts under high alternating or fluctuating stresses.

### (1) Most Important.

Tighten bolt effectively to ensure an induced tension or preload in excess of the maximum external load.

(2) Bolt extension in tightening should be high. This can be achieved by:–

a) At least 1 x bolt diameter of "free" thread length under the nut.

b) Use of small high strength bolts in preference to larger low strength bolts.

c) In extreme cases a "waisted shank" bolt can be considered.

(3) Rolled threads are preferable to machined threads.

(4) Under conditions of extreme vibration the use of locknuts such as the Conelock or Nyloc nut should be considered to avoid possibility of a loosened nut vibrating right off the bolt before detection.

(5) Bolt head and nut should be on parallel surfaces to avoid bending.

(6) Non axial bolt loading producing a "prising" action should be avoided where possible.

## Flexible Gasket Joints for Sealing Liquids or Gases Under Pressure

This type of joint differs from the two preceding types in that the stress in the bolt varies with the working load. This is because the flexible gasket material has a much lower elastic modulus than the bolt, and continues to exert virtually the same force on the bolts when additional load is applied to the joint. The resulting effect is that the working load is added to the bolt preload in this case, so the design procedure must be modified accordingly.

AJAX FASTENERS

# Design of Bolted Joints for General Engineering

**(1) Design Pressure Load.** Determine the design load Q on the joint by multiplying the effective area A on which the pressure is acting by the liquid or gas pressure P by S where S is the safety factor selected from Table 17.

$Q = APS$

**(2) Total Preload Required.** To the design pressure load, Q add 10%, and this is the sum of the preload F that should be applied to the bolts comprising the joint.

$$F = Q + \frac{100}{10Q}$$

i.e. $F = 1.1Q$

**(3) Total Design Load on Bolts.** In the case of a flexible gasket type of joint the design pressure load Q on the joint is added to the preload F on the bolts, giving the total design load W on the bolts.

$W = Q + F$

**(4) Select Bolt Material.** From the following table of yield stresses select the bolt material.

**Table 18**

| Bolt Type | Proof Load Stress lbf/in$^2$ | Proof Load Stress MPa |
|---|---|---|
| Ajax AS 2451 Bolts — | | |
| 1/4" – 3/4" | 35,900 | 248 |
| Over 3/4" | 33,600 | 232 |
| Ajax Metric Commercial bolts | 32,630 | 225 |
| Ajax Metric Precision PC 8.8 bolts | 95,725 | 660 |
| Ajax SAE Grade 5 High Tensile Bolts — | | |
| 1/4" – 1" | 85,000 | 586 |
| Ajax SAE Grade 8 High Tensile Bolts | 120,000 | 827 |

**(5) Select Bolt Size and Determine Number of Bolts.** From the desired bolt size and the corresponding Stress Area "As". (see Tables 5-14) determine the number of bolts N from the yield stress Y and the total design load W on the bolts.

Number of bolts required $N = \frac{W}{YAs}$

Don't RISK it ! .. specify AJAX

# Design of Bolted Joints for General Engineering

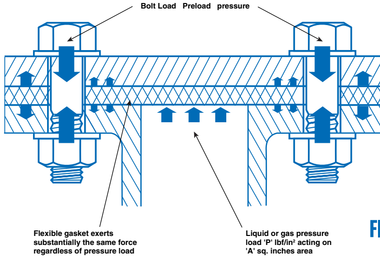



FIGURE 12

## (6) Setting of Tightening Torque.

In this case the bolts can only be tightened to a preload well below the yield stress so the torque figure T for the bolt size and material selected listed in Tables 21-26 must be reduced by multiplying by a factor of 0.806.

Tightening torque to be applied to bolts of a flexible gasket type of joint.

t = 0.8 T

## Metal to Metal Pressure Tight Joints

The stress in the bolts in a flexible gasket type joint varies with load, and under rapidly fluctuating loads they can be subject to fatigue. It is therefore desirable to use. Wherever possible, metal to metal pressure tight joints, as these are not subject to fatigue.

The design procedure for a metal to metal pressure tight joint is exactly the same as for joints carrying direct tensile loads once the pressure load is determined.

# Tightening of Bolted Joints

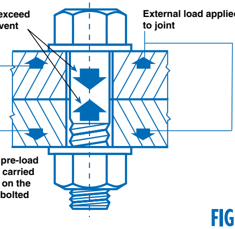



FIGURE 13

## How a Bolted Joint Carries Load

A bolted joint can carry loads in tension (Fig.13), in shear (Fig.14) or by a combination of these.
The static load capacity of the joint will be determined largely by the size, strength grade and number of bolts installed. The capacity of a bolted joint to maintain integrity indefinitely under dynamic loading is dependent on installing the bolts with sufficient tension to prevent relative movement of the joined members.

## Tension

The external load is resisted directly by bolt tension. If the joined members are rigid and the bolts are pre-tensioned, the mating faces will not separate until the externally applied load exceeds the total pre-load. This is because stress and strain are fundamentally related (the relationship constant is called Young's modulus in the range of elastic behaviour), so that the joint can't separate until the bolt length increases and the bolt length can't increase until the tension in it exceeds the pre-load (assuming service temperature below the creep range). This concept is valid when the joint members are stiffer (suffer less strain under a given force) than the bolt shank. It is true enough to be important even when the joint members and bolt are of the same material (e.g. steel), i.e., have the same modulus, because the area in compression between the bolt head and nut is much greater than the area of the bolt shank in tension and so compresses much less than the bolt extends at any given bolt tension. Thus cyclic external load is experienced more as a change in pressure at the joint face than a change of tension in the bolt and in a well designed joint, the stress range in the bolts will be below their fatigue endurance limit.

## Shear

The pre-load in the bolt(s) clamping the members together produces friction between them which resists the external load. The external force which this friction is capable of resisting without movement is proportional to the pre-load in the bolts and the coefficient of friction on the mating surfaces. When the frictional load transfer capacity is exceeded the ultimate capacity of the joint will be determined by shear on the fasteners and bearing on the joined members.

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# Tightening of Bolted Joints

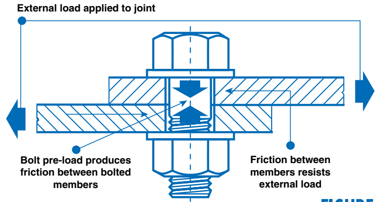



FIGURE 14

## Methods of Control of Bolt Tightening

Several methods are available for controlling the establishment of a desired level of pre-load in bolts with the cost rising with increasing accuracy more or less as indicated in Table 19. Each method has its applications and the choice should be made after an assessment of the particular requirements.

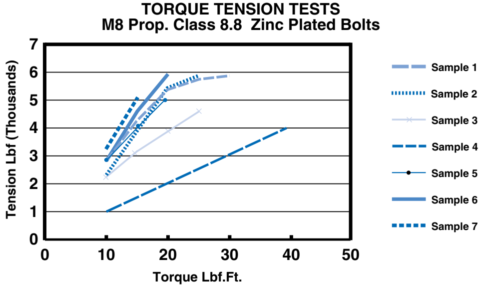
### (1) Torque

Although torque bears no fixed relationship to fastener tension, the use of torque wrenches is the most common method of pre-load control because of simplicity and relative economy. Many factors, including surface texture (cut or rolled threads), surface coatings/lubrication, thread interference and speed of tightening affect the torque-tension relationship and up to ± 25% variation in pre-load, has been measured on similar fasteners receiving identical torque. Closer control of torque/tension calibration for a particular lot can reduce variation to ± 15%. With manual torque wrenches, the torque may be preset from or read off a built-in scale. Power tools are more productive when large numbers of bolts are to be tightened and may be pneumatic, electric or hydraulic, but generally require tightening of sample bolts in a bolt load measuring device to set a pressure regulator or stall-torque for the desired bolt tension rather than

### Table 19

| Pre-load Measuring Method | % Accuracy | Relative Cost |
|---|---|---|
| Feel (Operators Judgement) | ± 35 | 1 |
| Torque Wrench | ± 25 | 1.1/2 |
| Turn-Of-The-Nut | ± 15 | 3 |
| Load Indicating Washers | ± 10 | 3.1/2 |
| Fastener Elongation | ± 3 – 5 | 15 |
| Strain Gauges | ± 1 | 20 |

# Tightening of Bolted Joints




First tightening of 6 assemblies.
As plated — no lubrication.
Sample 1 is theoretical from previously published data.

FIGURE 15

measuring torque directly. This requirement will give more accurate control of tension if setting is performed under job conditions with the bolts to be tightened.

## Torquing of Bolts and Nuts

The purpose of controlling the torque applied to a fastener assembly is to induce a desired level of tensile force in the bolt (equals clamping force on the joint). Unless limited by some characteristic of the joint (e.g., a soft gasket), the amount of tension aimed for in general engineering practice is 65-75% of the minimum elastic capacity (proof load) of the bolt. By selecting bolts such that this level of tension is not exceeded by service load on the joint, loosening of the nut should not be a problem in most applications. Nyloc or Conelock nuts are recommended for joints where such pre-tensioning is not applicable and as an added insurance against loss of the nut, should be the initial pre-tension be lost. The 65-75% of Proof Load level of pre-tension is sufficiently conservative to give reasonably reliable torque controlled tightening with indefinite reuseability of the assembly. For critical applications closer control or calibration checking is recommended. Because friction is the major unknown variable affecting the relationship between torque applied and tension induced, the presence of light oil lubrication is the minimum standard recommended for consistency in controlled tightening of fasteners. Most plain finish fasteners are supplied with a sufficient oil residue from their processing but plated finishes will generally require oiling or adjustment to the torque recommended in Ajax Fasteners' Technical Data. For bolts with special surface finishes or assembled with anti-seize compounds or heavily greased, the torque-induced pre-load relationship is likely to be altered and the recommendations to require modification.

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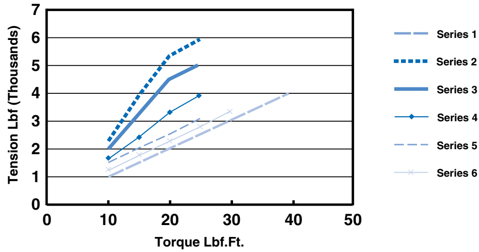
# Tightening of Bolted Joints

TORQUE TENSION TESTS
M8 Prop. Class 8.8 Zinc Plated Bolts




**Tightening 1 sample 5 times.**
**As plated — no lubrication.**
**Series 1 is theoretical from previously published data.**

FIGURE 16

## Table 20

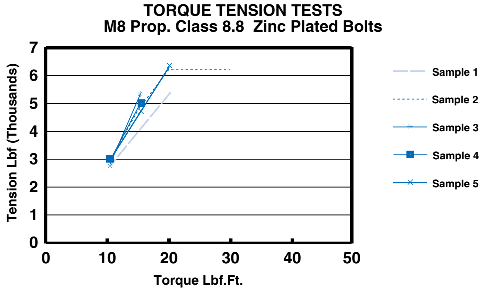
| Surface Condition | | Factor |
|---|---|---|
| Galvanised | — Degreased<br>— Lightly oiled | 2.1<br>1.1 |
| Zinc Plated | — Degreased | 0.7 |
| Cadmium Plated | — Degreased<br>— Lightly oiled | 1.0<br>0.7 |
| Phosphated & oiled | | 0.7 |
| Standard finish plus heavy grease | | 0.7 |

Such published general information can only ever be regarded as a guide and verification of applicability for a specific application is advisable both initially and over time, particularly if any parameters are known to have changed.

It should be remembered also that such guidance is based on first tightening of single assemblies in isolation and that interactions in multifastener joints may result in changes to initial tension such that a detailed tightening sequence may need to be developed and followed for satisfactory service of the joint.

As well as scatter in the torque-tension relationship for different assemblies from the same lot, retightening of the same bolt may give a different torque tension relationship. Both the scatter and shift on retightening are minimised by good lubrication of threads and bearing face.

In recent tests of bright zinc plated parts the tension at a given torque was found to progressively reduce by 50% over five tightenings of an unlubricated assembly while a well lubricated assembly showed no reduction over five retightenings and only a 9% over twelve retightenings. The results of these tests are shown in Figures 15-18.




1st Tightening, 4 samples, good lubrication.
Sample 1 is theoretical from previously published data.

**FIGURE 17**

Table 20 lists factors based on averages for the torque-induced pre-load relationship by which the tabulated figures should be multiplied to correct for the most common surface condition variations. For other surface treatments or for specialized bolt assemblies involving higher pre-load requirement or special lock nut, etc., it may be desirable to experimentally determine the torque-induced pre-load relationship. Attention is drawn to the fact that because static friction is greater than dynamic friction, the best accuracy and consistency of torque control tightening is obtained when rotation of the fastener is steadily maintained until the torque increases to the set level. Allowing for this effect becomes more important as the set torque is approached; another purchase should be taken early enough to avoid stall before rotation continues. Difficulty maintaining steady movement up to the set torque is a drawback of some hydraulic tools used for large diameter fasteners. The steady impacting of pneumatic tools gives better results.

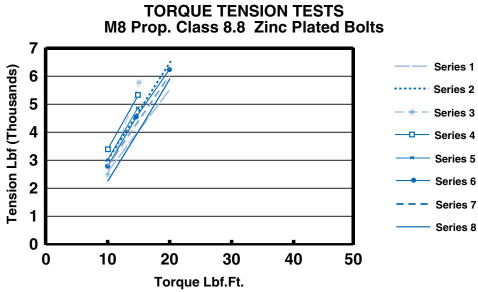
## (2) Strain Control

a) Part Turn Tightening: This method involves imparting a controlled strain or extension to the bolt by measuring relative rotation from the point where the joint members are solidly compacted. It is most widely used in tensioning bolts in structural steel work.

b) Direct Tension Indicators: These proprietary devices are also based on controlled strain, but make use of design features in a bolt head, nut or washer to make the strain visible and measurable as a permanent witness of proper bolt tensioning.

c) Measurement of Bolt Extension: This is a time consuming but very accurate method. Bolt Length may be measured before and after tightening, with a micrometer in some joint configurations or by an electronic "sonar" type device from one end. Greatest accuracy is achieved when the strain value is obtained from the load extension curve of the fastener being used, but calculation based on Hooke's

# Tightening of Bolted Joints




Tightening 1 sample 7 times, good lubrication.
Series 1 is theoretical from previously published data.

FIGURE 18

Law gives good correlation when allowance is made for the respective lengths and cross-sectional areas of the plain and threaded portions of the bolt shank effectively in the grip.

d) Pre-Assembly Straining: The most common development of this method is the snug tightening of a normal nut on a bolt which has been heated to produce a calculated degree of thermal expansion. A hollow bolt with a hydraulically actuated internal loading ram is available which makes removal as easy as installation.

e) Strain Gauges: These are usually applied to the bolt shank and calibrated in a load measuring machine.

## (3) Combination Methods

Electronic sensors and microprocessors have been developed which simultaneously measure torque and/or angular rotation and/or instantaneous rate of change in these characteristics. Hand-held models are available with capacity for the size range common in automotive application but the methods are essentially confined to high volume application such as the simultaneous tightening of automotive engine head “bolts” (really cap screws.) Their accuracy allows designs for bolts tensioned to their actual yield point and the implementation of this method has resulted in re-design with higher strength of standard metric nuts so that they are unlikely to strip on bolts so tightened.

## (4) Direct Tensioning

In the most economic development of this method, tension applied by a calibrated hydraulic jack attached to an extension of the bolt or stud thread is transferred to a normal nut after it is snugged up to the joint. The relaxation of tension due to bedding in and deflection of the mating threads is consistent for given assembly types and can be allowed for to maintain accuracy of the desired residual tension. This may be the most practicable method for bolts over M36/1.1/2” diameter and is particularly suitable for sealing of high pressure gasketed joints because manifolding of jacks enables simultaneous, uniform tensioning of many bolts.

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# Tightening of Bolted Joints

**Table 21** Recommended Assembly Torques

| Bolt Type | Diameter mm | Bolt Tension Corresponding to 65% of Proof Load kN | lbf | Recommended Assembly Torque Nm | lbft |
|---|---|---|---|---|---|
| AS 1111 Ajax Property Class 4.6 Commercial Low Tensile Bolts | 5 | 2.08 | 468 | 2.1 | 1.5 |
| | 6 | 2.94 | 660 | 3.5 | 2.5 |
| | 8 | 5.34 | 1200 | 8.5 | 6.3 |
| | 10 | 8.45 | 1900 | 17 | 12 |
| | 12 | 12.4 | 2790 | 30 | 22 |
| | 14 | 16.8 | 3780 | 47 | 35 |
| | 16 | 22.9 | 5150 | 73 | 54 |
| | 18 | 28.1 | 6320 | 101 | 75 |
| | 20 | 35.8 | 8050 | 143 | 106 |
| | 22 | 44.3 | 9960 | 195 | 145 |
| | 24 | 51.6 | 11600 | 248 | 183 |
| | 27 | 67.0 | 15060 | 362 | 265 |
| | 30 | 81.9 | 18410 | 491 | 362 |
| | 33 | 101 | 22800 | 669 | 495 |
| | 36 | 120 | 26980 | 864 | 637 |
| | 39 | 143 | 32150 | 1115 | 820 |
| | 42 | 164 | 36870 | 1378 | 1020 |

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# Tightening of Bolted Joints

**Table 21** Recommended Assembly Torques continued

| Bolt Type | Diameter mm | Bolt Tension Corresponding to 65% of Proof Load kN | lbf | Recommended Assembly Torque Nm | lbft |
|---|---|---|---|---|---|
| AS 1111 Ajax Property Class 4.6 Commercial Low Tensile Bolts | 48 | 215 | 48330 | 2064 | 1520 |
| | 56 | 298 | 66990 | 3338 | 2460 |
| | 64 | 393 | 88350 | 5030 | 3710 |

The Ajax Fasteners stocked range of bolts extends only to M24 diameter. Other sizes are given for information only. The Nut stock range does extend to M64 and includes the non-preferred sizes M27, M33 and M39.
The torques listed are for plain finish (uncoated) fasteners as supplied. Refer to page 50 and table 20 for effects of various finishes.

# Tightening of Bolted Joints

**Table 22** Recommended Assembly Torques

| Bolt Type | Diameter and Thread | Induced Bolt Preload or Tension Corresponding to 65% of Yield Load lbf | Recommended Assembly Torque to Give Induced Preload Equal to 65% of Yield Load lbft |
|---|---|---|---|
| AS 2451 Ajax BSW Low Tensile Bolts (Formerly AS B100) | 1/4 BSW | 750 | 3 |
| | 5/16 BSW | 1230 | 6 |
| | 3/8 BSW | 1820 | 12 |
| | 7/16 BSW | 2480 | 19 |
| | 1/2 BSW | 3250 | 28 |
| | 5/8 BSW | 5300 | 55 |
| | 3/4 BSW | 7830 | 98 |
| | 7/8 BSW | 10200 | 150 |
| | 1 BSW | 13300 | 230 |
| | 1.1/8 BSW | 16700 | 320 |
| | 1.1/4 BSW | 21500 | 450 |
| | 1.1/2 BSW | 30800 | 780 |

The torques listed are for plain finish (uncoated) fasteners as supplied. Refer to page 50 and table 20 for effects of various finishes.

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# Tightening of Bolted Joints

**Table 23** Recommended Assembly Torques

| Bolt Type | Diameter and Thread | | Induced Bolt Preload or Tension Corresponding to 65% of Yield Load lbf | Recommended Assembly Torque to Give Induced Preload Equal to 65% of Yield Load lbft |
|---|---|---|---|---|
| AS 2465 Ajax Grade 5 Unified High Tensile Bolts (Same as SAE J429 Grade 5). | 1/4 | UNF | 2020 | 8 |
| | 5/16 | UNF | 3190 | 17 |
| | 3/8 | UNF | 4840 | 30 |
| | 7/16 | UNF | 6570 | 48 |
| | 1/2 | UNF | 8840 | 74 |
| | 5/8 | UNF | 14170 | 150 |
| | 3/4 | UNF | 20610 | 260 |
| | 7/8 | UNF | 28150 | 410 |
| | 1 | UNF | 36660 | 610 |
| | 1/4 | UNC | 1760 | 7 |
| | 5/16 | UNC | 2890 | 15 |
| | 3/8 | UNC | 4290 | 27 |
| | 7/16 | UNC | 5880 | 43 |
| | 1/2 | UNC | 7870 | 66 |
| | 5/8 | UNC | 12480 | 130 |
| | 3/4 | UNC | 18400 | 230 |
| | 7/8 | UNC | 25550 | 370 |
| | 1 | UNC | 33480 | 560 |

The torques listed are for plain finish (uncoated) fasteners as supplied. Refer to page 50 and table 20 for effects of various finishes.

AJAX FASTENERS

# Tightening of Bolted Joints

**Table 24** Recommended Assembly Torques

| Bolt Type | Diameter and Thread | | Induced Bolt Preload or Tension Corresponding to 65% of Yield Load lbf | Recommended Assembly Torque to Give Induced Preload Equal to 65% of Yield Load lbft |
|---|---|---|---|---|
| AS 2465 Ajax Grade 8 Unified High Tensile Bolts (Same as SAE J429 Grade 8) | 1/4 | UNF | 2830 | 12 |
| | 5/16 | UNF | 4520 | 23 |
| | 3/8 | UNF | 6830 | 43 |
| | 7/16 | UNF | 9230 | 67 |
| | 1/2 | UNF | 12500 | 104 |
| | 5/8 | UNF | 19960 | 207 |
| | 3/4 | UNF | 29120 | 363 |
| | 7/8 | UNF | 39720 | 577 |
| | 1 | UNF | 51740 | 859 |
| | 1/4 | UNC | 2470 | 10 |
| | 5/16 | UNC | 4100 | 21 |
| | 3/8 | UNC | 6050 | 38 |
| | 7/16 | UNC | 8320 | 60 |
| | 1/2 | UNC | 11050 | 92 |
| | 5/8 | UNC | 17620 | 183 |
| | 3/4 | UNC | 26070 | 325 |
| | 7/8 | UNC | 36010 | 523 |
| | 1 | UNC | 47200 | 785 |

The torques listed are for plain finish (uncoated) fasteners as supplied. Refer to page 50 and table 20 for effects of various finishes.

# Tightening of Bolted Joints

**Table 25** Recommended Assembly Torques

| Bolt Type | Diameter mm | Bolt Tension Corresponding to 65% of Yield Load kN | lbf | Recommended Assembly Torque Nm | lbft |
|---|---|---|---|---|---|
| AS 1110 Ajax Property Class 8.8 Precision High Tensile Bolts ISO Coarse Series Threads | 5 | 5.4 | 1210 | 5 | 4 |
| | 6 | 7.6 | 1710 | 9 | 7 |
| | 8 | 13.8 | 3100 | 22 | 16 |
| | 10 | 21.9 | 4920 | 44 | 32 |
| | 12 | 31.8 | 7150 | 77 | 57 |
| | 14 | 43.4 | 9680 | 121 | 90 |
| | 16 | 59.2 | 13310 | 190 | 140 |
| | 18 | 74.8 | 16690 | 269 | 198 |
| | 20 | 95.6 | 21490 | 370 | 270 |
| | 22 | 118 | 26390 | 520 | 380 |
| | 24 | 138 | 31020 | 640 | 470 |
| | 27 | 177 | 39480 | 955 | 700 |
| | 30 | 219 | 49230 | 1310 | 970 |
| | 33 | 270 | 60330 | 1785 | 1320 |
| | 36 | 319 | 71710 | 2300 | 1690 |
| | (39) | 380 | 84980 | 2970 | 2190 |
| | (42) | 437 | 98240 | 3670 | 2710 |

The torques listed are for plain finish (uncoated) fasteners as supplied. Refer to page 50 and table 20 for effects of various finishes.

# Tightening of Bolted Joints

**Table 25** Recommended Assembly Torques continued

| Bolt Type | Diameter mm | Bolt Tension Corresponding to 65% of Yield Load kN | lbf | Recommended Assembly Torque Nm | lbft |
|---|---|---|---|---|---|
| AS 1110 Ajax Property Class 8.8 Precision High Tensile Bolts | (48) | 573 | 128820 | 5500 | 4060 |
| | (56) | 792 | 178050 | 8870 | 6540 |
| | (64) | 1045 | 234930 | 13380 | 9870 |

( ) Sizes not covered in standard.
Data for sizes above this is given for information only.
The torques listed are for plain finish (uncoated) fasteners as supplied. Refer to page 50 and table 20 for effects of various finishes.

# Tightening of Bolted Joints

**Table 26** Recommended Assembly Torques

| Bolt Type | Diameter mm | Bolt Tension Corresponding to 65% of Yield Load kN | lbf | Recommended Assembly Torque Nm | lbft |
|---|---|---|---|---|---|
| AS 1110 Ajax Property Class 10.9 Precision High Tensile Bolts | 5 | 7.67 | 1720 | 8 | 6 |
| | 6 | 10.86 | 2440 | 13 | 10 |
| | 8 | 19.76 | 4440 | 32 | 12 |
| | 10 | 31.27 | 7030 | 63 | 46 |
| | 12 | 45.50 | 10230 | 109 | 81 |
| | 14 | 62.00 | 13960 | 175 | 130 |
| | 16 | 84.50 | 19000 | 270 | 200 |
| | 18 | 103.00 | 23160 | 370 | 275 |
| | 20 | 131.95 | 36900 | 528 | 390 |
| | 22 | 164.00 | 42820 | 720 | 530 |
| | 24 | 190.45 | 55750 | 915 | 675 |
| | 27 | 248.00 | 68100 | 1340 | 990 |
| | 30 | 302.90 | 83410 | 1820 | 1340 |
| | 33 | 371.00 | 99070 | 2450 | 1810 |
| | 36 | 440.70 | 99070 | 3170 | 2340 |
| | 39 | 527.00 | 118470 | 4110 | 3030 |

The torques listed are for plain finish (uncoated) fasteners as supplied. Refer to page 50 and table 20 for effects of various finishes.

# Tightening of Structural Joints

Bolting Categories 8.8TF/8.8TB

**The design, fabrication, assembly and inspection of steel structures using metric high strength structural bolts and nuts to AS1252 are covered in AS4100 – SAA Steel Structures Code which should be referred to for more detailed information.**

The requirements for bolting Categories 8.8TF/8.8TB are in essence the same as those previously given in AS1511 – 1984. The SAA High Strength Structural Bolting Code which was withdrawn on 26/10/91.

***There is no 'tightening torque' for AS1252 structural bolts. Only tensioning methods permitted by AS4100 should be used.***

The following are abstracts from AS4100.

## (1) Assembly

Each bolt and nut shall be assembled with at least one washer and where only one washer is used it shall be placed under the rotating component. Tightening of the bolts shall proceed from the stiffest part of the joint toward the free edges.

Under no circumstances shall bolts which have been fully tightened be reused in another joint or structure. They may be retightened once in the same hole. Galvanized bolts may not be retightened under any circumstances.

## (2) Methods of Tightening

Tightening methods permitted can be either "part turn method" or use of "direct tension indicators" (Coronet Load Indicators).

a) Part Turn Tightening Method

On assembly all bolts and nuts in the joint are first tightened to a snug tight condition. Snug tight is defined as the tightness attained by the full effort of a man using a standard podger spanner or by a few impacts of an impact wrench. Location marks are then established to mark the relative position of the bolt and nut. The bolts are then finally tightened by the amount shown in Table 27.

b) Direct Tension Indicators

Tightening of bolts and nuts shall be in accordance with the manufacturer's instructions and the following procedure. On assembly all bolts and nuts in the joint are first tightened to the snug tight condition. Then the bolt and nut are tightened to provide the minimum tension specified in Table 28.

b.1) This method of tightening can be carried out with Coronet Load Indicators. Refer page 84.

# Tightening of Structural Joints

Bolting Categories 8.8TF/8.8TB

**Table 27** AS4100 – 1990 Nut Rotation from the Snug-Tight condition.

| Bolt length (underside of head to end of bolt) | Disposition of outer face of bolted parts (See notes 1, 2 ,3 4) | | |
|---|---|---|---|
| | Both Faces normal to axis | One Face normal to bolt axis and other sloped | Both Faces sloped |
| Up to and including 4 diameters | 1/3 turn | 1/2 turn | 2/3 turn |
| Over 4 diameters but not exceeding 8 diameters | 1/2 turn | 2/3 turn | 5/6 turn |
| Over 8 diameters but not exceeding 12 diameters (see note 5) | 2/3 turn | 5/6 turn | 1 turn |

## NOTES

1. Tolerance on rotation: for 1/2 turn or less, one twelfth of a turn (30°) over and nil under tolerance; for 2/3 turn or more, one eighth of a turn (45°) over and nil under tolerance.
2. The bolt tension achieved with the amount of nut rotation specified in Table 27 will be at least equal to the minimum bolt tension specified in Table 28.
3. Nut rotation is the rotation relative to the bolt, regardless of the component turned.
4. Nut rotations specified are only applicable to connections in which all material within the grip of the bolt is steel.
5. No research has been performed to establish the turn-of-nut procedure for bolt lengths exceeding 12 diameters. Therefore, the required rotation should be determined by actual test in a suitable tension measuring device which simulates conditions of solidly fitted steel.

# Tightening of Structural Joints



b.2) AS4100 requires that the suitability of the device shall be demonstrated by testing at least three specimens for each diameter and grade in a calibration device capable of indicating bolt tension and proving that the device indicates a tension at least 105% of the specified minimum.

### (3) Inspection

Bolts and nuts that show on visual inspection any evidence of physical defects shall be removed and replaced by new ones. The following methods shall be used to check that all bolts are fully tightened. For “part turn” tightening, by ensuring that the correct part turn from the snug tight position can be measured or observed. For “direct tension indicator” tightening, by ensuring that the manufacturer’s specified tightening procedure has been followed and that the development of the minimum bolt tension is indicated by the tension indicating device.

a) Direct Tension Indicators

Inspect according to the manufacturer’s recommendations. In the event that Ajax Fasteners Coronet Load Indicators have been used, these recommendations are set out on page 84.

### (4) Inspection of Bolt Tension using a Torque Wrench

a) In the event that the specified procedure for part-turn tightening ie. method verification and application of match marking for later inspection, was not followed and direct tension indicators were not installed some method for subsequent checking of bolt tension is sometimes required by the inspection engineer.

Note that tightening by torque control was found to be unreliable in practice not least because few erectors purchased the equipment necessary to perform the procedure for calibration of the bolts/wrench combinations which are to be used in the structure, and was deleted from the SAA High Strength Bolting Code. Logically, it is also not reliable for inspection of the correct tension in bolts either.

The procedure given in the following is suitable for detecting gross under-tension, eg. bolts which have been “snugged” only, but cannot be relied upon to distinguish bolts which although tightened well beyond snug may not have been fully tensioned.

# Tightening of Structural Joints

Bolting Categories 8.8TF/8.8TB

**NOTE:**

The principal factors which limit the reliability of the method are:–

a) the equivalence of thread and bearing face surface condition and lubrication of the calibration samples and job bolts.

b) the occurrence of galling during tightening.

c) the time lapse between tensioning and inspection especially as regards corrosion which may have occurred.

It is emphasised that correct tensioning can only be assured by –

1. Using the correct bolts and nuts (Ajax AS 1252 High Strength Structural)
2. Verifying proper snugging of all bolts in the joint. (This should be the time of first inspection – joint should be solid)
3. Applying match marks – desirably permanent, or verifying about 1-2mm gap at Coronet load indicator. The load indicator inherently provides a permanent witness of correct tensioning.
4. Witnessing that the tooling available can easily achieve the required part-turn or crush the load indicator to the specified average gap.

## Bolt Tension Information for setting Inspection Wrenches

(4.1) Calibration

Inspection Wrench. The inspection wrench may be either a hand-operated or adjustable power-operated wrench. It should be calibrated at least once per shift or more frequently if the need to closely simulate the conditions of the bolts in the structure so demands.

The torque value determined during the calibration may not be transferred to another wrench.

### Table 28
### Bolt Tension Information for setting inspection wrenches

| Nominal bolt diameter | Bolt Tension | | |
|---|---|---|---|
| | Minimum | | |
| | kN | Kips | ton f |
| M16 | 95 | 21.3 | 9.5 |
| M20 | 145 | 32.6 | 14.55 |
| M24 | 210 | 48.6 | 21.07 |
| M30 | 335 | 77.1 | 33.62 |
| M36 | 490 | 112.9 | 49.17 |

# Tightening of Structural Joints

Bolting Categories 8.8TF/8.8TB

***The point being that there is no "inspection torque" for each size of bolt!***

***Each lot of bolts and each tool to be deployed must be individually calibrated at the time of tightening/inspection.***

Adequate inspection with a torque wrench is virtually impossible because it is practically impossible to obtain samples for the calibration procedure which truly represent the bolts to be inspected. This is illustrated by Fig.19. which shows the torque-tension calibration of three M24 galvanised bolt assemblies submitted from a site by a party required to apply torque-wrench inspection.

**Samples.** At least three bolts, desirably of the same size (minimum length may have to be selected to suit the calibration device) and condition as those under inspection should be placed individually in a calibration device capable of indicating bolt tension.

**IMPORTANT: Without this calibrating device torque wrench inspection to the code is not possible!**

A hardened washer should be placed under the part turned.

Each calibration specimen should be tensioned in the calibrating device by any convenient means to the minimum tension shown for that diameter in Table 28 The inspection wrench then should be applied to the tensioned bolt and the torque necessary to turn the nut or bolt head 5 degrees (approximately 25mm at 300mm radius) in the tensioning direction should be determined. The average torque measured in the tests of at least three bolts should be taken as the job inspection torque.

## (4.2) Inspection

Bolts represented by the sample prescribed in Paragraph B2 (AS 4100) which have been tensioned in the structure should be inspected by applying, in the tensioning direction, the inspection wrench and its job inspection torque to such proportion of the bolts in the structure as the supervising engineer prescribes.

**NOTE:** For guidance it is suggested that a suitable sample size would be 10 per cent of the bolts but not less than two bolts in each connection are to be inspected.

# Tightening of Structural Joints

Bolting Categories 8.8TF/8.8TB

### (4.3) Action

Where no nut or bolt is turned by the job inspection torque, the connection should be accepted as properly tensioned. Where any nut or bolt head is turned by the application of the job-inspection torque this torque should then be applied to all other bolts in the connection and all bolts whose nut or head is turned by the job inspection torque should be tensioned and reinspected. Alternatively, the fabricator or erector at his option, may retension all of the bolts in the connection and then resubmit the connection for inspection.

# Tightening of Structural Joints

Bolting Categories 8.8TF/8.8TB

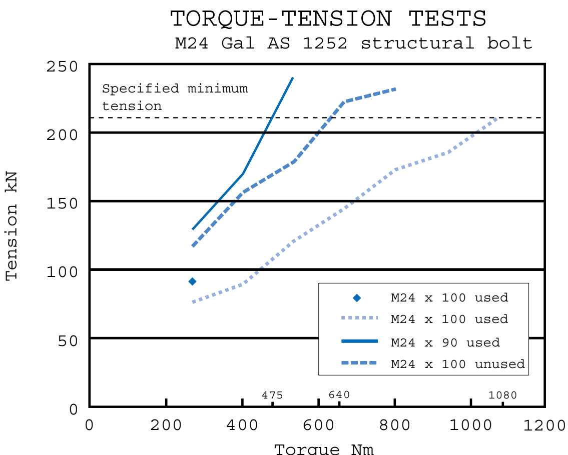


**Figure 19**

This data, established on specimans returned from a site where inspection was required by the responsible Engineer, illustrates the difficulty of applying torque inspection to establish the correct tensioning of Bolting Categories 8.8 TF/8.8TB connections.

The plotted points show tension against the more consistant dynamic friction (nut in motion) torque rather than the torque to overcome static friction of a stationary nut as in the procedure in the Australian Structural Steel Code. Either way the calibration torque is determined on freshly tensioned assemblies which may or may not be what is to be inspected.

The first point for the M24 x 100 removed from the structure is plotted twice as the wrench ran out of travel before reaching the 270 Nm set point the first time.

# Structural Design Using Ajax Bolts

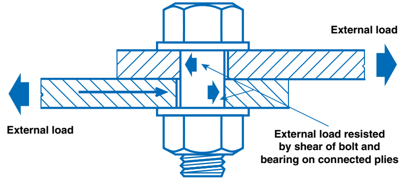


FIGURE 20

***Acknowledgement: The following summary of design procedures to AS 4100-1990 is by Arun Syam and Arthur Firkins of AISC – Technical Services.***

The two basic types of metric bolt used in structural engineering in Australia are:

- **commercial bolts to AS 1111 (Property Class 4.6)**
- **high strength structural bolts to AS 1252 (Property Class 8.8)**

The design provisions for structural bolts are contained in Australian Standard 4100-1990: Steel Structures. This standard, in limit states design format, superseded AS 1250-1981 which was in a working stress format. AS 4100-1990 also incorporates the design and installation clauses of high strength bolts from AS 1511-1984: High Strength Bolting Code – which it also superseded.

## Australian Material Standards

The relevant material standards referenced by AS 4100-1990 are the current editions of:

| | |
|---|---|
| AS 1110 | ISO metric hexagon precision bolts and screws |
| AS 1111 | ISO metric hexagon commercial bolts and screws |
| AS 1112 | ISO metric hexagon nuts, including thin nuts, slotted nuts and castle nuts. |
| AS 1252 | High strength steel bolts with associated nuts and washers for structural engineering. |
| AS 1275 | Metric screw threads for fasteners. |
| AS 1559 | Fasteners – Bolts, nuts and washers for tower construction. |

## References

Further design guidance is available in the following publications by the

**Australian Institute of Steel Construction (AISC):**


[1] Design Capacity Tables for Structural Steel, 1st Edition, 1991.

[2] Bolting of Steel Structures, 3rd Edition, 1991.

[3] Design of Structural Connections, 4th Edition, 1991.

[4] Economical Structural Steelwork, 3rd Edition, 1991.

# Structural Design Using Ajax Bolts

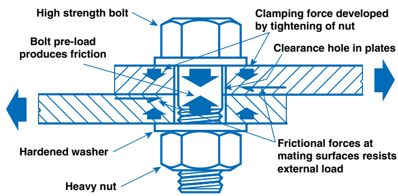


**FIGURE 21**

## Bolting Categories

The strength of bolts is normally specified in terms of the tensile strength of the threaded fastener. As a consequence, grades of bolts are identified in the following manner:

### Property Class X.Y

(eg Property Class 4.6 or Property Class 8.8) where

X – is one hundredth of the nominal tensile strength (MPa)

Y – is one tenth of the ratio between nominal yield stress and nominal tensile strength expressed as a percentage

A standard bolting category identification system has been adopted in AS 4100-1990. These are:

- snug tightened (applies to commercial and high strength structural bolts) – designated **4.6/S** and **8.8/S** respectively;
- fully tensioned friction type (high strength structural bolts only) – designated **8.8/TF**;
- fully tensioned, bearing type (high strength structural bolts only) – designated **8.8/TB**;

*The system of category designation identifies the bolt being used by using its strength grade designation (4.6 or 8.8) and identifies the installation procedure by a supplementary letter (S – snug; T – full tensioning). For 8.8/T categories, the type of joint is identified by a additional letter (F – friction-type joint; B – bearing-type joint).*

Category **4.6/S** refers to commercial bolts of Property Class 4.6 conforming to AS 1111, tightened using a standard wrench to a 'snug-tight' condition.

AS 4100-1990 describes 'snug-tight' as "the tightness attained by a few impacts of an impact wrench or by the full effort of a person using a standard podger spanner". The aim of this installation is to achieve a level of tightness so that all plies in a joint are in full contact. It is a final mode of bolt tightening for 4.6/S and 8.8/S bolting categories, and the first step in full tensioning to 8.8/TF and 8.8/TB bolting categories – see page 70.

Category **8.8/S** refers to any bolt of Property Class 8.8 tightened to a 'snug-tight' condition as described above. These bolts are used as a higher grade bolt replacing a commercial bolt to increase the capacity of certain connection types.

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# Structural Design Using Ajax Bolts

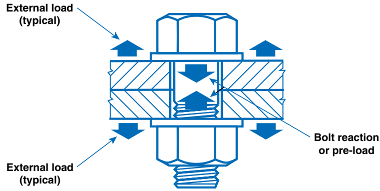


**FIGURE 22**

Categories **8.8/TF** and **8.8/TB** (or **8.8/T** when referring to both types) refer specifically to high strength structural bolts of Property Class 8.8 conforming to AS 1252 fully tensioned in a controlled manner to the requirements of AS 4100-1990. The benefit of this bolting category is the increase in performance of the bolted joint in the serviceability limit state (ie limited joint slip), though for a penalty of installed cost – see Refs [2] and [4] abovementioned. It is recommended that 8.8/TF category be used only in rigid joints were a no-slip joint is essential.

See Table 29 for a summary of the above types and bolting categories.

## Modes of Force Transfer

In the design of individual bolts in bolted structural connections, there are three fundamental modes of force transfer to be considered. These are:

a) **Shear/bearing mode** where the forces are perpendicular to the bolt axis and are transferred by shear and bearing on the bolt and bearing on the connected plies (see Fig-20). Relevant bolting categories are 4.6/S, 8.8/S and 8.8/TB;

b) **Friction mode,** which is similar to the shear/bearing mode in that forces to be transferred are perpendicular to the bolt axis. However, the transfer of forces does not rely on shear and bearing but is dependant upon the frictional resistance of the mating surfaces (see Fig-21). The relevant bolting category is 8.8/TF;

c) **Axial tension mode,** when the forces to be transferred are parallel to the bolt axis (see Fig-22). All bolting categories may apply to this.

These modes of force transfer may occur independently or with one another.

## Minimum Design Actions on Bolted Connections to AS 4100-1990

Minimum design actions on connections must be considered and these are set out in Clause 9.1.4 of AS 4100-1990. Also, bolts which are required to carry a design tensile force must be proportioned to resist any additional tensile force due to prying action.

AJAX FASTENERS

# Structural Design Using Ajax Bolts

## Design Procedure to AS 4100-1990

AS4100-1990 uses the limit states design method in the design, fabrication, erection and modification of steelwork in structures. For a description of 'limit states' reference should be made to Ref [1] above. In limit states design the following fundamental inequality must be satisfied:

$$S^* \leq \phi R_u$$

where

- $S^*$ = design action effect (ie design shear load and/or design tension load) on the bolt
- $R_u$ = nominal capacity of the bolt
- $\phi$ = capacity factor (from Table 28, 29 of AS 4100)

This inequality states the **design action effect ($S^*$)** must be less than or equal to the **design capacity of the bolt ($\phi R_u$)** for the design action considered. The nominal capacity of the bolt is given in AS 4100-1990. It should be noted that the **design action effect ($S^*$)** is calculated from an acceptable form of analysis using the *factored* limit state load as set out in AS 1170-1989: Minimum Design Loads on Structures (known as the SAA Loading Code).

In bolting design there are three limit states that have to be considered.

They are:

i) strength limit state;
ii) serviceability limit state;
iii) fatigue limit state

### Strength Limit State

In AS 4100-1990 the strength limit state design provisions which apply for static load applications are found in Clause 9.3.2. This applies for all the commonly used bolting categories of 4.6/S, 8.8/S, 8.8/TB and 8.8/TF.

### Bolt in shear – strength limit state

The following inequality must be satisfied for a bolt subjected to a design shear force ($V_f^*$) for strength limit state:

$$V_f^* \leq \phi V_f$$

where

- $\phi$ = 0.8 (Table 3.4 of AS 4100-1990)
- $V_f$ = nominal shear capacity of a bolt

Shear strengths obtained from research have shown that, for bolts in shear, the average shear strength of the bolt was 62% of the tensile strength ($f_{uf}$). The shear strength of a bolt is directly proportional to the shear area available, this being the core area ($A_c$) when considering the threaded part of the bolt or the shank area ($A_o$) when considering the unthreaded part. Therefore, in AS 4100-1990 the

AJAX FASTENERS

# Structural Design Using Ajax Bolts

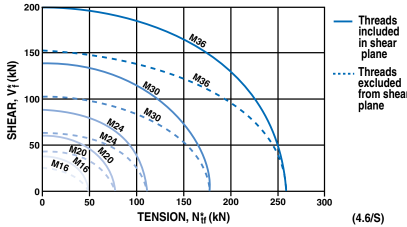


**FIGURE 23**

nominal shear capacity of a bolt ($V_f$) is given by:

$$V_f = 0.62 f_{uf} k_r (n_n A_c + n_x A_o)$$

where

$f_{uf}$ = minimum tensile strength of the bolt (see Table 29)

$k_r$ = reduction factor to account for the length of a bolted lap connection – $L_j$ (see Table 32). For all other, $k_r$=1.0

$n_n$ = number of shear planes with threads intercepting the shear plane

$A_c$ = minor (core) diameter area of the bolt as defined in AS 1275

$n_x$ = number of shear planes without threads intercepting the shear plane

$A_o$ = nominal plain shank area of the bolt

See Table 30 (Property Class 4.6) and Table 31 (Property Class 8.8) for listings of bolt design shear capacity – strength limit state ($\phi V_{fn}$ and $\phi V_{fx}$) – for the commonly used structural bolts.

**Note:** In Tables 30 and 31 –

$\phi V_{fn} = \phi 0.62 f_{uf} A_c$ for threads included in **single** shear plane, and $\phi V_{fx} = \phi 0.62 f_{uf} A_o$ for threads excluded from **single** shear plane.

## Bolt in tension – strength limit state

The following inequality must be satisfied for a bolt subjected to a design tension force ($N_{tf}^*$) for strength limit state:

$$N_{tf}^* \leq \phi N_{tf}$$

where

$\phi$ = 0.8 (Table 3.4 of AS 4100-1990)

$N_{tf}$ = nominal tension capacity of a bolt = $A_s f_{uf}$

and

$A_s$ = tensile stress area of a bolt as specified in AS 1275

$f_{uf}$ = minimum tensile strength of the bolt (see Table 29)

See Table 28 (Property Class 4.6) and Table 29 (Property Class 8.8) for the listings of bolt design tension capacity – strength limit state ($\phi N_{tf}$) – for the commonly used structural bolts.

Bolts that are fully tensioned have, for design purposes, no reduction in nominal tension capacity (see Ref [2] above).

## Bolt subject to combined shear and tension – strength limit state

For bolts subject to simultaneous shear and tension forces, tests have shown that the following elliptical interaction relationship applies:

$$(V_f^* / \phi V_f)^2 + (N_{tf}^* / \phi N_{tf})^2 \leq 1.0$$

where $V_f^*$, $V_f$, $N_{tf}^*$, $N_{tf}$ and $\phi$ are described above.

AJAX FASTENERS

# Structural Design Using Ajax Bolts

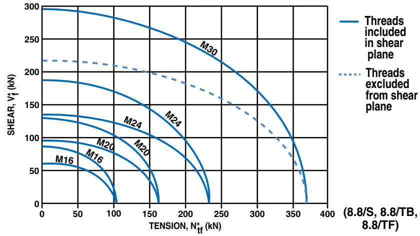


FIGURE 24

See Fig-23 (Property Class 4.6) and Fig-24 (Property Class 8.8) for a plot of the shear-tension interaction relationship – strength limit state – for the commonly used structural bolts.

## Ply in bearing – strength limit state

Design provisions for a ply loaded by a bolt in bearing are found in Clause 9.3.2.4 of AS 4100-1990. This considers that for a ply subject to a design bearing force ($V_b^*$) due to a bolt in shear, the following must be satisfied:

$$V_b^* \le \phi V_b$$

where

$\phi$ = 0.9 (Table 3.4 of AS 4100-1990)

$V_b$ = nominal bearing capacity of a ply

$V_b$ is calculated from the *lesser* of:

$V_b$ = design bearing capacity due to ply local bearing failure

= $3.2 d_f t_p f_{up}$

and

$V_b$ = design bearing capacity due to plate tearout

= $a_e t_p f_{up}$

where

$d_f$ = diameter of the bolt

$t_p$ = thickness of the ply

$f_{up}$ = tensile strength of the ply

$a_e$ = minimum distance from the edge of a hole to the edge of a ply, measured in the direction of the component of a force, plus half the bolt diameter. The edge of a ply can include the edge of an adjacent bolt hole.

For Property Class 4.6 bolting category, for all reasonable combinations of ply thickness, bolt diameter and end distance, the design capacity for a ply in bearing($\phi V_b$) exceeds both cases of threads included in and excluded from the shear plane (i.e. $\phi V_f$ as described above for the bolt in shear – strength limit state).

For the 8.8/S, and 8.8/TB and 8.8/TF bolting categories see Table 29 for listings of $\phi V_b$ for plate tearout and ply local bearing failure. For further details see Ref [1], [2] and [3] above.

## Assessment of the Strength of a Bolt Group

Depending on whether loading is in-plane, out-of-plane and also if a couple, shear or both act on the bolt group, Clause 9.4 of AS 4100-1990 should be consulted for the design actions on individual or critically loaded bolts.

## Serviceability Limit State

The use of a bolted connection which does not slip or has limited slip under **serviceability** loads may be advisable under certain conditions. This type of

AJAX FASTENERS

# Structural Design Using Ajax Bolts

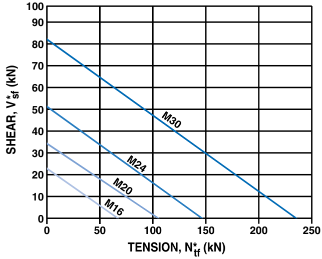


FIGURE 25

connection is known as a friction-type joint and is identified as 8.8/TF bolting category. In AS 4100-1990 the serviceability limit state design provisions are found in Clause 9.3.3. The strength limit state, as mentioned above, should be assessed separately.

## Bolt in shear – serviceability limit state

The following inequality must be satisfied for a bolt subjected only to a design shear force ($V^*_{sf}$) in the plane of the interfaces for serviceability limit state:

$$V^*_{sf} \leq \phi V_{sf}$$

where

$\phi$ = 0.7 (Clause 3.5.5 of AS 4100-1990)

$V_{sf}$ = nominal shear capacity of bolt, for a friction-type connection

= $\mu n_{ei} N_{ti} k_h$

where

$\mu$ = slip factor

= 0.35 for clean as-rolled surfaces or determined by testing in accordance with Appendix J of AS 4100-1990

$n_{ei}$ = number of effective interfaces

$N_{ti}$ = minimum bolt tension at installation as specified in Clause 15.2.5.1 of AS 4100-1990 (see Table 33)

$k_h$ = factor for different hole types as specified in Clause 14.3.5.2 of AS 4100-1990

= 1.0 for standard holes

= 0.85 for short slotted and oversize holes

= 0.70 for long slotted holes

The condition of the faying (or contact) surfaces is of prime importance, *since the slip factor (m) achieved in practice is directly related to the condition of the faying surfaces.* The slip factor 0.35 given for design purposes in AS 4100-1990 assumes faying surfaces of bare steel to bare steel – i.e. in the "as-rolled condition".

Often steel members are painted or galvanised and it is important to know what influence this may have on the slip factor. Typical values of the slip factor for various surface preparations are given in Table 34.

See Table 35 for the listings of bolt design shear capacity – service-ability limit state ($\phi V_{sf}$) – for the commonly used structural bolts.

## Bolt in tension – serviceability limit state

Not relevant in this limit state. Tension loadings for serviceability limit state are only considered when interacting with shear loads at serviceability limit state – see next page.

# Structural Design Using Ajax Bolts

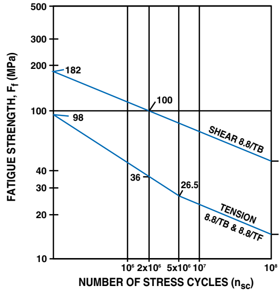


FIGURE 26

## Bolt subject to combined shear and tension – serviceability limit state

For bolts subject simultaneously to shear and tension forces, the following linear interaction relationship applies:

$$(V^*_{sf}/\phi V_{sf})^2 + (N^*_{tf}/\phi N_{tf})^2 \leq 1.0$$

where $V^*_{sf}$, $V_{sf}$ and $\phi$ are described above. For the tension loads:

$N^*_{tf}$ = design tension force on the bolt

$N_{tf}$ = nominal tension capacity of the bolt

= $N_{ti}$

= the minimum bolt tension at installation as specified in Clause 15.2.5.1 of AS 4100-1990 (See Table 33)

See Fig-25 for a plot of the shear-tension interaction relationship – serviceability limit state – for the commonly used structural bolts.

## FATIGUE LIMIT STATE

It is not possible to review here the fatigue provisions of AS 4100-1990 Section 11. reference should be made to *AS 4100 Supplement 1-1990: Steel Structures – Commentary*. In summary, a detail category is assigned to bolted connections subject to normal stress (tension) and shear stress.

This detail category is a number which corresponds to the fatigue strength at 2 x $10^6$ cycles on the appropriate S-N curves, a different S-N curve being used for each detail category.

For bolts, AS 4100-1990 provides two detail categories, namely

## Detail category 100

Bolts in shear, 8.8/TB bolting category where shear stress must be calculated on the core area, $A_c$.

## Detail category 36

Bolts in tension, tensile stress being calculated on the tensile stress area, $A_s$. Additional tension forces due to prying must be taken into account.

## Bolt in shear – fatigue limit state

For shear stress, the uncorrected fatigue strength ($f_f$) for detail category 100 subject to $n_{sc}$ (number of stress cycles) of loading or stress is given by

$$f^5_f = (10^5 \times 2 \times 10^6)/n_{sc}$$
$$\text{when } n_{sc} \leq 10^8$$

This relationship is shown in Fig-26.

For bolts subject to shear force, the fatigue provisions of AS 4100-1990 (Section 11) gives no guidance for 4.6/S and 8.8/S bolting categories.

# Structural Design Using Ajax Bolts

Only 8.8/TF and 8.8/TB are recommended. As no slip occurs with category 8.8/TF, no separate design for fatigue of the bolts is required. AS 4100-1990 does contain design fatigue provisions for 8.8/TB bolting category.

## Bolt in tension – fatigue limit state

For normal stress (tension), the uncorrected fatigue strength ($f_f$) for detail category 36 subject to $n_{sc}$ cycles of loading or stress is given by

$$f_f^3 = (36^3 \times 2 \times 10^6)/n_{sc}$$

$$\text{when } n_{sc} \leq 5 \times 10^6$$

$$f_f^5 = (36^5 \times 10^8)/n_{sc}$$

$$\text{when } 5 \times 10^6 < n_{sc} \leq 10^8$$

This relationship is shown in Fig-26.

For bolts subject to tension force, bolting categories 4.6/S and 8.8/S are not recommended and 8.8/TF and 8.8/TB are recommended.

## Bolt subject to combined shear and tension – fatigue limit state

AS 4100-1990 does not contain design provisions for bolts subject to combined shear and tension under fatigue conditions.

The following reference contains a review of research on fatigue in bolted connections: *Guide to Design Criteria for Bolted and Riveted Joints,* Kulak, G.L., Fisher, J.W. and Struik. J.H.A., 2nd Edition, John Wiley, 1987.

## Design Detail for Bolts

Clause 9.6 of AS 4100-1990 gives the provisions for design details of bolts. This includes minimum pitch, minimum edge distance, maximum pitch, and maximum edge distance. Listings of minimum pitch between centres of fastener holes, and minimum edge distance from the centre of a fastener to the edge of a plate or the flange of a rolled section is given in Table 36(a) and 36(b) respectively. Note that minimum edge distance criteria must also be observed from Clause 9.3.2.4 of AS 4100-1990.

# Ajax Structural Bolts

**Table 29** Bolt Types and Bolting Categories

| Bolting Category | Details of bolt used | | | | | Method of Tensioning Remarks |
|---|---|---|---|---|---|---|
| | Property Class | Minimum Tensile strength (MPa) | Minimum Yield Strength (MPa) | Name | Australian Standard | |
| 4.6/S | 4.6 | 400 | 240 | Commercial | AS 1111 | Use **S**nug tightened. Least costly and most commonly available 4.6 PC bolt. |
| 8.8/S | 8.8 | 830 | 660 | High Strength Structural | AS 1252 | Bolts used are **S**nug tightened. The high strength structural has a large bolt head and nut because it is designed to withstand full tensioning (see 8.8T category description). However, it can also be used in a snug tight condition. |
| 8.8/TF<br>**8.8/T** | 8.8 | 830 | 660 | High Strength Structural Bolt – Fully **T**ensioned **F**riction Type Joint | AS 1252 | In both applications bolts are fully **T**ensioned to the requirements of AS 4100.<br>Cost of tensioning is an important consideration in the use of these bolting categories. |
| 8.8/TB | 8.8 | 830 | 660 | High Strength Structural Bolt – Fully **T**ensioned **B**earing Type Joint | | |

# Ajax Structural Bolts

**Table 30** Design Shear and Tension Capacities – Strength Limit State
Commercial Bolts 4.6/S Bolting Category
($f_{uf}$ = 400 MPa)

**Property Class 4.6**

| Bolt Size | Axial Tension $\phi N_{tf}$ | Shear Values (Single Shear) Threads included in Shear Plane — N $\phi V_{fn}$ | Shear Values (Single Shear) Threads excluded from Shear Plane — X $\phi V_{fx}$ |
|---|---|---|---|
| | kN | kN | kN |
| M12 | 27.0 | 15.1 | 22.4 |
| M16 | 50.2 | 28.6 | 39.9 |
| M20 | 78.4 | 44.6 | 62.3 |
| M24 | 113 | 64.3 | 89.7 |
| M30 | 180 | 103 | 140 |
| M36 | 261 | 151 | 202 |
| | $\phi$ = 0.8 | $\phi$ = 0.8 | $\phi$ = 0.8 |
| | | 4.6N/S | 4.6X/S |

**NOTE 1.**
Bearing/Plate Tearout Design Capacity. For all reasonable combinations of ply thickness, bolt diameter and end distance, the design capacity for a ply in bearing ($ØV_b$) exceeds both $ØV_{fn}$ and $ØV_{fx}$.

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# Ajax Structural Bolts

**Table 31** Design Shear and Tension Capacities – Strength Limit State
High Strength Structural Bolts
8.8/S 8.8/TB 8.8/TF Bolting Categories
($f_{uf}$ = 830 MPa)

**Property Class 8.8**

| Bolt size | Axial Tension | Single Shear | | Plate Tearout | | | | | | | | | | | | Bearing | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Threads included in Shear Plane | Threads excluded from Shear Plane | $øV_b$ for $t_p$ & $a_e$ of: | | | | | | | | | | | | $øV_b$ for $t_p$ | | |
| | $øN_{tf}$ | $øV_{fn}$ | $øV_{fx}$ | $t_p$ = 6 | | | $t_p$ = 8 | | | $t_p$ = 10 | | | $t_p$ = 12 | | | 6 | 8 | 10 |
| | kN | kN | kN | 35 | 40 | 45 | 35 | 40 | 45 | 35 | 40 | 45 | 35 | 40 | 45 | | | |
| M16 | 104 | 59.3 | 82.7 | | | | | | | | | | | | | 113 | 151 | 189 |
| M20 | 163 | 92.6 | 129 | 79 | 89 | 100 | 103 | 118 | 133 | 129 | 148 | 166 | 155 | 177 | 199 | 142 | 189 | 236 |
| M24 | 234 | 133 | 186 | | | | | | | | | | | | | 170 | 227 | 283 |
| M30 | 373 | 214 | 291 | | | | | | | | | | | | | 213 | 283 | 354 |
| | | | | $a_e < a_{emin} = 1.5\, d_f$ | | | | | | | | | | | | | | |
| | ø = 0.8 | ø = 0.8 | | ø = 0.9 | | | | | | | | | | | | ø = 0.9 | | |
| | | 8.8N/S | 8.8X/S | $f_{up}$ = 410MPa | | | | | | | | | | | | $f_{up}$ = 410 MPa | | |

# Ajax Structural Bolts

**Table 32** Reduction Factor for Lap Connections ($k_r$)

| Length | $L_j < 300$ | $300 \leq L_j \leq 1300$ | $L_j > 1300$ |
|---|---|---|---|
| $k_r$ | 1.0 | $1.075 - L_j/4000$ | 0.75 |

NOTE: $L_j$ = length of a bolted lap splice connection.

**Table 33** Minimum Bolt Tension at Installation

| Nominal diameter of bolt | Minimum bolt Tension, kN |
|---|---|
| M16 | 95 |
| M20 | 145 |
| M24 | 210 |
| M30 | 335 |
| M36 | 490 |

**NOTE:** The minimum bolt tensions given in this Table are approximately equivalent to the minimum proof loads given in AS 1252.

**Table 34** Summary of Slip Factors

| Surface Treatment | Average Slip Factor |
|---|---|
| **Uncoated** | |
| Clean as-rolled | 0.35 |
| Flame cleaned | 0.48 |
| Abrasive blasted | 0.53 |
| **Painted** | |
| Red oxide zinc chromate | 0.11 |
| Inorganic zinc silicate | 0.50 |
| **Hot-dip galvanised** | |
| Clean as-galvanised | 0.18 |
| Lightly abrasive blasted | 0.30 – 0.40 |

# Ajax Structural Bolts

**Table 35** Design Shear Capacity – Serviceability Limit State
High Strength Structural Bolts 8.8/TF Bolting Category
($\mu$ = 0.35 $n_{ei}$ = 1 ø = 0.7)

**Property Class 8.8**

| Bolt Size | Bolt Tension at Installation | Design Capacity in Shear ($øV_{sf}$) for | | |
|---|---|---|---|---|
| | | $k_h$ = 1 | $k_h$ = 0.85 | $k_h$ = 0.7 |
| | kN | kN | kN | kN |
| M16 | 95 | 23.3 | 19.8 | 16.3 |
| M20 | 145 | 35.5 | 30.2 | 24.9 |
| M24 | 210 | 51.5 | 43.7 | 36.0 |
| M30 | 335 | 82.1 | 69.8 | 57.5 |

**Table 36a** Minimum Pitch between Centres of Fastener Holes
(Clause 9.6.1 of AS 4100–1990)

| Bolt Size | Minimum distance between centres of fastener holes mm |
|---|---|
| M12 | 30 |
| M16 | 40 |
| M20 | 50 |
| M24 | 60 |
| M30 | 75 |
| M36 | 90 |

NOTE: The edge distance may also be affected by Clause 9.3.2.4 of AS 4100-1990.

**Table 36b** Minimum Edge Distance
(Clause 9.6.2 of AS 4100–1990)

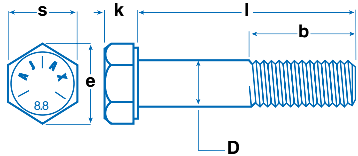
| Bolt Size | Sheared or Hand Flame Cut Edge (mm) | Rolled Plate; Machine Flame Cut, Sawn or Planed Edge (mm) | Rolled Edge of a Rolled Section (mm) |
|---|---|---|---|
| M12 | 21 | 18 | 15 |
| M16 | 28 | 24 | 20 |
| M20 | 35 | 30 | 25 |
| M24 | 42 | 36 | 30 |
| M30 | 53 | 45 | 38 |
| M36 | 63 | 54 | 45 |

NOTE: The edge distance may also be affected by Clause 9.3.2.4 of AS 4100-1990.

AJAX FASTENERS

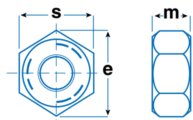
# Ajax High Strength Structural Bolts

Property Class 8.8 Thread
ISO Metric Coarse Pitch
Series Dimensions to AS 1252-1996




Bolt

FIGURE 27




Nut

FIGURE 28

## Table 37

| Bolt Dimensions | | | | | | | | | Nut Dimensions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size D | Pitch of Thread | Body Dia. D1 | | Width Across Flats s | | Width Across Corners e | Head Thickness k | | Width Across Flats s | | Thickness m | |
| | | Max. | Min. | Max. | Min. | Min. | Max. | Min. | Max. | MIn. | Max. | Min. |
| M16 | 2.0 | 16.70 | 15.30 | 27 | 26.16 | 29.56 | 10.75 | 9.25 | 27 | 26.16 | 17.1 | 16.0 |
| M20 | 2.5 | 20.84 | 19.16 | 32 | 31.00 | 35.03 | 13.90 | 12.10 | 32 | 31.00 | 21.3 | 20.0 |
| M24 | 3.0 | 24.84 | 23.16 | 41 | 40.00 | 45.20 | 15.90 | 14.10 | 41 | 40.00 | 25.3 | 24.0 |
| M30 | 3.5 | 30.84 | 29.16 | 50 | 49.00 | 55.37 | 19.75 | 17.65 | 50 | 49.00 | 31.3 | 30.0 |
| M36 | 4.0 | 37.00 | 35.00 | 60 | 58.80 | 66.44 | 23.55 | 21.45 | 60 | 58.80 | 37.6 | 36.0 |

All dimensions in Millimetres.
Nominal thread lengths see Table 45. For details refer AS 1252 – 1983

AJAX FASTENERS

# Ajax High Strength Structural Bolts

## (Flat Round Washers)

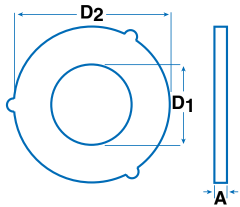



FIGURE 29

**Table 38** Dimensions of Flat Round Structural Washers

| Nominal Diameter of Bolt | Inside Diameter $D_1$ | | Outside Diameter $D_2$ | | Thickness A | |
|---|---|---|---|---|---|---|
| | Max. | Min. | Max. | Min. | Max. | Min. |
| M16 | 18.43 | 18.0 | 34.0 | 32.4 | 4.6 | 3.1 |
| M20 | 22.52 | 22.0 | 39.0 | 37.4 | 4.6 | 3.1 |
| M24 | 26.52 | 26.0 | 50.0 | 48.4 | 4.6 | 3.4 |
| M30 | 33.62 | 33.0 | 60.0 | 58.1 | 4.6 | 3.4 |
| M36 | 39.62 | 39.0 | 72.0 | 70.1 | 4.6 | 3.4 |

All Dimensions in Millimetres.

AJAX FASTENERS

# Coronet Load Indicators

For direct-tension indication
tightening of Ajax Fasteners
High Strength Structural Bolts AS 1252-1983

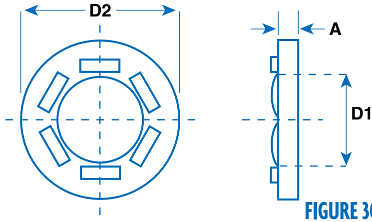



FIGURE 30

Coronet Load Indicators are designed for use with Ajax high strength structural bolts and they provide a simple and accurate aid to tightening and inspection. They can be supplied with galvanized coating for good corrosion resistance.

The Load Indicators are special hardened washers carrying 4 to 7 protrusions, depending on bolt diameter (Figure 30) and these are assembled with the protrusions bearing against the under side of the bolt head, leaving a gap. The nut is then tightened until the protrusions are flattened and the gap reduced to that shown in Table 39. The induced bolt tension at this average gap will be not less than the minimum specified tension in Table 40. In applications where it is necessary to rotate the bolt head rather than the nut in tightening, the Coronet Load Indicator can be fitted under the nut using an extra hard round washer under the nut and protrusions bear against this washer (Figure 32). In tightening with Load Indicators it is still required that this tightening be carried out in two stages. First stage involves a preliminary tightening to a "snug tight" condition using a podger spanner or pneumatic impact wrench. The object of the preliminary tightening is to draw the mating surfaces into effective contact. On large joints take a second run to ensure that all bolts are "snug tight". Carry out final tightening by reducing gap between bolt head and load indicator to 0.40mm or less and this can be checked with a feeler gauge (Figure 31,33).

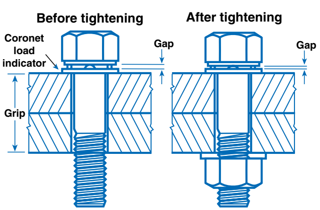



FIGURE 31

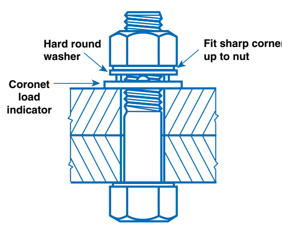



FIGURE 32

Don't RISK it! ... specify AJAX

AJAX FASTENERS

# Coronet Load Indicators

For direct-tension indication tightening of Ajax Fasteners High Strength Structural Bolts AS 1252-1983

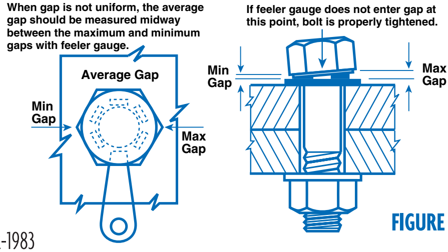



FIGURE 33

## Table 39

Load Indicator Gaps to Give Required Minimum Shank Tension

| Load Indicator Fitting | AS 4100 (1511) |
|---|---|
| Under Bolt Head Black Finish Bolts | 0.4mm |
| All Plating except Galvanized Bolts | 0.4mm |
| Galvanized Bolts | 0.25mm |
| Under Nut with Hard Flat Washer. Black and all Flat Washer Coatings | 0.25mm |

## Table 40

Load Indicator Gaps to Give Required Minimum Shank Tension (All dimensions in millimetres)

| Nom. Bolt Dia. | Outside Dia. D2 | Inside Dia. D1 | Thickness A Max. | Minimum Bolt Tension kN |
|---|---|---|---|---|
| M16 | 35.45 | 16.70 | 4.26 | 100 |
| M20 | 41.67 | 20.84 | 4.26 | 150 |
| M24 | 50.69 | 24.84 | 4.26 | 220 |
| M30 | 59.59 | 30.84 | 4.26 | 350 |
| M36 | 80.00 | 37.50 | 4.26 | 515 |

## MOST IMPORTANT:

A nut should not be slackened after fully tightening with a Load Indicator. If this is necessary fit a new Load Indicator for the second tightening.

# Unified High Tensile Hexagon Bolts

Threads, UNC, UNF, Class 2A
Dimensions to ANSI/ASME B18.2.1 AS 2465-1999

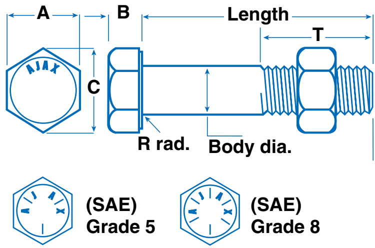



FIGURE 34

## Table 41

| Size | Threads per inch | | Body diameter | | Width Across Flats A | | | Head thickness B | | Across Corners C | Thread Length T |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | UNF | UNC | Max. | Min. | Nom. | Max. | Min. | Max. | Min. | Max. | Min. |
| 1/4 | 28 | 20 | 0.250 | 0.245 | 7/16 | 0.438 | 0.428 | 0.163 | 0.150 | 0.505 | 3/4 |
| 5/16 | 24 | 18 | 0.3125 | 0.3065 | 1/2 | 0.500 | 0.489 | 0.211 | 0.195 | 0.577 | 7/8 |
| 3/8 | 24 | 16 | 0.3750 | 0.3690 | 9/16 | 0.562 | 0.551 | 0.243 | 0.226 | 0.650 | 1" |
| 7/16 | 20 | 14 | 0.4375 | 0.4305 | 5/8 | 0.625 | 0.612 | 0.291 | 0.272 | 0.722 | 1.1/8 |
| 1/2 | 20 | 13 | 0.5000 | 0.4930 | 3/4 | 0.750 | 0.736 | 0.323 | 0.302 | 0.866 | 1.1/4 |
| 9/16 | 18 | 12 | 0.5625 | 0.5545 | 13/16 | 0.812 | 0.798 | 0.371 | 0.348 | 0.938 | 1.3/8 |
| 5/8 | 18 | 11 | 0.6250 | 0.6170 | 15/16 | 0.938 | 0.922 | 0.403 | 0.378 | 1.083 | 1.1/2 |
| 3/4 | 16 | 10 | 0.750 | 0.741 | 1.1/8 | 1.125 | 1.100 | 0.483 | 0.455 | 1.299 | 1.3/4 |
| 7/8 | 14 | 9 | 0.875 | 0.866 | 1.5/16 | 1.312 | 1.285 | 0.563 | 0.531 | 1.516 | 2" |
| 1 | 12 | 8 | 1.000 | 0.990 | 1.1/2 | 1.500 | 1.469 | 0.627 | 0.591 | 1.732 | 2.1/4 |
| 1.1/8 | 12 | 7 | 1.125 | 1.114 | 1.11/16 | 1.688 | 1.631 | 0.718 | 0.658 | 1.949 | 2.1/2 |
| 1.1/4 | 12 | 7 | 1.250 | 1.239 | 1.7/8 | 1.875 | 1.812 | 0.813 | 0.749 | 2.165 | 2.3/4 |
| 1.1/2 | 12 | 6 | 1.500 | 1.488 | 2.1/4 | 2.250 | 2.175 | 0.974 | 0.902 | 2.598 | 3.1/4 |

For nut dimensions refer page 102.
All dimensions in inches.

# Unified High Tensile Hexagon Head Set Screws

Threads, UNC, UNF,
Dimensions to ANSI/ASME B18.2.1 AS 2465-1999

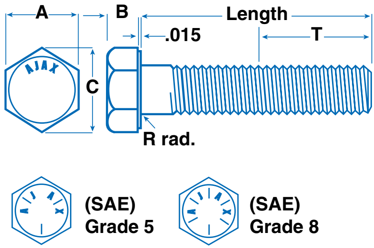



FIGURE 35

**Table 42**

| Size | Threads per inch | | Head Across Flats A | | Head Depth B | | Head Across Corners C | | Radius Under Head R | |
|---|---|---|---|---|---|---|---|---|---|---|
| | UNF | UNC | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. |
| 1/4 | 28 | 20 | 0.438 | 0.428 | 0.163 | 0.150 | 0.505 | 0.488 | 0.025 | 0.015 |
| 5/16 | 24 | 18 | 0.500 | 0.489 | 0.211 | 0.195 | 0.577 | 0.557 | 0.025 | 0.015 |
| 3/8 | 24 | 16 | 0.562 | 0.551 | 0.243 | 0.226 | 0.650 | 0.628 | 0.025 | 0.015 |
| 7/16 | 20 | 14 | 0.625 | 0.612 | 0.291 | 0.272 | 0.722 | 0.698 | 0.025 | 0.015 |

**NOTE:** Set Screws shall be threaded to within 2 ½ pitches of the underside of the head.
All dimensions in inches.

AJAX FASTENERS

# Metric Hexagon Precision Bolts and Set Screws

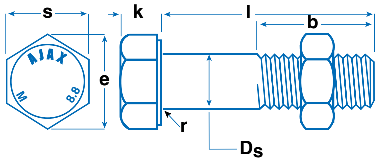



FIGURE 36

Thread, ISO Metric Coarse Series, Class 6g, Property Class 8.8 & 10.9 Dimensions to AS 1110-1995

## Table 43

| Size<br>D | Pitch of Thread | Body Diameter Ds | | Width Across Flats s | | Head Thickness k | | Across Corners e |
|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Max. | Min. | Max. | Min. | Min. |
| M5 | 0.8 | 5.0 | 4.82 | 8.0 | 7.78 | 3.65 | 3.35 | 8.79 |
| M6 | 1.0 | 6.0 | 5.82 | 10.0 | 9.78 | 4.15 | 3.85 | 11.06 |
| M8 | 1.25 | 8.0 | 7.78 | 13.0 | 12.73 | 5.45 | 5.15 | 14.38 |
| M10 | 1.5 | 10.0 | 9.78 | 16.0 | 15.73 | 6.58 | 6.22 | 17.77 |
| M12 | 1.75 | 12.0 | 11.73 | 18.0 | 17.73 | 7.68 | 7.32 | 20.03 |
| M14 | 2.0 | 14.0 | 13.73 | 21.0 | 20.67 | 8.98 | 8.62 | 23.35 |
| M16 | 2.0 | 16.0 | 15.73 | 24.0 | 23.67 | 10.18 | 9.82 | 26.75 |
| M18 | 2.5 | 18.0 | 17.73 | 27.0 | 26.67 | 11.72 | 11.28 | 30.14 |
| M20 | 2.5 | 20.0 | 19.67 | 30.0 | 29.67 | 12.72 | 12.28 | 33.53 |
| M22 | 2.5 | 22.0 | 21.67 | 34.0 | 33.38 | 14.22 | 13.78 | 37.72 |
| M24 | 3.0 | 24.0 | 23.67 | 36.0 | 35.38 | 15.22 | 14.78 | 39.98 |
| M27 | 3.0 | 27.0 | 26.67 | 41.0 | 40.38 | 17.05 | 16.35 | 45.63 |
| M30 | 3.5 | 30.0 | 29.67 | 46.0 | 45.00 | 19.12 | 18.28 | 50.85 |
| M33 | 3.5 | 33.0 | 32.61 | 50.0 | 49.00 | 20.92 | 20.08 | 55.37 |
| M36 | 4.0 | 36.0 | 35.61 | 55.0 | 53.80 | 22.92 | 22.08 | 60.79 |
| (M39) | 4.0 | 39.0 | 38.61 | 60.0 | 58.80 | 25.42 | 24.53 | 66.44 |

All dimensions in Millimetres

( ) AS 1110 covers sizes to M36 only. Data for sizes above this is given for information only.

# Metric Hexagon Precision Bolts and Set Screws

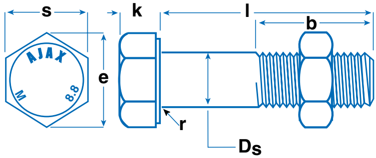



FIGURE 37

Thread ISO Metric Fine Pitch Series, Thread Class 6g,
Property Class 8.8 Dimensions to DIN 960 and DIN 961 (Set Screws)

**Table 44**

| Size D | Pitch of Thread | Body Diameter (On Bolts) Ds | | Width Across Flats s | | Head Thickness k | | Across Corners e |
|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Max. | Min. | Max. | Min. | Min. |
| M8 | 1.0 | 8.00 | 7.78 | 13.00 | 12.73 | 5.45 | 5.15 | 14.38 |
| M10 | 1.25 | 10.00 | 9.78 | 17.00 | 16.73 | 6.58 | 6.22 | 18.90 |
| M12 | 1.25 | 12.00 | 11.73 | 19.00 | 18.67 | 7.68 | 7.32 | 21.10 |
| M14 | 1.5 | 14.00 | 13.73 | 22.00 | 21.67 | 8.98 | 8.62 | 24.49 |
| M16 | 1.5 | 16.00 | 15.73 | 24.00 | 23.67 | 10.18 | 9.82 | 26.75 |
| M18 | 1.5 | 18.00 | 17.73 | 27.00 | 26.67 | 11.72 | 11.28 | 30.14 |
| M20 | 1.5 | 20.00 | 19.67 | 30.00 | 29.67 | 12.72 | 12.28 | 33.53 |
| M22 | 1.5 | 22.00 | 21.67 | 32.00 | 31.61 | 14.22 | 13.78 | 35.72 |
| M24 | 2.0 | 24.00 | 23.67 | 36.00 | 35.38 | 15.22 | 14.78 | 39.98 |

**Table 45**

Nominal Thread Lengths for Bolts. Set Screws are Threaded to Head

| Nominal Length of Bolt *l* | Min. Length of Thread b |
|---|---|
| Up to and including 125mm | 2D + 6mm |
| Over 125 up to and including 200mm | 2D + 12mm |
| Over 200mm | 2D + 25mm |

For nut dimensions refer page 100.
Where D = Nominal Diameter in Millimetres.
Note: Property Classes 5.8 and 10.9 are dimensionally the same as Property Class 8.8.

AJAX FASTENERS

# Metric Hexagon Commercial Bolts and Set Screws

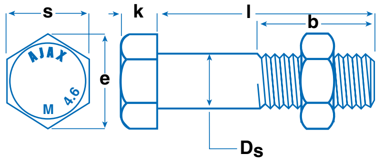



FIGURE 38

Thread ISO Metric Coarse Pitch Series, Thread Class 8g,
Property Class 4.6 Dimensions to AS 1111-1996

## Table 46

| Size D | Pitch of Thread | Body Diameter (On Bolts) Ds | | Width Across Flats s | | Head Thickness k | | Across Corners e |
|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Max. | Min. | Max. | Min. | Min. |
| M6 | 1.0 | 6.48 | 5.52 | 10.0 | 9.64 | 4.38 | 3.62 | 10.89 |
| M8 | 1.25 | 8.58 | 7.42 | 13.0 | 12.57 | 5.68 | 4.92 | 14.20 |
| M10 | 1.5 | 10.58 | 9.42 | 16.0 | 15.57 | 6.85 | 5.95 | 17.59 |
| M12 | 1.75 | 12.70 | 11.30 | 18.0 | 17.57 | 7.95 | 7.05 | 19.85 |
| M14 | 2.0 | 14.70 | 13.30 | 21.0 | 20.16 | 9.25 | 8.35 | 22.78 |
| M16 | 2.0 | 16.70 | 15.30 | 24.0 | 23.16 | 10.75 | 9.25 | 26.17 |
| M18 | 2.5 | 18.70 | 17.30 | 27.0 | 26.16 | 12.40 | 10.60 | 29.56 |
| M20 | 2.5 | 20.84 | 19.16 | 30.0 | 29.16 | 13.40 | 11.60 | 32.95 |
| M22 | 2.5 | 22.84 | 21.16 | 34.0 | 33.00 | 14.90 | 13.10 | 37.29 |
| M24 | 3.0 | 24.84 | 23.16 | 36.0 | 35.00 | 15.90 | 14.10 | 39.55 |
| M27 | 3.0 | 27.84 | 26.16 | 41.0 | 40.00 | 17.90 | 16.10 | 45.20 |
| M30 | 3.5 | 30.84 | 29.16 | 46.0 | 45.00 | 19.75 | 17.65 | 50.85 |
| M33 | 3.5 | 34.00 | 32.00 | 50.0 | 49.00 | 22.50 | 19.95 | 55.37 |
| M36 | 4.0 | 37.00 | 35.00 | 55.0 | 53.80 | 23.55 | 21.45 | 60.79 |
| M39 | 4.0 | 40.00 | 38.00 | 60.0 | 58.80 | 26.05 | 23.95 | 66.44 |
| M42 | 4.5 | 43.00 | 41.00 | 65.0 | 63.10 | 27.67 | 24.35 | 71.30 |
| M48 | 5.0 | 49.00 | 47.00 | 75.0 | 73.10 | 31.65 | 28.35 | 82.60 |
| M56 | 5.5 | 57.20 | 54.80 | 85.0 | 82.80 | 36.95 | 33.05 | 93.56 |
| M64 | 6.0 | 65.20 | 62.80 | 95.0 | 92.80 | 41.95 | 39.05 | 104.86 |

All dimensions in Millimetres. See Table 48 for minimum thread length.

AJAX FASTENERS

# Hexagon Head Bolts

Threads BSW Free Class
Tensile Strength 28 tonf/in$^2$ min.
Dimensions to AS 2451-1998

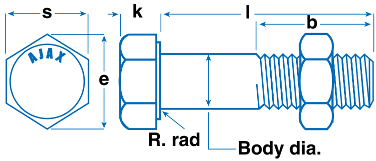



FIGURE 39

## Table 47

| Size | Threads per inch | Body Diameter | Head Across Flats s | | Head Depth k | | Across Corners e | Radius Under Head R |
|---|---|---|---|---|---|---|---|---|
| | | Max. | Max. | Min. | Max. | Min. | Min. | Min. |
| 1/4 | 20 | 0.280 | 0.445 | 0.435 | 0.186 | 0.166 | 0.51 | 0.031 |
| 5/16 | 18 | 0.342 | 0.525 | 0.515 | 0.228 | 0.208 | 0.61 | 0.031 |
| 3/8 | 16 | 0.405 | 0.600 | 0.585 | 0.270 | 0.250 | 0.69 | 0.031 |
| 7/16 | 14 | 0.468 | 0.710 | 0.695 | 0.312 | 0.292 | 0.82 | 0.031 |
| 1/2 | 12 | 0.530 | 0.820 | 0.800 | 0.363 | 0.333 | 0.95 | 0.031 |
| 5/8 | 11 | 0.665 | 1.010 | 0.985 | 0.447 | 0.417 | 1.12 | 0.046 |
| 3/4 | 10 | 0.790 | 1.200 | 1.175 | 0.530 | 0.500 | 1.34 | 0.046 |
| 7/8 | 9 | 0.915 | 1.300 | 1.270 | 0.623 | 0.583 | 1.45 | 0.062 |
| 1 | 8 | 1.040 | 1.480 | 1.450 | 0.706 | 0.666 | 1.65 | 0.062 |

For nut dimensions refer to page 101. Nominal thread length = 2D + 1/4 inch min.
Set Screws are threaded to head. All dimensions in inches.

## Table 48

Nominal Thread Lengths for Bolts. Set Screws are Threaded to within 2 1/2 pitches of the head.

| Nominal Length of Bolt *l* | Min. Length of Thread b |
|---|---|
| Up to and including 125mm | 2D + 6 mm |
| Over 125mm up to and including 200mm | 2D + 12 mm |
| Over 200mm | 2D + 25 mm |

Where D = Nominal Diameter in Millimetres.
For nut dimensions refer to page 101.

AJAX FASTENERS

# Hexagon Head Set Screws

Threads BSW Free Class
Tensile Strength 28 tonf/in$^2$ min.
Dimensions to AS 2451-1998

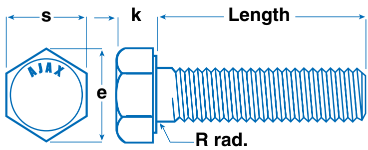



FIGURE 40

## Table 49

| Size | Threads Per Inch | Head Across Flats s | | Head Depth k | | Head Across Corners e | Radius Under Head R |
|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Max. | Min. | Min. | Min. |
| 1/4 | 20 | 0.445 | 0.435 | 0.186 | 0.166 | 0.51 | 0.031 |
| 5/16 | 18 | 0.525 | 0.515 | 0.228 | 0.208 | 0.61 | 0.031 |
| 3/8 | 16 | 0.600 | 0.585 | 0.270 | 0.250 | 0.69 | 0.031 |
| 7/16 | 14 | 0.710 | 0.695 | 0.312 | 0.292 | 0.82 | 0.031 |
| 1/2 | 12 | 0.820 | 0.800 | 0.363 | 0.333 | 0.95 | 0.031 |
| 5/8 | 11 | 1.010 | 0.985 | 0.447 | 0.417 | 1.12 | 0.046 |
| 3/4 | 10 | 1.200 | 1.175 | 0.530 | 0.500 | 1.34 | 0.046 |
| 7/8 | 9 | 1.300 | 1.270 | 0.623 | 0.583 | 1.45 | 0.062 |
| 1 | 8 | 1.480 | 1.450 | 0.706 | 0.666 | 1.65 | 0.062 |

**NOTE:** Set Screws shall be threaded to within 2 $^1/_2$ pitches of the underside of the head.
All dimensions in inches.

AJAX FASTENERS

# Metric Cup Head Square Neck Bolts

Thread ISO Metric Coarse Pitch Series
Property Class 4.6 Dimensions to AS 1390-1997

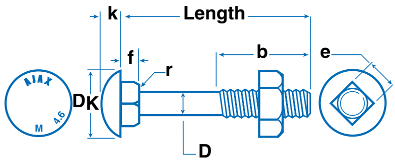



FIGURE 41

**Table 50** Metric Series Cup Square Bolts

| Size | Pitch | Body Diameter D | | Head Diameter Dk | | Head Thickness K | | Across Flats Square Neck E | | Length of Square Neck F | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. |
| M6 | 1.0 | 6.48 | 5.10 | 13.50 | 12.40 | 3.6 | 3.0 | 6.48 | 5.52 | 3.6 | 3.0 |
| M8 | 1.25 | 8.58 | 7.00 | 18.00 | 16.90 | 4.8 | 4.0 | 8.58 | 7.42 | 4.8 | 4.0 |
| M10 | 1.5 | 10.58 | 8.80 | 22.50 | 21.20 | 5.8 | 5.0 | 10.58 | 9.42 | 5.8 | 5.0 |
| M12 | 1.75 | 12.70 | 10.60 | 27.00 | 25.70 | 6.8 | 6.0 | 12.70 | 11.30 | 6.8 | 6.0 |
| M16 | 2.0 | 16.70 | 14.40 | 36.00 | 34.40 | 8.9 | 9.0 | 16.70 | 15.30 | 8.9 | 8.0 |
| M20 | 2.5 | 20.84 | 18.10 | 45.00 | 43.40 | 10.9 | 10.0 | 20.84 | 19.16 | 10.9 | 10.0 |
| M24 | 3.0 | 24.84 | 21.70 | 54.00 | 52.10 | 13.1 | 12.0 | 24.84 | 23.16 | 13.1 | 12.0 |

For nut dimensions refer to page 100. All dimensions in millimetres.

## Standard Thread Length for Bolts

| Nominal length of Bolt *l* | Minimum Length of Thread b | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | M5 | M6 | M8 | M10 | M12 | M16 | M20 | M24 |
| Up to and including 125mm | 16 | 18 | 22 | 26 | 30 | 38 | 46 | 54 |
| Over 125 up to and including 200mm | 22 | 24 | 28 | 32 | 36 | 44 | 52 | 60 |
| Over 200mm | — | — | 41 | 45 | 49 | 57 | 65 | 73 |

Maximum thread length shall not exceed 80mm.

## Mechanical Properties:

Tensile Strength = 400 MPa (N/mm$^2$) minimum
= 58,000 lbf/in$^2$ minimum
= 25.9 tonf/in$^2$ minimum

# Cup Head Square Neck Bolts

Threads BSW Free Class
Tensile strength 26 tonf/in$^2$ min.
Dimensions to AS B108

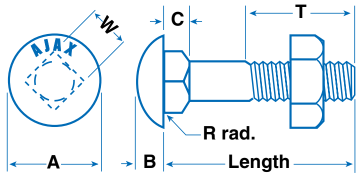



FIGURE 44

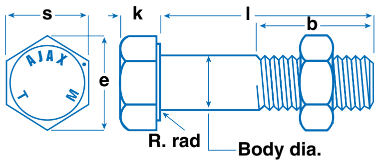
**Table 53**

| Size | Threads per inch | Head Diameter A | | Head Thickness B | | Depth of square C | | Width of square W | |
|---|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. |
| 3/16 | 24 | 0.451 | 0.391 | 0.113 | 0.093 | 0.125 | 0.094 | 0.197 | 0.183 |
| 1/4 | 20 | 0.592 | 0.532 | 0.145 | 0.125 | 0.156 | 0.125 | 0.260 | 0.245 |
| 5/16 | 18 | 0.733 | 0.673 | 0.176 | 0.156 | 0.187 | 0.156 | 0.323 | 0.307 |
| 3/8 | 16 | 0.873 | 0.813 | 0.207 | 0.187 | 0.219 | 0.188 | 0.388 | 0.368 |
| 7/16 | 14 | 1.014 | 0.954 | 0.238 | 0.218 | 0.250 | 0.219 | 0.451 | 0.431 |
| 1/2 | 12 | 1.155 | 1.095 | 0.270 | 0.250 | 0.281 | 0.250 | 0.515 | 0.492 |

For nut dimensions refer to page 101.
Nominal thread length = 2D + $^1/_4$ inch min.
All dimensions in inches.

AJAX FASTENERS

# Metric Hexagon Tower Bolts




Thread ISO Metric Coarse Pitch Series
Property Class 5.8
Dimensions to AS 1559 - 1986

**FIGURE 42**

## Table 51a

| Size | Pitch of Thread | Body Diameter | | Width Across Flats s | | Head Thickness k | | Across Corner e |
|---|---|---|---|---|---|---|---|---|
| | | Max | Min | Max | Min | Max | Min | Min |
| M12* | 1.75 | 12.43 | 11.30 | 18.0 | 17.57 | 7.95 | 7.05 | 19.86 |
| M16 | 2.0 | 16.43 | 15.3 | 24.0 | 23.16 | 10.75 | 9.25 | 26.17 |
| M20 | 2.5 | 20.52 | 19.16 | 30.0 | 29.16 | 13.40 | 11.60 | 32.95 |
| M24 | 3.0 | 24.52 | 23.16 | 36.0 | 35.0 | 15.90 | 14.10 | 39.55 |
| M30 | 3.5 | 30.52 | 29.16 | 46.0 | 45.0 | 19.75 | 17.65 | 50.85 |

*M12 is a non-preferred diameter by AS 1559 - 1986. All dimensions are millimetres.

Grip Lengths to AS 1559 – 1986 Double Nut Type

## Table 51b

| Nominal Length (*l*) | Grip Length mm | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | M16 | | M20 | | M24 | | M30 | |
| | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. |
| 50 | 9.8 | 11.3 | - | - | - | - | - | - |
| 55 | 14.8 | 16.3 | - | - | - | - | - | - |
| 60 | 19.8 | 21.3 | 12.6 | 14.1 | - | - | - | - |
| 65 | 24.8 | 26.3 | 17.6 | 19.1 | 9.9 | 11.4 | - | - |
| 70 | 29.8 | 31.3 | 22.6 | 24.1 | 14.9 | 16.4 | - | - |
| 75 | 34.8 | 36.3 | 27.6 | 29.1 | 19.9 | 21.4 | 10.9 | 12.4 |
| 80 | 39.8 | 41.3 | 32.6 | 34.1 | 24.9 | 26.4 | 15.9 | 17.4 |
| 85 | 44.8 | 46.3 | 37.6 | 39.1 | 29.9 | 31.4 | 20.9 | 22.4 |
| 90 | 49.8 | 51.3 | 42.6 | 44.1 | 34.9 | 36.4 | 25.9 | 27.4 |
| 95 | 54.8 | 56.3 | 47.6 | 49.1 | 39.9 | 41.4 | 30.9 | 32.4 |
| 100 | 59.8 | 61.3 | 52.6 | 54.1 | 44.9 | 46.4 | 35.9 | 37.4 |
| 105 | 64.8 | 66.3 | 57.6 | 59.1 | 49.9 | 51.4 | 40.9 | 42.4 |
| 110 | 69.8 | 71.3 | 62.6 | 64.1 | 54.9 | 56.4 | 45.9 | 47.4 |
| 115 | 74.8 | 76.3 | 67.6 | 69.1 | 59.9 | 61.4 | 50.9 | 52.4 |
| 120 | 79.8 | 81.3 | 72.6 | 74.1 | 64.9 | 66.4 | 55.9 | 57.4 |
| 125 | 84.8 | 86.3 | 77.6 | 79.1 | 69.9 | 71.4 | 60.9 | 62.4 |

For nut dimensions refer p100

# AJAX FASTENERS

# Metric Hexagon Tower Bolts

Thread ISO Metric Coarse
Pitch Series
Property Class 5.8
Dimensions to AS 1559 - 1986

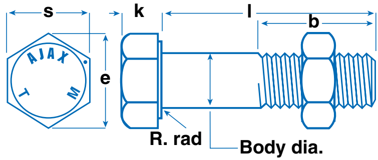



**FIGURE 43**

Grip Lengths to AS 1559 – 1986 Single Nut Type

## Table 52

| Nominal Length (l) | Grip Length mm | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | M16 | | M20 | | M24 | | M30 | |
| | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. |
| 35 | 9.6 | 11.1 | - | - | - | - | - | - |
| 40 | 14.6 | 16.1 | 10.6 | 12.1 | - | - | - | - |
| 45 | 19.6 | 21.1 | 15.6 | 17.1 | 11.4 | 12.9 | - | - |
| 50 | 24.6 | 26.1 | 20.6 | 22.1 | 16.4 | 17.9 | 11.5 | 13.0 |
| 55 | 29.6 | 31.1 | 25.6 | 27.1 | 21.4 | 22.9 | 16.5 | 18.0 |
| 60 | 34.6 | 36.1 | 30.6 | 32.1 | 26.4 | 27.9 | 21.5 | 23.0 |
| 65 | 39.6 | 41.1 | 35.6 | 37.1 | 31.4 | 32.9 | 26.5 | 28.0 |
| 70 | 44.6 | 46.1 | 40.6 | 42.1 | 36.4 | 37.9 | 31.5 | 33.0 |
| 75 | 49.6 | 51.1 | 45.6 | 47.1 | 41.4 | 42.9 | 36.5 | 38.0 |
| 80 | 54.6 | 56.1 | 50.6 | 52.1 | 46.4 | 47.9 | 41.5 | 43.0 |
| 85 | 59.6 | 61.1 | 55.6 | 57.1 | 51.4 | 52.9 | 46.5 | 48.0 |
| 90 | 64.6 | 66.1 | 60.6 | 62.1 | 56.4 | 57.9 | 51.5 | 53.0 |
| 95 | 69.6 | 71.1 | 65.6 | 67.1 | 61.4 | 62.9 | 56.5 | 58.0 |
| 100 | 74.6 | 76.1 | 70.6 | 72.1 | 66.4 | 67.9 | 61.5 | 63.0 |
| 105 | 79.6 | 81.1 | 75.6 | 77.1 | 71.4 | 72.9 | 66.5 | 68.0 |
| 110 | 84.6 | 86.1 | 80.6 | 82.1 | 76.4 | 77.9 | 71.5 | 73.0 |
| 115 | 89.6 | 91.1 | 85.6 | 87.1 | 81.4 | 82.9 | 76.5 | 78.0 |
| 120 | 94.6 | 96.1 | 90.6 | 92.1 | 86.4 | 87.9 | 81.5 | 83.0 |
| 125 | 99.6 | 101.1 | 95.6 | 97.1 | 91.4 | 92.9 | 86.5 | 88.0 |
| 130 | - | - | - | - | 96.4 | 97.9 | 91.5 | 93.0 |
| 135 | - | - | - | - | 101.4 | 102.9 | 96.5 | 98.0 |
| 140 | - | - | - | - | 106.4 | 107.9 | 101.5 | 103.0 |
| 145 | - | - | - | - | 111.4 | 112.9 | 106.5 | 108.0 |
| 150 | - | - | - | - | 116.4 | 117.9 | 111.5 | 113.0 |
| 155 | - | - | - | - | 121.4 | 122.9 | 116.5 | 118.0 |
| 160 | - | - | - | - | 126.4 | 127.9 | 121.5 | 123.0 |

AJAX FASTENERS

# Coach Screws - Hexagon Head Metric Series

Property Class 4.6

Dimensions to AS 1393-1996

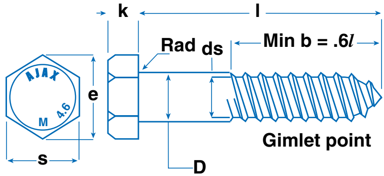



FIGURE 45

**Table 54** Metric Series Coach Screws. All dimensions in millimetres.

| Nom. Size | Pitch of Thread | | Body Diameter D | | Width Across Flats s | | Width Across Corners e | Head Thickness k | | Root Dia. of Thread ds | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | Max. | Min. | Max. | Min. | Max. | Min. | Min. | Max. | Min. | Max. | Min. |
| 6 | 2.86 | 2.34 | 6.48 | 5.52 | 10.0 | 9.64 | 10.89 | 4.38 | 3.62 | 4.5 | 3.7 |
| 8 | 3.96 | 2.80 | 8.58 | 7.42 | 13.0 | 12.57 | 14.20 | 5.68 | 4.92 | 5.9 | 5.0 |
| 10 | 4.95 | 3.60 | 10.58 | 9.42 | 16.0 | 15.57 | 17.59 | 6.85 | 5.95 | 7.4 | 6.2 |
| 12 | 5.50 | 4.20 | 12.70 | 11.30 | 18.0 | 17.57 | 19.85 | 7.95 | 7.05 | 8.4 | 7.5 |
| 16 | 6.60 | 5.10 | 16.70 | 15.30 | 24.0 | 23.16 | 26.17 | 10.75 | 9.25 | 12.4 | 11.3 |
| 20 | 7.70 | 5.60 | 20.84 | 19.16 | 30.0 | 29.16 | 32.95 | 13.40 | 11.60 | 15.5 | 14.2 |

## Mechanical Properties

Tensile Strength = 400 MPa (N/mm$^2$) minimum
= 58,000 lbf/in$^2$ minimum
= 25.9 tonf/in$^2$ minimum

AJAX FASTENERS

# Cup Oval Fishbolts

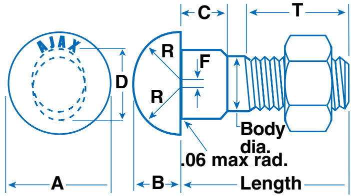



FIGURE 46

## Threads BSW Free Class

Dimensions to AS E25

### Table 55(a)

| Size | Thrds per Inch | Body Diameter | | Head Diameter A | | Head Depth B | | Depth of Oval Neck C | | Width of Oval Neck D | | Flat on Head F | Rad. R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Min. | Max. | Nom. | Nom. |
| 7/8 | 9 | 0.890 | 0.860 | 1.656 | 1.594 | 0.781 | 0.719 | 0.781 | 0.719 | 1.156 | 1.094 | 0.125 | 0.750 |

For nut dimensions refer to page 101. All dimensions in inches.

## Threads ISO Metric Coarse

Dimensions to AS 1085.4-1997

### Table 55(b)

| Size | Thread pitch | Body Diameter | | Head Diameter A | | Head Depth B | | Depth of Oval Neck C | | Width of Oval Neck D | | Flat on Head F | Rad. R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Min. | Max. | Nom. | Nom. |
| M24 | 3.0 | 24.8 | 23.6 | 46.0 | 43.0 | 20 | 18 | 20 | 18 | 30.5 | 32.5 | – | 1 |

For nut dimensions refer to page 82. All dimensions in millimetres.

## Heat Treated Fishbolts

Tensile Strength: 150,000 lbf/in$^2$ min (1034 MPa)

AJAX FASTENERS

# Elevator Bolts Four Peg

Threads BSW Free Class

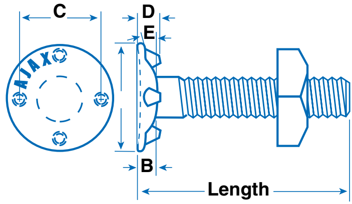



FIGURE 47

## Table 56

| Size | Threads per Inch | Head Diameter A | | Head Depth B | | Pitch Dia. of Pegs C | | Length of Peg D | | Angle Under Head E | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. |
| 1/4 | 20 | 0.697 | 0.667 | 0.120 | 0.100 | 0.510 | 0.490 | 0.156 | 0.136 | 17° | 13° |
| 5/16 | 18 | 0.859 | 0.829 | 0.160 | 0.140 | 0.635 | 0.615 | 0.194 | 0.174 | 22° | 18° |
| 3/8 | 16 | 1.077 | 1.047 | 0.194 | 0.174 | 0.760 | 0.740 | 0.237 | 0.217 | 24° | 20° |

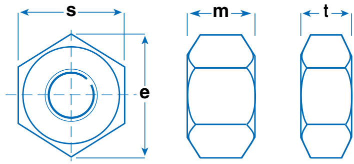
## Mechanical Properties:

All dimensions in inches
Tensile Strength: 28 tonf/in$^2$.
Supplied with nut and washer.

For nut dimensions refer to page 101. All dimensions in inches.

AJAX FASTENERS

# Metric Hexagon Nuts




Standard nut Thin nut

FIGURE 48

Threads ISO Metric Coarse Pitch Series.
Class 6H. These nuts are stocked in
Property Class 8 M5 to M30 inclusive
Property Class 5 M20–M64 inclusive

Dimensions to AS1112-1996
Proof load stress 855 MPa min.
Proof load stress 500 MPa min

**Table 57**

* Refer p13 for nut markings

| Size | Pitch of Thread | Width Across Flats s | | Width Across Corners e | Thickness Standard Nut m | | Thickness Thin Nut t | |
|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Min. | Max. | Min. | Max. | Min. |
| M5 | 0.8 | 8.0 | 7.78 | 8.79 | 4.70 | 4.40 | 2.7 | 2.45 |
| M6 | 1.0 | 10.0 | 9.78 | 11.05 | 5.20 | 4.90 | 3.2 | 2.90 |
| M8 | 1.25 | 13.0 | 12.73 | 14.38 | 6.80 | 6.44 | 4.0 | 3.70 |
| M10 | 1.5 | 16.0 | 15.73 | 17.77 | 8.40 | 8.04 | 5.0 | 4.70 |
| M12 | 1.75 | 18.0 | 17.73 | 20.03 | 10.80 | 10.37 | 6.0 | 5.70 |
| M16 | 2.0 | 24.0 | 23.67 | 26.75 | 14.80 | 14.10 | 8.0 | 7.42 |
| M20 | 2.5 | 30.0 | 29.16 | 32.95 | 18.00 | 16.90 | 10.0 | 9.10 |
| M24 | 3.0 | 36.0 | 35.00 | 39.55 | 21.50 | 20.20 | 12.0 | 10.90 |
| M27 | 3.0 | 41.0 | 40.00 | 45.20 | 23.80 | 22.50 | 13.5 | 12.40 |
| M30 | 3.5 | 46.0 | 45.00 | 50.85 | 25.60 | 24.30 | 15.0 | 13.90 |
| M33 | 3.5 | 50.0 | 49.00 | 55.37 | 28.70 | 27.40 | 16.5 | 15.40 |
| M36 | 4.0 | 55.0 | 53.80 | 60.79 | 31.00 | 29.40 | 18.0 | 16.90 |
| M39 | 4.0 | 60.0 | 58.80 | 66.44 | 34.30 | 31.80 | 19.5 | 18.20 |
| M42 | 4.5 | 65.0 | 63.10 | 72.02 | 34.90 | 32.40 | 21.0 | 19.70 |
| M48 | 5.0 | 75.0 | 73.10 | 82.60 | 38.90 | 36.40 | 29.0 | 22.70 |
| M56 | 5.5 | 85.0 | 82.80 | 93.56 | 45.90 | 43.40 | – | – |
| M64 | 6.0 | 95.0 | 92.80 | 104.86 | 52.40 | 49.40 | – | – |

All dimensions in Millimetres

AJAX FASTENERS

# Hexagon Nuts and Hexagon Lock Nuts

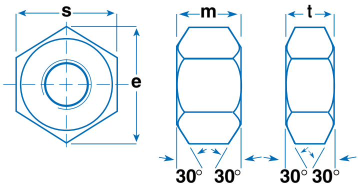



FIGURE 49

Threads BSW
Proof load stress 28 tonf/in² min.
Dimensions to AS 2451* (sizes in parenthesis are not listed in standard).
*Hexagon Nuts only. (Lock Nut thicknesses included for information only.)

**Table 58** (All dimensions in inches)

* Refer p13 for nut markings

| Size | Threads per Inch | Width Across Flats s | | Width Across Corners e | Thickness Nuts m | | Thickness Lock Nut t | |
|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Min. | Max. | Min. | Max. | Min. |
| (3/16) | 24 | 0.324 | 0.319 | 0.36 | 0.157 | 0.157 | | |
| 1/4 | 20 | 0.445 | 0.435 | 0.50 | 0.200 | 0.180 | 0.185 | 0.180 |
| 5/16 | 18 | 0.525 | 0.515 | 0.59 | 0.250 | 0.230 | 0.210 | 0.200 |
| 3/8 | 16 | 0.600 | 0.585 | 0.67 | 0.312 | 0.292 | 0.260 | 0.250 |
| 7/16 | 14 | 0.710 | 0.695 | 0.79 | 0.375 | 0.355 | 0.275 | 0.265 |
| 1/2 | 12 | 0.820 | 0.800 | 0.91 | 0.437 | 0.417 | 0.300 | 0.290 |
| (9/16) | 12 | 0.920 | 0.900 | 1.02 | 0.500 | 0.480 | 0.33 | 0.323 |
| 5/8 | 11 | 1.010 | 0.985 | 1.12 | 0.562 | 0.542 | 0.410 | 0.375 |
| 3/4 | 10 | 1.200 | 1.175 | 1.34 | 0.687 | 0.668 | 0.490 | 0.458 |
| 7/8 | 9 | 1.300 | 1.270 | 1.45 | 0.750 | 0.720 | 0.550 | 0.500 |
| 1 | 8 | 1.480 | 1.450 | 1.65 | 0.875 | 0.835 | 0.630 | 0.583 |
| 1.1/8 | 7 | 1.670 | 1.640 | 1.87 | 1.000 | 0.960 | 0.720 | 0.666 |
| 1.1/4 | 7 | 1.860 | 1.815 | 2.07 | 1.125 | 1.108 | 0.810 | 0.750 |
| 1.3/8 | 6 | 2.050 | 2.005 | 2.29 | 1.250 | 1.119 | 0.890 | 0.833 |
| 1.1/2 | 6 | 2.220 | 2.175 | 2.48 | 1.375 | 1.315 | 0.980 | 0.916 |
| 1.5/8 | 5 | 2.410 | 2.365 | 2.70 | 1.580 | 1.500 | 1.060 | 1.000 |
| 1.3/4 | 5 | 2.580 | 2.520 | 2.87 | 1.725 | 1.625 | 1.160 | 1.083 |
| 2 | 4.5 | 2.760 | 2.700 | 3.08 | 1.850 | 1.750 | 1.250 | 1.166 |
| 2.1/4 | 4 | 3.150 | 3.090 | 3.52 | 1.975 | 1.875 | 1.430 | 1.250 |
| 2.1/2 | 4 | 3.550 | 3.490 | 3.98 | 2.225 | 2.125 | 1.600 | 1.416 |

AJAX FASTENERS

# Unified Hexagon Nuts and Hexagon Lock Nuts

Threads UNC, UNF, Class 2B
Dimensions to ANSI/ASME B18.2.2 AS 2465

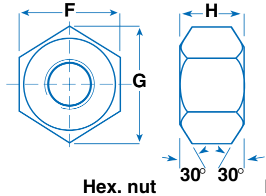



FIGURE 50

**Table 59** (All dimensions in inches) * Refer p13 for nut markings

| Dia | Threads per Inch | Across Flats F | | Across Corners G | | Thickness Standard H | | Thickness Jam Nut T | | Approx. Wt. lbs per 100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Std. | Jam. |
| 1/4 | 20 UNC<br>28 UNF | 0.438 | 0.428 | 0.505 | 0.488 | 0.226 | 0.212 | 0.163 | 0.150 | 0.753 | 0.515 |
| 5/16 | 18 UNC<br>24 UNF | 0.500 | 0.489 | 0.577 | 0.557 | 0.273 | 0.258 | 0.195 | 0.180 | 1.10 | 0.767 |
| 3/8 | 16 UNC<br>24 UNF | 0.562 | 0.551 | 0.650 | 0.628 | 0.337 | 0.320 | 0.227 | 0.210 | 1.60 | 1.05 |
| 7/16 | 14 UNC<br>20 UNF | 0.688 | 0.675 | 0.794 | 0.768 | 0.385 | 0.365 | 0.260 | 0.240 | 2.84 | 1.86 |
| 1/2 | 13 UNC<br>20 UNF | 0.750 | 0.736 | 0.866 | 0.840 | 0.448 | 0.427 | 0.323 | 0.302 | 3.75 | 2.62 |
| 9/16 | 12 UNC<br>18 UNF | 0.875 | 0.861 | 1.010 | 0.982 | 0.496 | 0.473 | 0.324 | 0.301 | 5.83 | 3.68 |
| 5/8 | 11 UNC<br>18 UNF | 0.938 | 0.922 | 1.083 | 1.051 | 0.559 | 0.535 | 0.387 | 0.363 | 7.33 | 4.93 |
| 3/4 | 10 UNC<br>16 UNF | 1.125 | 1.088 | 1.299 | 1.240 | 0.665 | 0.617 | 0.446 | 0.398 | 11.9 | 7.70 |
| 7/8 | 9 UNC<br>14 UNF | 1.312 | 1.269 | 1.516 | 1.447 | 0.776 | 0.724 | 0.510 | 0.458 | 19.0 | 12.0 |
| 1 | 8 UNC<br>12 UNF | 1.500 | 1.450 | 1.732 | 1.653 | 0.887 | 0.831 | 0.575 | 0.519 | 28.3 | 17.6 |

Proof load stress see Table 60.

# Unified Hexagon Nuts and Hexagon Lock Nuts

**Table 60** Mechanical Properties (Hexagon Nuts)

| Size Range | Strength Specifications | Thread | "Proof Load" Stress lbf/in$^2$ |
|---|---|---|---|
| Up to and including 1" | SAE Grade 5 | UNC | 120,000 |
| | SAE J995 | UNF | 109,000 |
| 3/4" to 1" inclusive | SAE Grade 8 | UNC | 150,000 |
| | SAE J995 | UNF | 150,000 |

AJAX FASTENERS

# Nyloc Nuts Metric

Thread, ISO Metric Coarse Series Class 6H

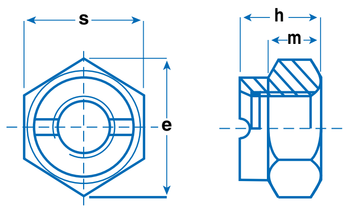



FIGURE 51

**Table 61** Dimensions, comply to P Type DIN 6924; T Type DIN 985.

| Nom. Dia. | Pitch of Thread | s | | e | | h | m | h | m |
|---|---|---|---|---|---|---|---|---|---|
| | | Across Flats | | Across Corners | | P TYPE | | T TYPE | |
| | | | | | | Nut Height | Thread Height | Nut Height | Thread Height |
| | | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. |
| M4 | 0.7 | 7.00 | 6.78 | 8.10 | 7.66 | 6.0 | 2.90 | – | – |
| M5 | 0.8 | 8.00 | 7.78 | 9.20 | 8.79 | 6.3 | 4.4 | – | – |
| M6 | 1.0 | 10.00 | 9.78 | 11.50 | 11.05 | 8.0 | 4.9 | 6 | 4 |
| M8 | 1.25 | 13.00 | 12.73 | 15.00 | 14.38 | 9.5 | 6.44 | 8 | 5.5 |
| M10 | 1.5 | 16.00 | 15.75 | 18.47 | 17.77 | 11.9 | 8.04 | 10 | 6.5 |
| M12 | 1.75 | 18.0 | 17.75 | 20.77 | 20.03 | 14.9 | 10.87 | 12 | 8 |
| M14 | 2.0 | 21.00 | 20.16 | 24.24 | 23.35 | 17.0 | 12.1 | 14 | 9.5 |
| M16 | 2.0 | 24.00 | 23.67 | 27.70 | 26.75 | 19.1 | 14.4 | 16 | 10.5 |
| M18 | 2.5 | 27.00 | 26.16 | 31.16 | 29.56 | 21.0 | 15.5 | 18.5 | 13.0 |
| M20 | 2.5 | 30.00 | 29.16 | 34.60 | 32.95 | 22.8 | 16.9 | 20.0 | 14.0 |
| M22 | 2.5 | 34.00 | 33.00 | 39.24 | 37.29 | 25.0 | 18.6 | 22.0 | 15.0 |
| M24 | 3.0 | 36.00 | 35.00 | 41.60 | 39.55 | 27.1 | 20.2 | 24.0 | 15.0 |
| M27 | 3.0 | 41.0 | 40.0 | 47.32 | 45.19 | 28.6 | 22.3 | 27.0 | 17.0 |
| M30 | 3.5 | 46.00 | 45.00 | 53.10 | 50.85 | 32.6 | 24.30 | 30.0 | 19.0 |

AJAX FASTENERS

# Nyloc Nuts Metric

Thread, ISO Metric Coarse Series Class 6H

**Table 61** Continued

| Nom. Dia. | Pitch of Thread | s | | e | | h | m | h | m |
|---|---|---|---|---|---|---|---|---|---|
| | | Across Flats | | Across Corners | | P TYPE | | T TYPE | |
| | | | | | | Nut Height | Thread Height | Nut Height | Thread Height |
| | | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. |
| M33 | 3.5 | 50.0 | 49.0 | 57.70 | 55.36 | 35.9 | 26.8 | 33.0 | 22.0 |
| M36 | 4.0 | 55.00 | 53.80 | 63.50 | 60.79 | 38.9 | 29.4 | 24.50 | 26.0 |
| M39 | 4.0 | 60.0 | 58.8 | 69.24 | 66.43 | 42.1 | 31.7 | 39 | 27.0 |
| M42 | 4.5 | 65.00 | 63.80 | 75.10 | 72.09 | 50.5 | 33.20 | 28.90 | 32.0 |
| M48 | 5.0 | 75.00 | 73.10 | 86.60 | 82.60 | 57.5 | 37.20 | 32.90 | 36.0 |

## Mechanical Properties:

| | | | |
|---|---|---|---|
| P Type | M4–M24 | Proof Load Stress 800 MPa | AS1285P.C.8 |
| P Type | M30–M36 | Proof Load Stress 400 MPa | – |
| T Type | M6–M16 | Proof Load Stress 600 MPa | AS1285P.C.6 |
| T Type | M20–M36 | Proof Load Stress 400 MPa | – |

AJAX FASTENERS

# Nyloc Nuts BSW

Threads BSW, AS B47 normal
Dimensions to manufacturers standard

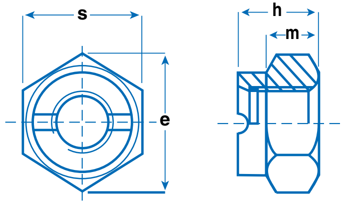



FIGURE 52

**Table 62** (All dimensions in inches)

| Nom. Dia. | Threads Per Inch | s | | e | h | m | h | m |
|---|---|---|---|---|---|---|---|---|
| | | Across Flats | | Across Corners | P TYPE | | T TYPE | |
| | | | | | Nut Height | Thread Height | Nut Height | Thread Height |
| | | Max. | Min. | Max. | Max. | Min. | Max. | Min. |
| 3/16 | 24 | 0.324 | 0.319 | 0.374 | 0.267 | 0.156 | – | – |
| 1/4 | 20 | 0.445 | 0.435 | 0.510 | 0.321 | 0.190 | 0.254 | 0.123 |
| 5/16 | 18 | 0.525 | 0.515 | 0.610 | 0.378 | 0.240 | 0.294 | 0.156 |
| 3/8 | 16 | 0.600 | 0.585 | 0.690 | 0.438 | 0.302 | 0.333 | 0.198 |
| 7/16 | 14 | 0.710 | 0.695 | 0.820 | 0.528 | 0.365 | 0.403 | 0.240 |
| 1/2 | 12 | 0.820 | 0.800 | 0.950 | 0.593 | 0.427 | 0.447 | 0.281 |
| 5/8 | 11 | 1.010 | 0.985 | 1.170 | 0.722 | 0.552 | 0.535 | 0.365 |
| 3/4 | 10 | 1.200 | 1.175 | 1.390 | 0.960 | 0.677 | 0.731 | 0.448 |
| 7/8 | 9 | 1.300 | 1.270 | 1.500 | 1.012 | 0.740 | 0.762 | 0.490 |
| 1 | 8 | 1.480 | 1.450 | 1.710 | 1.113 | 0.865 | 0.821 | 0.573 |
| 1.1/8 | 7 | 1.670 | 1.640 | 1.930 | 1.239 | 0.990 | 0.905 | 0.656 |
| 1.1/4 | 7 | 1.860 | 1.815 | 2.150 | 1.440 | 1.105 | 1.065 | 0.730 |
| 1.1/2 | 6 | 2.220 | 2.175 | 2.560 | 1.734 | 1.355 | 1.274 | 0.896 |
| 1.3/4 | 5 | 2.580 | 2.520 | 2.980 | 1.985 | 1.605 | 1.450 | 1.063 |
| 2 | 4.5 | 2.760 | 2.700 | 3.190 | 2.125 | 1.730 | 1.565 | 1.146 |

## Mechanical Properties:

P Type Proof Load Stress 28 tonf/in$^2$ (432 MPa) AS 2451
T Type Proof Load Stress 14 tonf/in$^2$ (216 MPa)

Don't RISK it ! ... specify AJAX

AJAX FASTENERS

# Nyloc Nuts UNC/UNF

Thread, Unified Dimensions comply to ESNA NM-NE light series

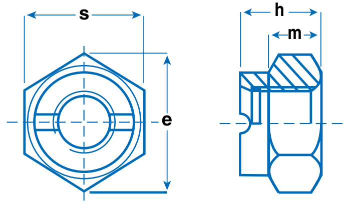



FIGURE 53

**Table 63** (All dimensions in inches)

| Nom. Dia. | Threads Per Inch UNC UNF | s Across Flats | | e Across Corners | h P TYPE Nut Height | m P TYPE Hex Height | h T TYPE Nut Height | m T TYPE Hex Height |
|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Max. | Max. | Ref. | Max. | Ref. |
| 1/4 | 20<br>28 | 0.439 | 0.430 | 0.488 | 0.328 | 0.225 | 0.240 | 0.128 |
| 5/16 | 18<br>24 | 0.502 | 0.492 | 0.557 | 0.359 | 0.250 | 0.265 | 0.158 |
| 3/8 | 16<br>24 | 0.564 | 0.553 | 0.628 | 0.468 | 0.335 | 0.348 | 0.220 |
| 7/16 | 14<br>20 | 0.627 | 0.615 | 0.698 | 0.468 | 0.324 | 0.328 | 0.225 |
| 1/2 | 13<br>20 | 0.752 | 0.741 | 0.840 | 0.609 | 0.464 | 0.328 | 0.190 |
| 9/16 | 12<br>18 | 0.877 | 0.865 | 0.982 | 0.656 | 0.469 | – | – |
| 5/8 | 11<br>18 | 0.940 | 0.928 | 1.051 | 0.765 | 0.593 | 0.406 | 0.265 |
| 3/4 | 10<br>16 | 1.064 | 1.052 | 1.191 | 0.890 | 0.742 | 0.421 | 0.288 |
| 7/8 | 9<br>14 | 1.312 | 1.269 | 1.447 | 1.022 | 0.758 | 0.484 | 0.340 |
| 1 | 8<br>12 | 1.500 | 1.450 | 1.615 | 1.098 | 0.858 | 0.578 | 0.405 |

AJAX FASTENERS

# Nyloc Nuts UNC/UNF

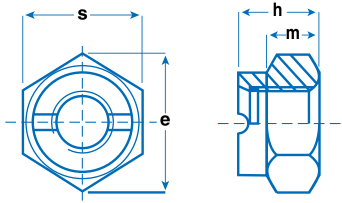



FIGURE 54

## Table 64 continued (All dimensions in inches)

| Nom. Dia. | Threads Per Inch UNC UNF | s | | e | h | m | h | m |
|---|---|---|---|---|---|---|---|---|
| | | Across Flats | | Across Corners | P TYPE | | T TYPE | |
| | | | | | Nut Height | Hex Height | Nut Height | Hex Height |
| | | Max. | Min. | Max. | Max. | Ref. | Max. | Ref. |
| 1.1/8 | 7<br>12 | 1.688 | 1.631 | 1.826 | 1.224 | 0.949 | – | – |
| 1.1/4 | 7<br>12 | 1.875 | 1.812 | 2.038 | 1.365 | 1.040 | 0.765 | 0.523 |
| 1.1/2 | 6<br>12 | 2.250 | 2.175 | 2.416 | 1.618 | 1.255 | 0.828 | 0.565 |
| 1.3/4 | 5<br>12 | 2.750 | 2.662 | 3.035 | 2.052 | 1.689 | 1.302 | 0.939 |
| 2 | 4.5<br>12 | 3.125 | 3.025 | 3.449 | 2.367 | 1.935 | 1.492 | 1.060 |

## Mechanical Properties:

| | | | | |
|---|---|---|---|---|
| UNC P Type | 1/4"– 3/4" | Proof Load Stress 120,000 lbf/in$^2$ | (827 MPa) | AS 2465 G5 |
| UNC P Type | 7/8"– 2" | Proof Load Stress 90,000 lbf/in$^2$ | (621 MPa) | AS 2465 G2 |
| UNF P Type | 1/4"– 3/4" | Proof Load Stress 109,000 lbf/in$^2$ | (952 MPa) | AS 2465 G5 |
| UNF P Type | 7/8"– 2" | Proof Load Stress 90,000 lbf/in$^2$ | (621 MPa) | AS 2465 G2 |
| UNC T Type | 1/4"– 1.1/2" | Proof Load Stress 72,000 lbf/in$^2$ | (496 MPa) | |
| UNC T Type | 1/4"– 1.1/2" | Proof Load Stress 65,000 lbf/in$^2$ | (448 MPa) | |

AJAX FASTENERS

# Correct Use of Jam or Lock Nuts

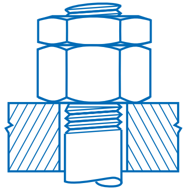


**FIGURE 55**
**WRONG**

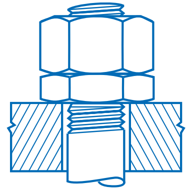


**FIGURE 56**
**RIGHT**

When a Jam or Lock Nut is to be used, it should always be placed as shown in Fig. 56, not as in Fig. 55.

The lock nut must always be assembled on the bolt first and pulled up snug, but not tightened severely enough to produce a high tension in the bolt.

The top nut is then assembled, and as it is tightened the threads of the lock nut must first bear upward on the bolt threads, then are free, and finally bear downward on the bolt threads, while the threads of the top nut bear upwards on the bolt threads.

Thus the two nuts are bearing in opposite directions on the threads and are **jammed.**

This locking effect will remain even if the bolt tension is lost.

The final bolt tension is therefore higher than that originally set up by the bottom nut, and may in fact be higher than could be sustained by the bottom nut alone, since most of the tension is now being supplied by the top nut.

## Conclusion

The bottom nut should be the Jam or Lock Nut. It should not have a tight thread fit. It should be applied with only moderate initial torque. The top nut should be wrenched on the full torque requirements. During final wrenching, the bottom nut should be held from turning.

AJAX FASTENERS

# Deck Spikes Square Shank – Chisel Pointed

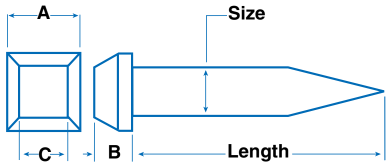



FIGURE 57

## Table 65

| Dimensions in Inches | | | |
|---|---|---|---|
| Size | A | B | C |
| 3/8 | 9/16 | 9/32 | 3/8 |
| 1/2 | 3/4 | 3/8 | 1/2 |

Enquire for stock availability.

# Dog Spikes Square Shank Sheared Pattern

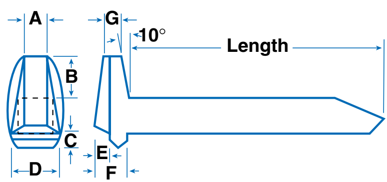



FIGURE 58

## Table 66

| Dimensions in Inches | | | | | | | |
|---|---|---|---|---|---|---|---|
| Size | A | B | C | D | E | F | G |
| 5/16 | 9/32 | 1/2 | 3/16 | 13/32 | 9/64 | 3/8 | 3/16 |
| 3/8 | 9/32 | 9/16 | 3/16 | 7/16 | 11/64 | 13/32 | 7/32 |

Enquire for stock availability.

# Corrosion Protective Coatings

***Acknowledgement is made to the American Industrial Fasteners Institute for information in this article***

## Corrosion Protective Coating

Approximately 90 per cent of all carbon steel fasteners are plated, coated, or furnished with some other type of supplementary finish. Although the principal reason is to protect against corrosion, such treatments also enhance appearance, control installation torque-tension relationships, minimise thread seizing, and assist product identification.

## Coating

Coatings are adherent layers applied to the surface of a base metal. For commercial fasteners, practically all deposition is accomplished by electroplating, hot-dipping or mechanically. Other processes such as, spraying molten metal, vacuum metalizing, chemical vapor deposition, ion plating, enameling and dip and bake are special purpose and economically impractical for stock commercial fasteners.

## Metallic Coatings

Zinc is by far the most widely used plating metal followed in popularity by cadmium and aluminum, which has modest use. Copper, tin, nickel, chromium, lead and silver are used to a lesser degree – all for special reasons.

## Zinc

Zinc, is favoured as a plating metal because in the Galvanic Series, it is less noble than carbon steel, stainless steel, and most other nonferrous metals used in fastener applications. In an electrochemical reaction, the plating metal corrodes, and through its sacrifice, the base metal remains protected. Only after the plating metal has been significantly lost to corrosion does corrosion of the base metal begin. Other plating metals are more noble than carbon steel. When the coating is breached, the base metal comes under immediate attack.

Zinc is the popular fastener coating also because it is the least expensive, has good appearance, can be applied in a broad range of thickness, by self passivation has good-to-excellent corrosion resistance, and is relatively non-toxic. Zinc plated fasteners may require more tightening torque to develop equivalent preloads in threaded fasteners. Also zinc coatings without some

# Corrosion Protective Coatings

supplementary protection develop a dull white corrosion product on their surface which is nicknamed "white rust". Because of its unsightly appearance, most zinc plated fasteners are given chromate treatment, which is a chemical conversion process to cover the zinc surface with a hard non-porous film. This added coating effectively seals the surface, protects it against early tarnishing, and reinforces the fastener's resistance to corrosion attack. Chromate coatings are available clear, iridescent, or in a variety of colours.

## Plating Thickness

As a general rule, fastener service life, in a corrosive atmosphere, is proportional to the thickness of its plating. The thicker the plating the longer it will survive.

Electroplated fasteners have plating thicknesses ranging from a "flash" coating of insignificant thickness, to a "commercial" thickness of 0.0002 in. 5μm, through to 0.0005 in. 12μm. Thicker electroplatings are possible but, from an economic viewpoint, quite impractical.

Hot-dip galvanising produces much thicker coatings, which in engineering standards are expressed in terms of mass of plating metal deposited per unit area of coated surface. Standard hot-dip galvanised fasteners have an average thickness coating of .002/in2 (50μm in thickness). Heavier coatings to .003 (80μm) are feasible, but such coatings may necessitate adjustments in mating thread fits to a degree that the fastener's strength properties may be adversely affected.

Mechanically plated coating thicknesses are available through the full range offered by either electroplating or hot-dip galvanising.

## Life Expectancy

For several years, the relative corrosion combating performance of zinc electroplated and hot-dip galvanised fasteners compared with mechanically plated fasteners has been under investigation. A range of exposure environments indicated equivalent performances for fasteners having the same coating thickness.

Useful service life expectancies of zinc plated fasteners in various environments are:

> Zinc plated with chromate treatment, 0.0005 In. plating thickness: up to 20 years indoors, about 4 years in a rural atmosphere,

# Corrosion Protective Coatings

2 years in coastal locations and less than 1 year in heavily polluted industrial atmosphere.

Hot-dip galvanised with an average thickness of 0.002in: over 40 years in a rural atmosphere, 25 to 30 years in coastal locations, and 5 years or longer in heavily polluted industrial atmosphere.

Survivability is almost a direct function of coating thickness. However, plating is expensive. Costs – and attendant problems – increase with increasing plating thickness. Consequently, the prudent engineer is advised to specify only that thickness of plating required to satisfy the application.

## Plating Distribution

The build up of plating on fastener surfaces occurs differently with each of the principal deposition methods.

Electroplating deposits the plating metal unevenly with exterior edges and corners receiving thicker coatings. In the fastener's threaded section, the thickest plating is located at the thread crests and becomes progressively thinner on the thread flanks, with the thinnest deposits in the thread roots. With hot-dip galvanising, it is just the opposite, with thicker coatings deposited at interior corners and in the thread roots. Because clogging of thread roots is difficult to control, it is usually impractical to hot-dip galvanize fasteners of nominal sizes smaller than M10 (3/8"). Mechanical plating tends to deposit the plating metal similarly to hot-dip galvanising but more smoothly and considerably more uniform in thickness over the entire surface.

## Plating Problems

Two serious problems are directly attributed to plating – thread assembly and hydrogen embrittlement.

## Thread Fit

The addition of a plating to its surface increases the size of the fasteners. When the plating thickness exceeds certain limits – generally one-fourth of the specified allowance for the class of thread fit – there is a distinct possibility the internally and externally threaded parts will not assemble. When interference between mating threads is likely, some accommodation must be made prior to plating. Recommended practices for adjusting thread fits of plated fasteners are discussed in AS 1897-1976.

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# Corrosion Protective Coatings

## Hydrogen Embrittlement

High strength, high hardness carbon steel fasteners have a susceptibility to embrittlement, which evidences itself in various mechanisms. Plated and coated fasteners, especially those that are electroplated, are vulnerable to the one known as hydrogen embrittlement.

Hydrogen embrittlement causes fastener failures, the actual fracture of the fastener into two separate pieces. The failure occurs in service (i.e. after the fastener has been installed and tightened in its application), it usually happens within hours, it's sudden, there's no advance warning or visible indication of imminence.

To neutralise the threat of hydrogen embrittlement, fasteners are thermally baked as early as possible after plating. Time delays seriously jeopardise the effectiveness and benefits of the baking. The purpose of the baking – generally at 190°–210° for 3 to 24 hours dependent on plating type and thickness – is to drive out the hydrogen by bleeding it through the plating. Baking is always done prior to chromating or application of any other supplementary coating.

In broad terms, fasteners with hardnesses less than Rockwell C32 have a low risk of enbrittlement. Those with higher hardnesses should be Hydrogen Embrittlement Relieved.

Because mechanical plating is non electrolytic, the hydrogen embrittlement threat is virtually eliminated. In fact, parts with hardness up to Rockwell C55, mechanically plated without post baking, have performed satisfactorily without evidence of embrittlement.

Hot-dip galvanized fasteners are rarely subject to hydrogen embrittlement. The primary reason is that engineering standards strongly discourage the hot-dip galvanizing of fasteners with hardnesses higher than Rockwell C35 – i.e. fasteners stronger than AS 1110 - 1995 – 8.8, AS 1252 - 1983 – 8.8 and AS 2465 - 1999 – Grade 5. The reason is that galvanised fasteners of higher strengths have a susceptibility to another embrittlement mechanism known as stress corrosion or stress corrosion cracking.

## Chemical Conversion Coatings

Chemical conversion coatings are adherent films chemically formed on a metal's surface when immersed in a bath of appropriate solution.

# Corrosion Protective Coatings

Chemical conversion coatings popularly specified for fasteners are chromate treatments on electroplated parts (mentioned earlier) and zinc and manganese phosphate coatings.

Zinc phosphate coatings, or manganese phosphate often used as a permitted alternative, are extensively specified for fasteners, particularly those intended for use in automotive application. The phosphate base provides an excellent substrate for painting and for retention of oils, waxes or other organic lubricating materials. Most zinc phosphated fasteners are additionally oiled to enhance corrosion resistance and to help control torque-tension relationships. Dry zinc phosphate is often used as a base for non-metallic locking elements on externally threaded fasteners.

The corrosion resistance of zinc phosphated and oiled fasteners is reasonably good in non-aggressive atmospheres. Significant improvements are possible through secondary treatments, such as painting.

Although phosphate-coated high strength fasteners are not immune to hydrogen embrittlement, susceptibility and frequency of occurrence are less than similar fasteners which have been electroplated. Unlike deposited plating, phosphate coatings do not significantly increase fastener size. Tolerance 6g/6H (Class 2A/2B) screw thread fits are usually adequate to permit assembly. Rarely is it necessary to make adjustments in thread size limits prior to coating.

One of the more important considerations when evaluating the possible use of phosphate coated fastener is cost. Phosphate and oiled coatings are less expensive than zinc electroplating with chromate treatment. However, the packaging and handling of phosphate and oiled fasteners has a degree of sensitivity because the oil may be removed by absorption into the packing materials.

## Fastener Coating Selection Chart

Table No 67 is condensed from Ajax Bulletin No. 6-69, where materials other than steel are included (e.g. stainless steel, brass, aluminium). It gives recommendations as to the finishes on steel bolts which are considered satisfactory – from the corrosion viewpoint – for the joining of metals which could cause "galvanic" effects.

# Corrosion Protective Coatings

## Australian Standards associated with corrosion protective coatings are:

### Metric

AS 1110-1995 ISO Metric Hexagon Precision Bolts and Screws
AS 1111-1996 ISO Metric Hexagon Commercial Bolts and Screws
AS 1112-1996 ISO Metric Hexagon Nuts
AS 1214-1983 Hot-dip Galvanised Coatings on Threaded Fasteners (ISO Metric)
AS 1252-1983 High Strength Steel Bolts with associated Nuts and Washers for Structural Engineering (ISO metric)
AS 1390-1997 Metric Cup Head Bolts
AS 1559-1986 Fasteners – Bolts, Nuts and Washers for Tower Construction
AS 1791-1986 Chromate Conversion Coatings Zinc and Cadmium
AS 1897-1976 Electroplated Coatings on Threaded Components (ISO Metric)

### Inch

AS B108-1952 Black Cup and Countersunk Bolts, Nuts and Washers
AS 2465-1999 Unified Hexagon Bolts, Screws and Nuts (UNC and UNF threads)
AS B193-1970 Hot Dip Galvanised Coating on Fasteners (BSW and UNC threads)
AS K132.2-1973 Electroplated Coating on Threaded Components (Zinc on Steel)
AS 1627.6-1977 Phosphate Treatment of Iron and Steel Surfaces.

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# Corrosion Protective Coatings

## Table 67

| Metal Joined | Bolt Coating | | | | | | |
|---|---|---|---|---|---|---|---|
| | Gal-vanised | Zinc Plated | Cad-mium Plated | Chrom-ium Plated 2 | Lead /Tin Plated | Black or Bright | Austen-itic S/Steel |
| Steel, Cast Iron | S | S | S | S | S | R | S |
| Zinc Coated Steel | R | S1 | S1 | S | S | U | S |
| Tin Coated Steel | U | U | U | S | U | U | R |
| Chromium Plated Steel | U | U | U | R | U | U | R |
| Stainless Steel | U | U | U | S | U | U | R |
| Aluminium | S3 | S3 | R | S | S | U | R |
| Copper, Brass | U | U | U | U | U | U | S |
| Nickel, Monel | U | U | U | S | U | U | S |
| Lead | U | U | U | S | R | | R |

**Key to performance** R = Recommended S = Satisfactory U = Unsuitable

## Notes

1. Protection of the small area of the fastener depends on amount of zinc available on the surrounding galvanised surface.
2. "Chromium plated" – including the trade term "chrome plated" – means plated with a thin layer of chromium over a more substantial layer of nickel (and perhaps copper).
3. Aluminium is the protected member of aluminium-zinc combinations, causing accelerated corrosion of the zinc. Since wastage of the zinc coating will eventually lead to exposure of the basis steel of the fastener, and then this bare steel could accelerate corrosion of the aluminium – and also cause staining – the greater the available amount of zinc the better. Thus, in the absence of painting, the more heavily coated hot dipped galvanised fastening is a better choice than its zinc plated counterpart.

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# Tapping Drill Tables

The tapping drills given in the following pages include millimetre sizes for the convenience of those who are working in or intend to work predominantly in metric units.

Drills have been selected from standard sizes which, when used with reasonable care, will produce holes within the minor diameter limits shown. From those drills the larger sizes are recommended to facilitate ease of tapping.
As a guide to relative clearances, index figures adjacent to the drill size show the difference between the nominal drill and minimum minor diameters.

**Table 68** ISO Metric Coarse Pitch Series

| Thread Size and Pitch | Minor Diameter of nut thread (A) | | Tapping Drill Sizes for Commercial Tapping | | |
|---|---|---|---|---|---|
| | Maximum | Minimum | Recommended | | Alternatives |
| mm | mm | mm | mm | Inch | mm |
| M 1.6 x 0.35 | 1.321 | 1.221 | 1.30$^{3}$ | 3/64$^{0}$ | 1.25$^{1}$ |
| M 2 x 0.4 | 1.679 | 1.567 | 1.65$^{4}$ | 1/16$^{1}$ | 1.60$^{1}$ |
| M 2.5 x 0.45 | 2.138 | 2.013 | 2.10$^{3}$ | No. 46$^{9}$ | 2.05$^{1}$ |
| M 3 x 0.5 | 2.599 | 2.459 | 2.55$^{3}$ | No. 41$^{0}$ | 2.50$^{1}$ |
| M 4 x 0.7 | 3.422 | 3.242 | 3.40$^{6}$ | No. 30$^{1}$ | 3.30$^{2}$ |
| M 5 x 0.8 | 4.334 | 4.134 | 4.30$^{6}$ | No. 19$^{3}$ | 4.20$^{2}$ |
| M 6 x 1.00 | 5.133 | 4.917 | 5.10$^{7}$ | No. 9$^{2}$ | 5.00$^{3}$ |
| M 8 x 1.25 | 6.912 | 6.647 | 6.90$^{10}$ | 17/64$^{4}$ | 6.80$^{6}$ |
| M10 x 1.5 | 8.676 | 8.376 | 8.60$^{9}$ | Q$^{2}$ | 8.50$^{5}$ |
| M12 x 1.75 | 10.441 | 10.105 | 10.40$^{11}$ | 13/32$^{8}$ | 10.20$^{4}$ |
| M16 x 2.00 | 14.210 | 13.835 | 14.00$^{6}$ | 35/64$^{2}$ | — |
| M20 x 2.5 | 17.744 | 17.294 | 17.50$^{8}$ | 11/16$^{7}$ | — |
| M24 x 3.0 | 21.252 | 20.752 | 21.00$^{10}$ | 53/64$^{11}$ | — |
| M30 x 3.5 | 26.771 | 26.211 | 26.50$^{11}$ | 1.3/64$^{15}$ | — |
| M36 x 4.0 | 32.270 | 31.670 | 32.00$^{13}$ | 1.17/64$^{19}$ | — |

(A) From AS 1275 for Class 6H.

The small index figures show the theoretical clearance **in thousandths of an inch** above the minimum minor diameter of the nut thread.

Letter and wire gauge drills are obsolescent and are being replaced by metric sizes.

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# Tapping Drill Tables

**Table 69** British Standard Whitworth – B.S.W.

| Thread size and threads per inch | Minor Diameter of nut thread (A) | | Tapping Drill Sizes for Commercial Tapping | | | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum | Recommended | | Alternatives | |
| | Inch | Inch | Inch | mm | Inch | |
| 1/8 – 40 | 0.1020 | 0.0930 | 39$^{7}$ | 2.55$^{7}$ | 40$^{5}$ | |
| 3/16 – 24 | 0.1474 | 0.1341 | 27$^{10}$ | 3.70$^{12}$ | 28$^{6}$ | |
| 1/4 – 20 | 0.2030 | 0.1860 | 9$^{10}$ | 5.00$^{11}$ | 10$^{7}$ | 12$^{3}$ |
| 5/16 – 18 | 0.2594 | 0.2413 | 1/4$^{9}$ | 6.40$^{11}$ | D$^{5}$ | C$^{1}$ |
| 3/8 – 16 | 0.3145 | 0.2950 | N$^{7}$ | 7.70$^{8}$ | 19/64$^{2}$ | S$^{2}$ |
| 7/16 – 14 | 0.3674 | 0.3461 | T$^{12}$ | 9.10$^{12}$ | Y$^{11}$ | X$^{4}$ |
| 1/2 – 12 | 0.4169 | 0.3932 | 13/32$^{13}$ | 10.40$^{13}$ | | |
| 9/16 – 12 | 0.4794 | 0.4557 | 15/32$^{13}$ | 12.00$^{7}$ | | |
| 5/8 – 11 | 0.5338 | 0.5086 | 17/32$^{23}$ | 13.50$^{23}$ | 33/64$^{7}$ | |
| 3/4 – 10 | 0.6490 | 0.6220 | 41/64$^{19}$ | 16.25$^{17}$ | 5/8$^{3}$ | |
| 7/8 – 9 | 0.7620 | 0.7328 | 3/4$^{17}$ | 19.00$^{15}$ | 47/64$^{2}$ | |
| 1 – 8 | 0.8720 | 0.8400 | 55/64$^{19}$ | 22.00$^{26}$ | 27/32$^{1}$ | |
| 1.1/8 – 7 | 0.9776 | 0.9420 | 31/32$^{27}$ | 24.50$^{22}$ | 61/64$^{11}$ | |
| 1.1/4 – 7 | 1.1026 | 1.0670 | 1.3/32$^{27}$ | 27.50$^{16}$ | 1.5/64$^{11}$ | |
| 1.1/2 – 6 | 1.3269 | 1.2866 | 1.5/16$^{26}$ | 33.00$^{12}$ | 1.19/64$^{11}$ | |
| 1.3/4 – 5 | 1.5408 | 1.4938 | 1.17/32$^{37}$ | 38.50$^{22}$ | 1.33/64$^{20}$ | |
| 2 – 4.5 | 1.7668 | 1.7154 | 1.3/4$^{35}$ | 44.50$^{37}$ | 1.47/64$^{20}$ | |

(A) From AS B47 – normal and medium classes.

The small index figures show the theoretical clearance **in thousandths of an inch** above the minimum minor diameter of the nut thread.

Letter and wire gauge drills are obsolescent and are being replaced by metric sizes.

# Thread Screw Pitches

## Table 70

| ø | Inch Series | | | |
|---|---|---|---|---|
| Diameter in inches | Threads per inch | | | |
| | BSW | BSF | UNC | UNF |
| No. 8 | — | — | 32 | 36 |
| No. 10 | — | — | 24 | 32 |
| 3/16 | 24 | 32 | — | — |
| 1/4 | 20 | 26 | 20 | 28 |
| 5/16 | 18 | 22 | 18 | 24 |
| 3/8 | 16 | 20 | 16 | 24 |
| 7/16 | 14 | 18 | 14 | 20 |
| 1/2 | 12 | 16 | 13 | 20 |
| 9/16 | 12 | 16 | 12 | 18 |
| 5/8 | 11 | 14 | 11 | 18 |
| 3/4 | 10 | 12 | 10 | 16 |
| 7/8 | 9 | 11 | 9 | 14 |
| 1 | 8 | 10 | 8 | 12 |
| 1.1/8 | 7 | 9 | 7 | 12 |
| 1.1/4 | 7 | 9 | 7 | 12 |
| 1.3/8 | 6 | 8 | 6 | 12 |
| 1.1/2 | 6 | 8 | 6 | 12 |
| 1.5/8 | 5 | 8 | — | — |

| ISO Metric Preferred Coarse Pitch Series | |
|---|---|
| Dia. in mm | Pitch in mm |
| 1.6 | 0.35 |
| 2 | 0.4 |
| 2.5 | 0.45 |
| 3 | 0.5 |
| 4 | 0.7 |
| 5 | 0.8 |
| 6 | 1 |
| 8 | 1.25 |
| 10 | 1.5 |
| 12 | 1.75 |
| 16 | 2 |
| 20 | 2.5 |
| 24 | 3 |
| 30 | 3.5 |
| 36 | 4 |
| 42 | 4.5 |
| 48 | 5 |
| 56 | 5.5 |
| 64 | 6 |

# Thread Screw Pitches

**Table 70** continued

| ø | Inch Series | | | |
|---|---|---|---|---|
| Diameter in inches | Threads per inch | | | |
| | BSW | BSF | UNC | UNF |
| 1.3/4 | 5 | 7 | 5 | — |
| 2 | 4.5 | 7 | 4.5 | — |
| 2.1/4 | 4 | 6 | 4.5 | — |
| 2.1/2 | 4 | 6 | 4 | — |
| 2.3/4 | 3.5 | 6 | 4 | — |
| 3 | 3.5 | 5 | 4 | — |

AJAX FASTENERS

# Hardness Conversion Table

## Table 71

| Vickers Hardness | Rockwell C-Scale 150 kg Load Brale Penetrator | Rockwell B-Scale 100kg Load 1/16" dia. Ball | Brinell Hardness No. 3000kg Load 10mm Ball | Tensile Strength (Approximate) | | | Shore Sclero scope Hardness No. | Rockwell A-Scale 60 kg Load Brale Penetrator | Rockwell D-Scale 100kg Load Brale Penetrator | Rockwell Superficial Hardness No. Superficial Brale Penetrator 15-N Scale 15 kg Load | 30-N Scale 30kg Load | 45-N Scale 45 kg Load |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HV | HRC | HRB | HB | lbf/in² x 1000 | tonf/in² | N/mm² | | HRA | HRD | HR 15-N | HR 30-N | HR 45-N |
| 940 | 68 | — | — | — | — | — | 97 | 85.6 | 76.9 | 93.2 | 84.4 | 75.4 |
| 900 | 67 | — | — | — | — | — | 95 | 85.0 | 76.1 | 92.9 | 83.6 | 74.2 |
| 865 | 66 | — | — | — | — | — | 92 | 84.5 | 75.4 | 92.5 | 82.8 | 73.3 |
| 832 | 65 | — | 739 | — | — | — | 91 | 83.9 | 74.5 | 92.2 | 81.9 | 72.0 |
| 800 | 64 | — | 722 | — | — | — | 88 | 83.4 | 73.8 | 91.8 | 81.1 | 71.0 |
| 772 | 63 | — | 705 | — | — | — | 87 | 82.8 | 73.0 | 91.4 | 60.1 | 69.9 |
| 746 | 62 | — | 688 | — | — | — | 85 | 82.3 | 72.2 | 91.1 | 79.3 | 68.8 |
| 720 | 61 | — | 670 | — | — | — | 83 | 81.8 | 71.5 | 90.7 | 78.4 | 67.7 |
| 697 | 60 | — | 654 | — | — | — | 81 | 81.2 | 70.0 | 90.2 | 77.5 | 66.6 |
| 674 | 59 | — | 634 | — | — | 2450 | 80 | 80.7 | 69.9 | 89.8 | 86.8 | 65.5 |
| 653 | 58 | — | 615 | — | — | 2320 | 78 | 80.1 | 69.2 | 89.3 | 75.7 | 64.3 |
| 633 | 57 | — | 595 | — | — | 2230 | 76 | 79.6 | 68.5 | 88.7 | 74.8 | 63.2 |
| 613 | 56 | — | 577 | — | — | 2180 | 75 | 79.0 | 67.7 | 88.3 | 73.9 | 62.0 |
| 595 | 55 | — | 560 | 301 | 134 | 2080 | 74 | 78.5 | 66.9 | 87.9 | 73.0 | 60.9 |
| 577 | 54 | — | 543 | 292 | 130 | 2010 | 72 | 78.0 | 66.1 | 87.4 | 72.0 | 59.8 |
| 560 | 53 | — | 525 | 283 | 126 | 1950 | 71 | 77.4 | 65.4 | 86.9 | 71.2 | 58.6 |
| 544 | 52 | — | 512 | 273 | 122 | 1880 | 69 | 76.8 | 64.6 | 86.4 | 70.2 | 57.4 |

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# Hardness Conversion Table

**Table 71** continued

| Vickers Hardness | Rockwell C-Scale 150 kg Load Brale Penetrator | Rockwell B-Scale 100kg Load 1/16" dia. Ball | Brinell Hardness No. 3000kg Load 10mm Ball | Tensile Strength (Approximate) | | | Shore Sclero scope Hardness No. | Rockwell A-Scale 60 kg Load Brale Penetrator | Rockwell D-Scale 100kg Load Brale Penetrator | Rockwell Superficial Hardness No. Superficial Brale Penetrator 15-N Scale 15 kg Load | 30-N Scale 30kg Load | 45-N Scale 45 kg Load |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HV | HRC | HRB | HB | lbf/in² x 1000 | tonf/in² | N/mm² | | HRA | HRD | HR 15-N | HR 30-N | HR 45-N |
| 528 | 51 | — | 496 | 264 | 118 | 1820 | 68 | 76.3 | 63.8 | 85.9 | 69.4 | 56.1 |
| 513 | 50 | — | 481 | 255 | 114 | 1760 | 67 | 75.9 | 63.1 | 84.4 | 68.5 | 55.0 |
| 498 | 49 | — | 469 | 246 | 110 | 1700 | 66 | 75.2 | 62.1 | 85.0 | 67.0 | 53.8 |
| 484 | 48 | — | 451 | 237 | 106 | 1630 | 64 | 74.7 | 61.4 | 84.5 | 66.7 | 52.5 |
| 471 | 47 | — | 442 | 229 | 102 | 1580 | 63 | 74.1 | 60.8 | 83.9 | 65.8 | 51.4 |
| 458 | 46 | — | 432 | 222 | 99 | 1530 | 62 | 73.6 | 60.0 | 83.5 | 64.8 | 50.3 |
| 446 | 45 | — | 421 | 215 | 96 | 1480 | 60 | 63.1 | 57.2 | 83.0 | 64.0 | 49.0 |
| 434 | 44 | — | 409 | 208 | 93 | 1430 | 58 | 72.5 | 58.5 | 82.5 | 63.1 | 47.8 |
| 423 | 43 | — | 400 | 201 | 90 | 1390 | 57 | 72.0 | 57.6 | 82.0 | 62.2 | 46.7 |
| 412 | 42 | — | 390 | 194 | 86.5 | 1340 | 56 | 71.5 | 56.9 | 81.5 | 61.3 | 45.5 |
| 402 | 41 | — | 381 | 188 | 84 | 1300 | 55 | 70.9 | 46.2 | 80.9 | 60.4 | 44.3 |
| 392 | 40 | — | 371 | 181 | 81 | 1250 | 54 | 70.4 | 45.4 | 80.4 | 59.4 | 43.1 |
| 382 | 39 | — | 362 | 176 | 78.5 | 1210 | 52 | 69.7 | 54.6 | 79.0 | 58.6 | 41.9 |
| 372 | 38 | — | 353 | 171 | 76.5 | 1180 | 51 | 69.4 | 53.8 | 77.4 | 57.7 | 40.8 |
| 363 | 37 | — | 344 | 168 | 75 | 1160 | 50 | 68.9 | 53.1 | 68.8 | 56.8 | 39.6 |
| 354 | 36 | (109.0) | 336 | 162 | 72.5 | 1120 | 49 | 68.4 | 52.3 | 78.3 | 55.9 | 38.4 |
| 345 | 35 | (108.5) | 327 | 157 | 70 | 1080 | 48 | 67.7 | 51.5 | 77.7 | 55.0 | 37.2 |

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# Hardness Conversion Table

## Table 71 continued

| Vickers Hardness | Rockwell C-Scale 150 kg Load Brale Penetrator | Rockwell B-Scale 100kg Load 1/16" dia. Ball | Brinell Hardness No. 3000kg Load 10mm Ball | Tensile Strength (Approximate) | | | Shore Sclero scope Hardness No. | Rockwell A-Scale 60 kg Load Brale Penetrator | Rockwell D-Scale 100kg Load Brale Penetrator | Rockwell Superficial Hardness No. Superficial Brale Penetrator | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 15-N Scale 15 kg Load | 30-N Scale 30kg Load | 45-N Scale 45 kg Load |
| HV | HRC | HRB | HB | lbf/in² x 1000 | tonf/in² | N/mm² | | HRA | HRD | HR 15-N | HR 30-N | HR 45-N |
| 336 | 34 | (108.0) | 319 | 153 | 68.5 | 1050 | 47 | 67.4 | 50.8 | 77.2 | 54.2 | 36.1 |
| 327 | 33 | (107.5) | 311 | 149 | 66.5 | 1030 | 46 | 66.8 | 50.0 | 66.6 | 53.3 | 34.9 |
| 318 | 32 | (107.0) | 301 | 145 | 64.5 | 1000 | 44 | 66.3 | 49.2 | 76.1 | 52.1 | 33.7 |
| 310 | 31 | (106.0) | 294 | 142 | 63.5 | 979 | 43 | 65.8 | 48.4 | 75.6 | 51.3 | 32.5 |
| 302 | 30 | (105.5) | 286 | 138 | 61.5 | 951 | 42 | 65.3 | 47.7 | 75.0 | 40.4 | 31.3 |
| 294 | 29 | (104.5) | 279 | 135 | 60.5 | 931 | 41 | 64.7 | 47.0 | 74.6 | 47.5 | 30.1 |
| 286 | 28 | (104.0) | 271 | 132 | 59 | 910 | 41 | 64.3 | 46.1 | 73.7 | 48.6 | 28.9 |
| 279 | 27 | (103.0) | 264 | 128 | 57 | 883 | 40 | 63.8 | 45.2 | 63.3 | 47.7 | 27.8 |
| 272 | 26 | (102.5) | 258 | 125 | 56 | 862 | 38 | 63.3 | 44.6 | 72.8 | 46.8 | 28.7 |
| 266 | 25 | (101.5) | 253 | 122 | 54.5 | 841 | 38 | 62.8 | 43.8 | 72.2 | 45.9 | 25.5 |
| 260 | 24 | (101.0) | 247 | 120 | 53.5 | 827 | 37 | 62.4 | 43.1 | 71.6 | 45.0 | 24.3 |
| 254 | 23 | 100.0 | 243 | 117 | 52 | 807 | 36 | 62.0 | 62.1 | 71.0 | 44.0 | 23.1 |
| 248 | 22 | 99.0 | 237 | 114 | 51 | 786 | 35 | 61.5 | 41.6 | 70.5 | 43.2 | 22.0 |
| 243 | 21 | 98.5 | 231 | 112 | 50 | 772 | 35 | 61.0 | 40.9 | 69.9 | 42.3 | 20.7 |
| 238 | 20 | 97.8 | 226 | 110 | 49 | 758 | 34 | 60.5 | 40.1 | 69.4 | 41.5 | 19.6 |
| 230 | (18) | 96.7 | 219 | 106 | 47.5 | 731 | 33 | — | — | — | — | — |
| 222 | (16) | 95.5 | 212 | 102 | 45.5 | 703 | 32 | — | — | — | — | — |

# Hardness Conversion Table

## Table 71 continued

| Vickers Hardness | Rockwell C-Scale 150 kg Load Brale Penetrator | Rockwell B-Scale 100kg Load 1/16" dia. Ball | Brinell Hardness No. 3000kg Load 10mm Ball | Tensile Strength (Approximate) | | | Shore Sclero scope Hardness No. | Rockwell A-Scale 60 kg Load Brale Penetrator | Rockwell D-Scale 100kg Load Brale Penetrator | Rockwell Superficial Hardness No. Superficial Brale Penetrator | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 15-N Scale 15 kg Load | 30-N Scale 30kg Load | 45-N Scale 45 kg Load |
| HV | HRC | HRB | HB | lbf/in² x 1000 | tonf/in² | N/mm² | | HRA | HRD | HR 15-N | HR 30-N | HR 45-N |
| 213 | (14) | 93.9 | 203 | 98 | 44 | 676 | 31 | — | — | — | — | — |
| 204 | (12) | 92.3 | 194 | 94 | 42 | 648 | 29 | — | — | — | — | — |
| 196 | (10) | 90.7 | 187 | 90 | 40 | 621 | 28 | | | | | |
| 188 | (8) | 89.5 | 179 | 87 | 39 | 600 | 27 | | | | | |
| 180 | (6) | 87.1 | 171 | 84 | 37.5 | 579 | 26 | | | | | |
| 173 | (4) | 85.5 | 165 | 80 | 35.5 | 552 | 25 | | | | | |
| 166 | (2) | 83.5 | 158 | 77 | 34.5 | 531 | 24 | | | | | |
| 160 | (0) | 81.7 | 152 | 75 | 33.5 | 517 | 24 | | | | | |
| 150 | — | 78.7 | 143 | 71 | 31.5 | 490 | 22 | | | | | |
| 140 | — | 75.0 | 133 | 66 | 29.5 | 455 | 21 | | | | | |
| 130 | — | 71.2 | 124 | 62 | 27.5 | 427 | 20 | | | | | |
| 120 | — | 66.7 | 114 | 57 | 25.5 | 393 | — | | | | | |
| 110 | — | 62.3 | 105 | — | — | — | — | | | | | |
| 100 | — | 56.2 | 105 | — | — | — | — | | | | | |
| 95 | — | 52.0 | 90 | — | — | — | — | | | | | |
| 90 | — | 48.0 | 86 | — | — | — | — | | | | | |
| 85 | — | 41.0 | 81 | — | — | — | — | | | | | |

The values shown in black type are agreed SAE-ASM-ASTM values as published in ASTM. E-140 Table 2. Values in blue type are given in SAE tables but are not agreed values. Values in ( ) are beyond the normal range and are for information only.

**IMPORTANT**

All conversions must be regarded as approximate and applying only to steels. Australian Standard B-161 indicates the limitations of accuracy of conversion. Tensile strength conversions do not specifically apply to cold worked steels.

# Welding of Fasteners

This discussion outlines the metallurgical aspects of fusion welding processing. Recent remarkable advances have given welding a more reliable position in the metal industry. It has become common practice to shape and prepare metal parts and then join them by welding to produce engineering structures.

The aim of this outline is not to describe in detail the equipment and technique but to reveal the metallurgical features that affect the satisfactory welding of fasteners. Also to consider the hazards and safety precautions that need to be considered when welding fasteners to a variety of structures.

Fusion welding is defined as a group of processes in which metals are joined by bringing them to the molten state at the abutting surfaces and the importance of the effect of heat in all welding operations must be recognised. Welding is usually employed to unite like metals where the joining is required to develop strength and transmit stress. In the case of fasteners these are made from different steels and can create a problem of loss of strength, embrittlement from hydrogen or quench hardness.

In most cases carbon steels are used in the structures and to a great extent mild steel is the main structural component.

To weld fasteners in a satisfactory manner, it is essential to know the composition of the steel fastener.

The two elements in the composition of steel are important and affect the weld area.

**Steel with a carbon content** greater than 0.39% is not suitable for welding without special pre-heat with or without post heating.

**Steel with a sulphur content** greater than 0.050% are not suitable for welding as both porosity and cracking can occur.

Fasteners fall into a number of general categories namely:

1. Low tensile bolts - mild steel As 1111, 1559, 1390
2. High tensile bolts - steel containing 0.4% carbon
   AS 1110, 1252, 2465
3. Low tensile nuts - sulphurised mild steel
   AS 1112 - Property Class 5
4. High tensile nuts - steel containing 0.4% carbon and sulphur
   AS 1112 - Property Class 8, 10 and 12

# Welding of Fasteners

## 1. Low Tensile Bolts

The welding of low tensile bolts made from mild steel is easily achieved by following the welding procedures for mild steel. One note of caution is that when cold worked mild steel bolts are welded the tensile of the bolt can be lowered by the stress relieving effect of the heat generated by the welding process.

## 2. High Tensile Bolts (not recommended)

The welding of high tensile steels is not easily performed. It is necessary to pre-heat with or without post heat the weld area to remove any of the harmful effects from welding which affects the quality of the finished joint. The weldability of this grade of steel depends upon the carbon content of the bolt steel because the rapid cooling may produce martensite structures, and the formation of these structures tends to make the weld area hard, brittle and have undesirable characteristics.

## 3 & 4. Nuts

In the case of both low and high tensile nuts the amount of sulphur present in the steel can have the most deleterious affect on welding, because of porosity and the hot shortness imposed on the zone of fusion during solidification and cooling through the range of hot shortness when stresses can produce cracking in the metal.

A range of **Weld Nuts** is available, made from a weldable steel for use with resistance welders.

When considering welding make sure you contact Ajax for advice on the particular application.

# Conversion Factors

Table 72

| Convert | | Into Loads | | Multiply By Factor |
|---|---|---|---|---|
| Tonf | => | lbf | x | 2240 |
| lbf | => | Tonf | x | 0.000446 |
| tonnef | => | kN | x | 10 |
| kN | => | tonnef | x | 0.1 |
| lbf | => | kN | x | 0.00445 |
| kN | => | lbf | x | 224.8 |

## Torque Conversion

| | | | | |
|---|---|---|---|---|
| lbft | => | Nm | x | 1.36 |
| Nm | => | lbft | x | 0.74 |

## Stress Conversion

| | | | | |
|---|---|---|---|---|
| MPa | => | psi | x | 145 |
| psi | => | MPa | x | 0.006896 |

## Length Conversion

| | | | | |
|---|---|---|---|---|
| mm | => | in | x | 0.0394 |
| in | => | mm | x | 25.4 |

**Abbreviations**

lbf = pounds - force
lbft = pounds - feet
psi = pounds per square inch
in = inches
kN = kiloNewton
Nm = Newton - metre
MPa = Megapascals
mm = millimetres

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