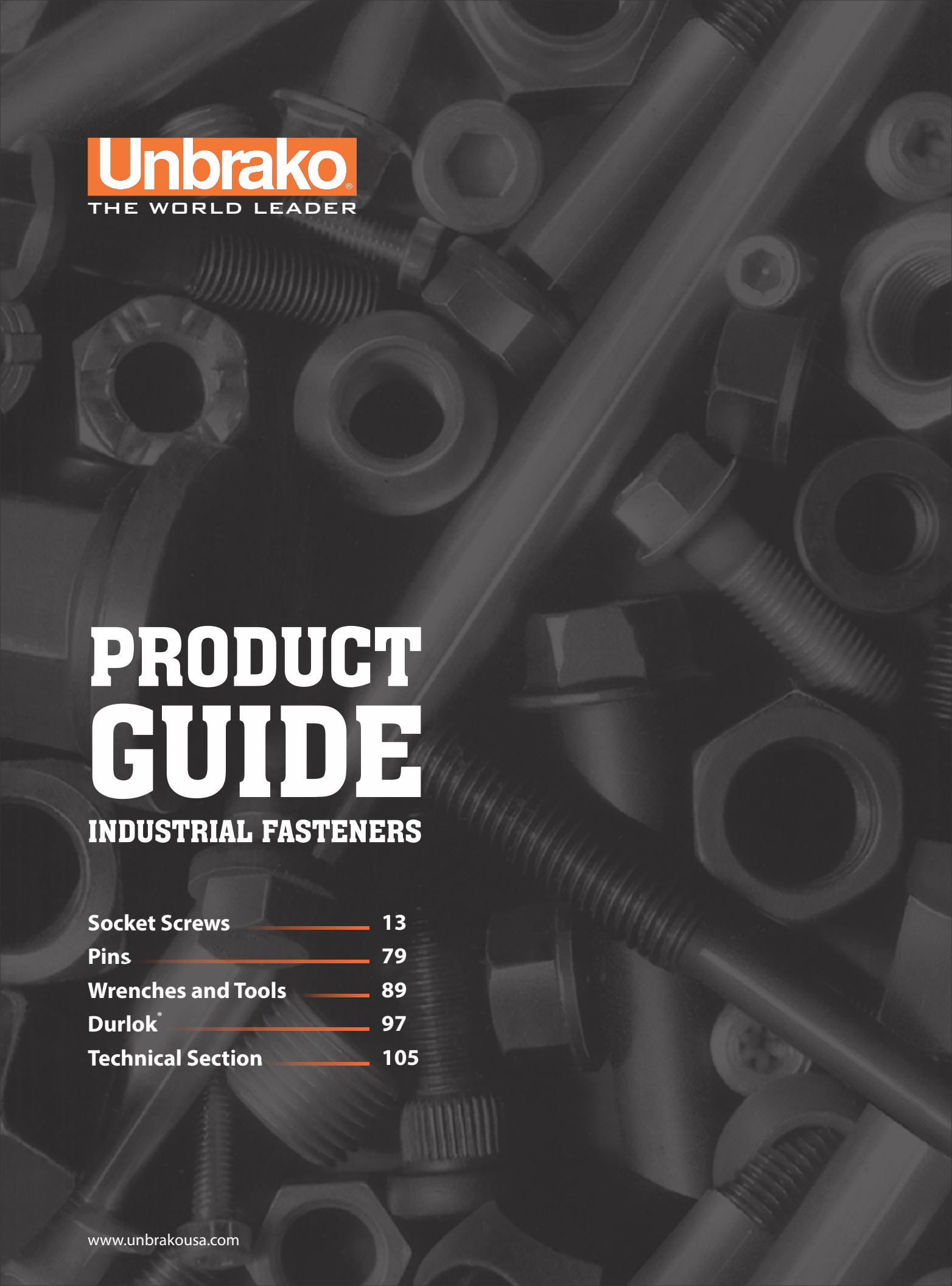

Unbrako®
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PRODUCT GUIDE

INDUSTRIAL FASTENERS

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Note: The proper tightening of threaded fasteners can have a significant effect on their performance. Many application problems such as self-loosening & fatigue can be minimized by adequate tightening. The recommended seating torques listed in the catalog tables serve as guidelines only. Even when using the recommended seating toques, the induced loads obtained may vary as much as ±25% depending upon the uncontrolled variables such as mating material, lubrication, surface finish, hardness, bolt/joint compliance, etc. Performance data listed is for standard production items only. It is suggested that the user verify performance for critical applications.

Unbrako
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Table of Contents

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About Unbrako

West Coast Distribution Center

Founded in 1911, Unbrako is the world leader in advancing the technology of bolted joints and meeting the needs of industry for stronger and better performing fasteners. Products such as the famous Unbrako® socket head cap screw and Durlok® fasteners are the solutions of choice for engineering applications across the world & is used by industries such as the automotive, power generation, petrochemical, heavy machinery, construction and military sectors.

With an extensive international network in 35 countries, Unbrako provides a complete range of industrial fastening hardware including bolts, screws, SEM's, nuts, studbolts, self-locking fasteners, thread forming fasteners, among others.

Unbrako products are primarily used in performance critical applications and incorporate unique design and work-manship features that meet or exceed recognized international standards, resulting in higher tensile strength, improved fatigue resistance, ease of installation, reduced total cost of maintenance and extended life cycle.

With advanced manufacturing, engineering and logistics facilities, ISO/TS and CE certification, Unbrako is equipped to provide technical support and full-service package. Unbrako's focus is on building long - term relationships with its customers. Full-service includes engineering and design support, procurement and purchasing services, localized warehousing and transport, a variety of packaging options and choice of delivery frequencies – to provide the right answer to any customer need.

In this Guide

In this guide you will find complete information about Unbrako socket screws, pins, hex keys, self locking Durlok® fasteners and related products, in high-tensile alloy steel. Everything you need to select, specify and order these precision products is at your finger tips including actual prices. Furthermore, all data has been organized to let you find the facts you want with the greatest speed and least effort.

Included in this guide are:

- Unbrako fastener product descriptions
- Features and technical data about each product
- Product sizes along with part numbers
- Technical discussions for application and use
- Product Prices

Packaging:

Unbrako provides a full-service package designed to suit customer needs, including a variety of packaging options and choice of delivery frequencies. The standard packaging is explained with each product.

Types of packaging:

Pieces per Box – small box packing

Pieces per Carton – bulk packing in a carton

Pieces per Bag – bulk packing in a bag

Important Information

The use of precision fasteners in the worldwide market has led to the creation of many standards. These standards specify the fastener requirements: dimensions, material, strength levels, inspection etc. Different standards are the responsibility of various organization and are not always identical. Unbrako supplies precision fasteners manufactured to Unbrako internal specifications, designed to achieve maximum interchangeability with all standards. Reference Consensus standards referred to in this guide were current at the time of publication. However, Reference Consensus standards are subject to change by any standards organizations at any time.

A direct or indirect reference to a consensus standard to represent that a fastener conforms to particular requirements of the consensus standard shall not be construed as a representation that the fastener meets all the requirements of the consensus standard.

UNBRAKO products are manufactured in accordance with revisions valid at time of manufacture. Unbrako reserves the right to update or modify its manufacturing specifications without prior notice.

The specifications and other particulars contained in this Guide are subject to change without notice.

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Limited Warranty and Exclusive Remedy

Deepak Fasteners Ltd., through its Unbrako Division and associated companies, warrants that these products conform to industry standards specified herein and will be free from defects in materials and workmanship. This warranty is expressly given in lieu of any and all other express or implied warranties, including any implied warranty of merchantability or fitness for a particular purpose, and in lieu of any other obligation on the part of Deepak Fasteners.

Deepak Fasteners will at its option, repair or replace free of charge (excluding all shipping and handling costs) any products which have not been subject to misuse, abuse, or modification and which in its sole determination were not manufactured in compliance with the warranty given above.

Deepak Fasteners makes no representations or warranties, express or implied, that anything imported, made, used, sold, or otherwise provided under any sale agreement is or will be free from infringement of patents / other proprietary rights of any third persons. Nothing in this application, or any agreement, shall be construed as giving rise to any obligation on Deepak Fasteners part to indemnify or hold harmless any Buyer from any liability relating to Buyer's purchase, use, or re-sale of Deepak Fasteners product, or the incorporation of Deepak Fasteners product into another manufactured product.

The remedy provided herein shall be the exclusive remedy for any breach of warranty or any claim arising in any way out of the manufacture, sale or use of these products. In no event shall Deepak Fasteners be liable for consequential, incidental or any other damages of any nature whatsoever except those specifically provided herein for any breach of warranty or any claim arising in any way of the manufacture, sale or use of these products. No other person is authorized by Deepak Fasteners to give any other warranty, written or oral, pertaining to the products.

Certified Laboratory

Our Laboratory is NABL ISO/IEC 17025:2005 certified, which facilitates in maintaining consistently high quality. The fasteners go through strict quality checks at every stage of the process. Our inspection facilities are equipped with state-of-the-art equipment for testing of both physical and metallurgical aspects of fasteners for the most demanding applications:

- Tensile & Hardness testing
- Salt spray testing
- Digital profile analysis
- X-ray analysis of coating thickness
- Chemical composition analysis (Spectrometer)
- Impact Testing
- Dynamic fatigue testing
- Torque tension and friction testing
- Eddy current Testing
- Metallurgical Microscope with Image Analyzer

ISO 9001:2008

AD 2000

ISO/TS 16949:2009

CE Certification
14399 & 15048

International Certifications

Our production facilities are ISO 9001, ISO/TS 16949, ISO 14001 and BS OHSAS 18001 Certified. Our fasteners meet or exceed International Standards like DIN, ISO, ASTM, IS, BS etc. We have expertise not only in standard products, but also in made-to-order customized products.

Specialized Coatings

We excel in a variety of coatings, which are done in-house. These are designed to provide required protection in different environments, e.g. Hot Dip Galvanizing, Mechanical Galvanizing, Electroplating (Zinc & Copper Cadmium), PTFE Coating, Zinc-Al Flake Coating (Geomet, Delta Protekt) and Unbrako Wiscoat Coating.

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Specialized Coatings

A Product's lifespan and performance is not only measured by it's quality, grade and and specification, but also by it's surface finish. Choosing the correct coating for the application will prevent corrosion, enhance aesthetic value and add strength to the fastener, extending it's life and performance.

Unbrako excels in a variety of coatings done in-house, designed specifically to provide the required protection in such harsh environment. Technical information of a few of these coatings is set out below:

MAIN COATINGS		ELECTROLYTIC COATINGS ZINC CADMIUM	HOT-DIP GALVANISATION	METALLIC COATING ZINC FLAKE	PTFE
Type of material		All metals	Steels	All metals	All metals
Process temperature		Bath t° < 90°C Baking temp. < 250°C	460°C - 550°C	20°C Process 300°C Baking	300°C Baking
Maximum service temperature without damage of coating		Zinc : 250°C Max Cadmium : 235°C Max chromating Zinc & Cadmium : 70°C max	300°C max	280°C max	280°C max
Usual thickness		Cadmium : 3 µm to 20 µm	Individual - 43µm Average - 54µm	5 µm - 15 µm	10 µm - 20 µm
Average Friction Coefficient	**without lubrication**	0.16 - 0.22	Seizure risks when bolt stress is >40% YS	0.15 - 0.25	0.15 - 0.25
Average Friction Coefficient	**with lubrication**	0.08 - 0.12	0.13 - 0.18	0.08 - 0.12	0.08 - 0.12
Salt spray test (red corrosion)		Zine 5 to 7µm : 48 h min Zinc chromating 5 to 7 µm : 96 h min Reinforced chromating : 200 h min	70µm : 400 h min	5-7 µm : 400h min 8-10 µm: 1000h min	1000h min
Hydrogen embrittlement		Descaling with inhibitor imperative baking for 100 Mpa steels	Descaling with inhibitor No risk process	No risk process	No risk process
Aspect		**Bright**	**Matt or glossy**	**Matt aluminum**	**Matt Blue**

NOTE:- Specialist assistance is recommended when selecting these coatings.

Quality Standards

1. Company Approvals:
Unbrako manufacturing facilities are approved to
BS EN ISO 9001:2008
ISO/TS 16949:2009
BS OHSAS 18001:2007
ISO/TS 14001:2004
ISO 9001:2008
EN 14399 & 15048

2. Quality Levels:
2.1 Final acceptance of a consignment is determined by applying attribute sampling plans as defined in BS 6001 Double sampling tables Level 1 (Normal Inspection).

2.2 Acceptance Levels are as follows :
2.2.1 Major Characteristics 1.5% A.Q.L.
2.2.2 Minor (A) Characteristics 2.5% A.Q.L.
2.2.3 Incidental (Minor B) Characteristics 4.0% A.Q.L.
2.2.4 A.Q.L. for characteristics identified as critical by the user will be established by negotiation.
2.2.5 Zero acceptance for mixed, scrap or mutilated parts (100% sort).

2.3 The following identifies the characteristics classified as Major, Minor (A) and Incidental (Minor B).

2.3.1 Major
i. Thread conformance
ii. Dimensions with a tolerance equal to or less than 0.002" total.
iii. Angles with a tolerance equal to or less than 1° total.
iv. Surface texture equal to or less than 16 CLA.
v. Post Heat Treatment physical testing.
vi. Surface discontinuities.
vii. Straightness
viii. Concentricity e.g. Head/Shank/Thread.
ix. Underhead fillet area / bearing surface squareness.
x. Thread run-out.
xi. Hexagon Socket.
xii. Grip Length.

2.3.2 Minor (A)
i. Dimensions with a tolerance greater than 0.002" but not exceeding 0.008".
ii. Angles with a tolerance varying from 1° up to and including 5°.
iii. Surface texture greater than 16 CLA and equal to or less than 32 CLA.
iv. Identification.
v. Burrs and tool marks.

2.3.3 Incidental (Minor B)
i. Dimensions with a tolerance greater than 0.008" total.
ii. Angles with a tolerance greater than 5° total.
iii. Surface texture greater than 32 CLA.
iv. Visual characteristics.

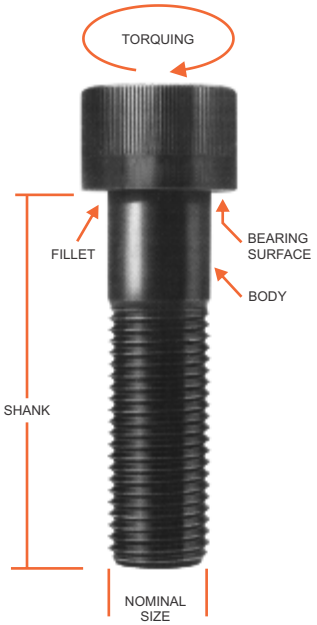
3. Certifications:
Unbrako Standard Socket screw products carry a Certificate of Conformity on each and every box, incorporating a lot traceable number, free of charge.

In addition Socket Head Cap Screws greater than and equal to ¼" and M5 have an e-code identifier stamped on the head of each part, allowing traceability even when the original box and label is not available.

Additionally, the following test certificates are available, subject to extra charge:

i. To DIN 50049 2.1 (EN10204 TYPE 2.1 CERT)
ii. To DIN 50049 2.2 (EN 10204 TYPE 2.2 CERT)
iii. To DIN 50049 2.3 (EN 10204 TYPE 2.2 CERT)
iv. To DIN 50049 3.1A (EN 10204 TYPE 3.1 CERT)
v. To DIN 50049 3.1B (EN 10204 TYPE 3.1 CERT)
vi. To DIN 50049 3.1C (EN 10204 TYPE 3.2 CERT)

Product Terminology



BODY
The unthreaded portion of the shank of a threaded fastener.

FILLET
Concave junction between the head and shank.

HEAD
A headed fastener has one end enlarged into a preformed shape.

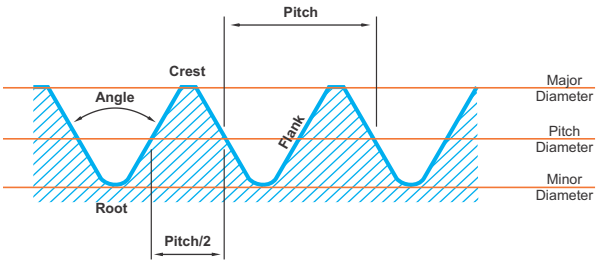
LENGTH
The length of a headed fastener is the distance from intersection between the bearing surface & the largest diameter to the extreme end of the fastener, measured parallel to the axis of the fastener. The length of a headless fastener is the distance from one extreme end to the other end, also measured parallel to the fastener.

NOMINAL SIZE
It is the basic major diameter of the thread.

SHANK
The portion of a headed fastener which lies between the head and the extreme end of the fastener.

TORQUING
It is the act of tightening a fastener by turning either the bolt or nut.

Thread Terminology



CREST
The outermost tip of a male thread as seen in a thread profile.

FLANK
The thread surface connecting the crest with the root.

BEARING SURFACE
The supporting or locating surface of a fastener with respect to the part it fastens or mates.

MAJOR DIAMETER
The largest diameter of a thread.

MINOR DIAMETER
The smallest diameter of a thread.

PITCH
The distance from a point on a screw thread to the corresponding point on the next screw thread.

PITCH DIAMETER
Is the diameter of a theoretical cylinder that passes through the threads at a position that the width of thread ridge and thread groove are equal.

ROOT
The bottom area between the sides of two adjacent threads.

Thread Terminology

THREAD LAPS
Are surface defects caused by the folding over of metal in the thread.

THREAD RUNOUT
is the area between the thread and shank or head of the fasteners The Unbrako radiused root runout provides a smooth from that distributes stress and increases the life of the fastener considerably.

THREAD STRESS AREA
The area of a cylindrical bar of the same material and properties as the thread and capable of supporting the same ultimate tensile load.

Mechanical Terminology

CREEP
Deformation that occurs over a period of time when a fastener is subjected to a constant stress at a constant high temperature.

ELONGATION
is the increase in the thread length or a fastener that would occur during tightening or loading.

ENDURANCE LIMIT
The strength level below which a bolt or joint member will have an essentially infinite life under cyclic loading.

FATIGUE LIFE
is the number of cycles of fluctuating stress and strain of a specified nature that a fastener will sustain before failure occurs.

IMPACT TEST
A test to determine the energy absorbed in fracturing a test bar at high velocity.

PROOF LOAD
is a specified test load which a fastener must withstand without any indication of failure.

PROOF TEST
is any specified test required for a fastener to indicate that is suitable for the purpose intended.

ROCKWELL HARDNESS (Hrc)
This is a specific method of measuring the hardness of a fastener. The "c" denotes a specific size indenter which penetrates the surface of the prepared specimen.

SHEAR JOINT
A joint in which the fastener has the load applied across the axis and which tends to sever it.

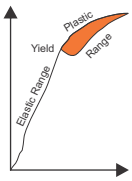
SHEAR STRENGTH
This is the maximum strength of the fastener when it is subjected to shear (transverse) loading.

TENSILE STRENGTH
Is the force or stress required to break a fastener when the force or stress is applied in straight tension.

TENSION JOINT
A joint in which the fastener has the load applied to the longitudinal direction and which tends to elongate it.

TORSION
is the twisting force applied to a fastener during tightening.

YIELD STRENGTH
This is the maximum force or stress that can be applied to a fastener without permanent (plastic) deformationoccurring.



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Influence of Chemicals in Steel

Steel alloys using difference chemical elements are produced in order to improve the physical properties of the material and to achieve special properties:

Carbon (C)

Although this is not considered to be an alloying element, it is the most important component in steel. It improves tensile strength, hardness and abrasion resistance. It reduces ductility, rigidity and machining.

Manganese (Mn)

This is an oxidiser and degasifier and reacts with sulphur to improve forgeability. It increases tensile strength, hardness and durability.

Phosphorus (P)

This increases tensile strength and hardness and improves machinability. It causes fragility in steel.

Sulphur (S)

Improves machining qualities in the presence of manganese. It reduces weldability, impact, roughness, and ductility.

Silicon (Si)

This is a deoxidiser and degasifier. It increases tensile strength, elasticity, hardness and forgeability.

Chromium (Cr)

Increase breaking strength, hardness, durability, roughness, and resistance to high temperatures.

Nickel (Ni)

This raises strength and hardness, while maintaining ductility and rigidity. It increases resistance to cracking and high temperatures.

Molybdenum (Mo)

This increases strength, hardness, durability, and rigidity, together with resistance to creaking & to high temperatures.

Titanium (Ti)

This is used as a stabilising element in stainless steels. It has a great affinity for carbon.

Unbrako
THE WORLD LEADER

Socket Screws

Page Contents

High-performance Socket Screws

Why Socket Screws? Why Unbrako?

The most important reasons for the increasing use of socket head cap screws in industry are safety, reliability and economy. All three reasons are directly traceable to the superior performance of socket screws vs. other fasteners due to their superior strength and advanced design.

Reliability, higher pressures, stresses and speeds in todays machines and equipment demand stronger, more reliable fasteners to hold them together.

Rising costs make failure and downtime intolerable. Bigger, more complex units break down more frequently despite every effort to prevent it.

This is why the reliability of every component has become critical. Components must stay together to function properly, and to keep them together joints must stay tight.

Unbrako developed the first internal hex socket screw and is the world's leading socket screw brand with more than 100 years' experience of supplying to the high-end industries, such as the automotive, infrastructure, aerospace, petrochemical, heavy machinery and military sectors.

UNBRAKO socket cap screws offer joint reliability, safety with maximum strength and fatigue resistance greater than any other threaded fastener**.**

Higher Tensile Strength

Unbrako 12.9 metric alloy steel socket head cap screws are manufactured to strength levels of 1300/1250 MPa (depending on dia) compared to the industry standard of 1220 MPa. For inch sizes, Unbrako manufactures to 190/180 Ksi compared to the industry standard per ASTM A574 of 180/170 Ksi.

This higher tensile strength can be translated into savings. Fewer socket screws of the same size can be used to achieve the same clamping force in the joint. A joint requiring 12 x 1-3/8” Grade 5 hex heads would need only 7 UNBRAKO socket head cap screws. Thus, there are fewer holes to drill & tap, fewer screws to buy & handle.

Using smaller diameter socket head cap screws vs. larger hex screws costs less to drill and tap, need less space**,** require no additional wrench space, take less energy to drive, and there is also weight saving.

Greater Fatigue Strength

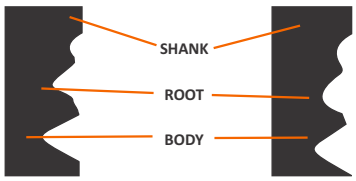
Joints that are subject to external stress loading are susceptible to fatigue failure. UNBRAKO socket screws have distinct advantages that give you an extra bonus of protection against this hazard, namely - design improvements, mechanical properties & closely controlled manufacturing processes.

High-performance Socket Screws

Head with increased bearing area for greater load carrying capability. Precision forged for symmetrical grain flow, maximum strength.

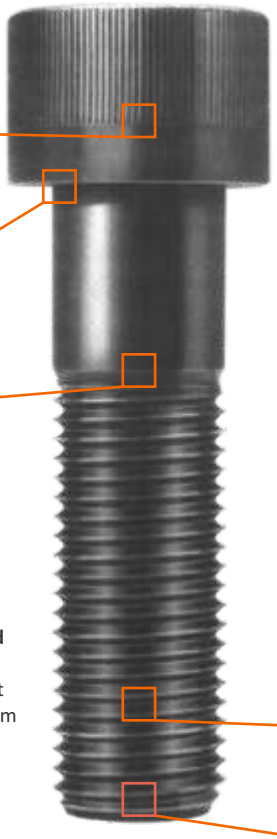
Specially designed Elliptical fillet doubles fatigue life at critical head-shank juncture.

"3-R" (radiused-root runout) increases fatigue life at this critical juncture.



CONVENTIONAL THREAD RUNOUT - Note sharp angle at root where high stress concentration soon develops crack which penetrates into body of the screw.

UNBRAKO "3-R" (Radiused Root Runout) THREAD - Controlled radius of runout root provides a smooth form that distributes stress and increases fatigue life of thread run-out as a much as 300% in certain sizes.

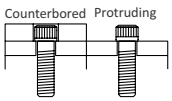
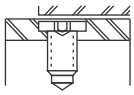
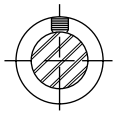
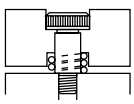
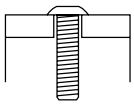
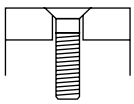


Total Traceability: Patented E-CODE™ head marking system allows tracing of test records to specific production batches

Deep, accurate socket for high torque wrenching. Knurls for easier handling. Marked for easier identification.

Fully formed radiused thread increases fatigue life 100% over flat root thread forms.

Controlled heat treatment produces maximum strength without brittleness and decarburization

Unbrako Socket Products		Application / Features
Socket Head Cap Screws Alloy / Stainless		 Suitable for all high tensile applications. Up to 190,000 psi/ 1300 Mpa– highest of any socket cap screw. Use Stainless for corrosive, cryogenic or elevated temperature environment.
Socket Head Cap Screws Low Head Series Alloy / Stainless		 Suitable for use in parts too thin for standard Socket Head Cap Screw and for applications with limited clearance.
Socket Set Screws (Grub Screws) Alloy / Stainless		 Fasten collars, sheaves, gears, knobs on shafts. Locate machine parts. Self-locking knurled cup point is standard. Special Points like Flat, Dog, Cone & Plain Cup are also available.
Shoulder Screws		 Replaces costly special parts – shafts, pivots, pins, guides, linkages and trunnion mountings. Also standard for tool and die industries.
Button Head Cap Screws Alloy / Stainless		 Low head streamline design. Use them in materials too thin to countersink; also for non-critical loading requiring heat treated screws
Flat Head Countersunk Socket Screws Alloy / Stainless		 Controlled angle under the head ensures maximum flushness and side wall contact. Non-slip Hex socket prevents marring of material.

Socket Head Cap Screws
Micro Series - M1.4 to M2.6

Suitable for all high tensile applications. Up to 1300 Mpa– highest of any socket cap screw.

Equivalent Standards

ISO 4762, DIN 912, ASME B18.3.1M
BS 4168-1

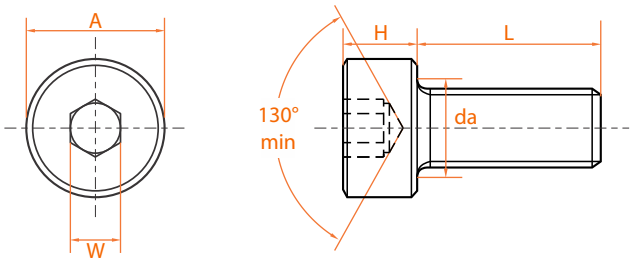
Mechanical Properties

Screw Size	≤M16	>M16
Heat Treatment	40-43 HRC	40-43 HRC
Tensile Strength	1300 N/mm^2	1250 N/mm^2
Yield Strength	1170 N/mm^2	1124 N/mm^2
Shear Strength	780 N/mm^2	750 N/mm^2
Min. Elongation	9%	9%

Notes:

1. Property Class : 12.9
2. Thread Class : 5g6g
3. Working Temperature : -50°C to +300°C

4. Torques calculated in accordance with VDI 2230 "Systematic calculation of high duty bolted joints" with σ 0.2 = 1080 N/mm^2 and μ = 0.125 for plain finish and μ = 0.094 for plated.



Product Dimensions (Micro Sizes)

Thread Size nom	Pitch	Head Diameter A max	Hex Socket Size W nom	Head Height H max	Transition Dia da nom	Length L min	Length L max
M1.4	0.30	2.6	1.27	1.4	1.8	3	6
M1.6	0.35	3.0	1.50	1.6	2.0	3	6
(M1.7)	0.35	3.0	1.50	1.7	2.1	3	6
M1.8	0.35	3.4	1.50	1.8	2.3	3	6
M2	0.40	3.8	1.50	2.0	2.6	3	12
(M2.3)	0.40	4.0	2.00	2.3	2.9	4	15
M2.5	0.45	4.5	2.00	2.5	3.1	4	15
(M2.6)	0.45	4.5	2.00	2.6	3.2	4	15

Thread Size	Recommended Torques Setting					
	Unplated		Plated		Induced Load	
nom	Nm	lbf.in	Nm	lbf.in	kN	lbf
M1.4	0.20	1.8	0.15	1.3	733	164
M1.6	0.29	2.6	0.22	2.0	930	208
(M1.7)	0.35	3.1	0.26	2.3	1,100	246
M1.8	0.44	3.9	0.33	2.9	1,300	291
M2	0.60	5.3	0.45	4.0	1,550	347
(M2.3)	0.95	8.4	0.71	6.3	2,230	500
M2.5	1.21	10.7	0.90	8.0	2,590	580
(M2.6)	1.37	12.1	1.03	9.1	2,860	640

Sizes in brackets are non-preferred standards

Suitable for all high tensile applications. Up to 1300 Mpa– highest of any socket cap screw. Use Stainless for corrosive, cryogenic or elevated temperature environments.

Equivalent Standards

ISO 4762, DIN 912, ASME B18.3.1M
BS 4168-1

Mechanical Properties

Screw Size	≤M16	>M16
Heat Treatment	40-43 HRC	40-43 HRC
Tensile Strength	1300 N/mm^2	1250 N/mm^2
Yield Strength	1170 N/mm^2	1124 N/mm^2
Shear Strength	780 N/mm^2	750 N/mm^2
Min. Elongation	9%	9%

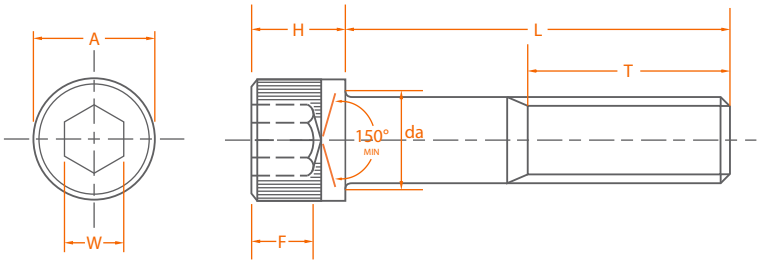
Notes:

1. Screws with lengths equal to or shorter than listed in column 'L' are threaded to head.
2. Property Class : 12.9
3. Thread Class : 5g6g
4. Working Temperature : -50°C to +300°C

5. Torques calculated in accordance with VDI 2230 "Systematic calculation of high duty bolted joints" with σ 0.2 = 1080 N/mm^2 and μ = 0.125 for plain finish and μ = 0.094 for plated.

Head Marking

- 'X' represents Lot Traceability E-CODE
- For Sizes M5 or Larger



Product Dimensions (Standard Sizes)

Thread Size nom.	Pitch	Head Diameter A max	Hex Socket Size W nom.	Head Height H max	Socket Depth F min.	Transition Dia da max	Length L Note 1	Thread Length T ref.
M3	0.50	5.5	2.5	3.0	1.3	3.60	20	18
M4	0.70	7.0	3.0	4.0	2.0	4.70	25	20
M5	0.80	8.5	4.0	5.0	2.5	5.70	25	22
M6	1.00	10.0	5.0	6.0	3.0	6.80	30	24
M8	1.25	13.0	6.0	8.0	4.0	9.20	35	28
M10	1.50	16.0	8.0	10.0	5.0	11.20	40	32
M12	1.75	18.0	10.0	12.0	6.0	13.70	50	36
(M14)	2.00	21.0	12.0	14.0	7.0	15.70	55	40
M16	2.00	24.0	14.0	16.0	8.0	17.70	60	44
(M18)	2.50	27.0	14.0	18.0	9.0	20.20	65	48
M20	2.50	30.0	17.0	20.0	10.0	22.40	70	52
(M22)	2.50	33.0	17.0	22.0	11.0	24.40	70	56
M24	3.00	36.0	19.0	24.0	12.0	26.40	80	60
M27	3.00	40.0	19.0	27.0	13.5	30.40	90	66
M30	3.50	45.0	22.0	30.0	15.5	33.40	100	72
M33	3.50	50.0	24.0	33.0	18.0	36.40	100	78
M36	4.00	54.0	27.0	36.0	19.0	39.40	110	84
M42	4.50	63.0	32.0	42.0	24.0	45.60	130	96

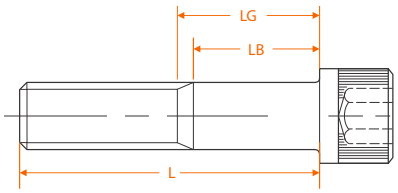
Thread Size nom.	Recommended Torques Setting				Induced Load	
	Unplated		Plated			
	N-m	in-lbs.	N-m	in-lbs.	kN	lbf
M3	2.1	18.6	1.6	14.2	3.99	890
M4	4.6	40.7	3.5	31.0	6.75	1,510
M5	9.5	84.1	7.1	62.8	11.10	2,480
M6	16.0	142.0	12.0	106.0	15.60	3,480
M8	39.0	345.0	29.0	257.0	28.70	6,400
M10	77.0	682.0	58.0	513.0	45.70	10,200
M12	135.0	1,200.0	101.0	894.0	66.70	14,900
(M14)	215.0	1,900.0	161.0	1,420.0	91.30	20,400
M16	330.0	2,920.0	248.0	2,190.0	126.00	28,100
(M18)	455.0	4,030.0	341.0	3,020.0	153.00	34,100
M20	650.0	5,750.0	488.0	4,320.0	197.00	44,000
(M22)	870.0	7,700.0	652.0	5,770.0	245.00	54,700
M24	1,100.0	9,740.0	825.0	7,300.0	284.00	63,400
M27	1,650.0	14,600.0	1,238.0	11,000.0	374.00	83,400
M30	2,250.0	19,900.0	1,688.0	15,000.0	454.00	101,000
M33	3,050.0	27,000.0	2,287.0	20,200.0	550.00	123,000
M36	3,850.0	34,100.0	2,888.0	25,000.0	664.00	148,000
M42	6,270.0	55,500.0	4,700.0	41,600.0	889.00	198,000

Sizes in brackets are non-preferred standards

Body and Grip Length Dimensions

- LG is the maximum grip length and is the distance from the bearing surface to the first complete thread.
- LB is the minimum body length and is the length of the unthreaded cylindrical portion of the shank.
- Dimensions for LB and LG are calculated from the following formula:

T Ref = (2x Nominal Dia) plus 12mm.
LG max = Nominal length "L" minus "T"
LB min = Nominal length "L" minus (T + 5 pitches)



Length	M3		M4		M5		M6		M8		M10		M12		M14		M16	
L Nom.	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)
25	4.5	7																
30	9.5	12	6.5	10	4	8												
35			11.5	15	9	13	6	11										
40			16.5	20	14	18	11	16	5.75	12								
45					19	23	16	21	10.75	17	5.5	13						
50					24	28	21	26	15.75	22	10.5	18						
55							26	31	20.75	27	15.5	23	10.25	19				
60							31	36	25.75	32	20.5	28	15.25	24	10	20		
65									30.75	37	25.5	33	20.25	29	15	25	11	21
70									35.75	42	30.5	38	25.25	34	20	30	16	26
80									45.75	52	40.5	48	35.25	44	30	40	26	36
90											50.5	58	45.25	54	40	50	36	46
100											60.5	68	55.25	64	50	60	46	56
110													65.25	74	60	70	56	66
120													75.25	84	70	80	66	76
130															80	90	76	86
140															90	100	86	96
150																	96	106
160																	106	116
180																		

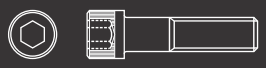
Length 'L' Tolerance (mm)

Screws Over	Up to and including	Tolerance
-	50	±0.25
50	80	±0.50
80	120	±0.71
120	250	±0.79
250	-	±1.02

Length	M18		M20		M22		M24		M27		M30		M33		M36		M42	
Nom.	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)	L_B (Min.)	L_G (Max.)
70	9.5	22																
80	19.5	32	15.5	28	11.5	24												
90	29.5	42	25.5	38	21.5	34	15	30										
100	39.5	52	35.5	48	31.5	44	25	40	19	34								
110	49.5	62	45.5	58	41.5	54	35	50	29	44	20.5	38	14.5	32				
120	59.5	72	55.5	68	51.5	64	45	60	39	54	30.5	48	24.5	42	16	36		
130	69.5	82	65.5	78	61.5	74	55	70	49	64	40.5	58	34.5	52	26	46		
140	79.5	92	75.5	88	71.5	84	65	80	59	74	50.5	68	44.5	62	36	56	21.5	44
150	89.5	102	85.5	98	81.5	94	75	90	69	84	60.5	78	54.5	72	46	66	31.5	54
160	99.5	112	95.5	108	91.5	104	85	100	79	94	70.5	88	64.5	82	56	76	41.5	64
180	119.5	132	115.5	128	111.5	124	105	120	99	114	90.5	108	84.5	102	76	96	61.5	84
200			135.5	148	131.5	144	125	140	119	134	110.5	128	104.5	122	96	116	81.5	104
220					151.5	164	145	160	139	154	130.5	148	124.5	142	116	136	101.5	124
240							165	180	159	174	150.5	168	144.5	162	136	156	121.5	144
260									179	194	170.5	188	164.5	182	156	176	141.5	164
280											190.5	208	184.5	202	176	196	161.5	184

All dimensions are in mm.

Socket Head Cap Screws - Metric



Unbrako

HIGH-GRADE ALLOY STEL

Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
M1.6 (0.35) - Key Size 1.5mm				
M1.6 x 4	104138	200	**144.65**	0.22
6	104150	200	**173.26**	0.28
M2 (0.4) - Key Size 1.5mm				
M2 x 3	104151	200	**30.44**	0.44
4	104152	200	**46.95**	0.48
5	104154	200	**48.73**	0.53
6	104155	200	**58.33**	0.57
8	104157	200	**61.12**	0.64
10	104159	200	**63.39**	0.73
12	106216	200	**65.92**	0.81
M2.5 (0.45) - Key Size 2mm				
M2.5 x 5	104161	200	**51.34**	0.77
6	104162	200	**52.60**	0.95
8	104163	200	**53.36**	1.08
10	104164	200	**55.30**	1.21
12	104166	200	**56.49**	1.32
M3 (0.5) - Key Size 2.5mm				
M3 x 5	106218	200	**27.45**	1.50
6	103002	200	**27.45**	1.58
10	113583	200	**19.10**	1.96
12	120870	200	**19.77**	2.13
14	400509	200	**20.05**	2.33
15	400506	200	**20.05**	2.42
16	103003	200	**20.18**	2.51
20	113623	200	**21.11**	2.88
25	103010	200	**25.28**	3.34
30	103013	200	**30.28**	3.94
35	106219	200	**34.78**	4.51
M4 (0.7) - Key Size 3mm				
M4 x 5	106220	200	**19.94**	3.06
6	106223	200	**19.94**	3.21
8	113810	200	**16.94**	3.54
10	113839	200	**16.94**	3.87
12	121077	200	**17.94**	4.22
14	400568	200	**18.27**	4.53
15	400511	200	**18.27**	4.58
16	103014	200	**18.27**	4.86
18	103015	200	**19.51**	5.21
20	125753	200	**19.51**	5.54
22	400521	200	**24.95**	5.87
25	125381	200	**24.95**	6.36
30	103018	200	**24.95**	7.39
35	103019	200	**25.10**	8.43
40	103021	200	**29.36**	9.46

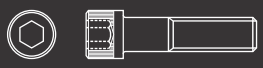
Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
M4 (0.7) - Key Size 3mm				
M4 x 45	103022	200	**32.87**	10.49
50	103023	200	**39.21**	11.53
M5 (0.8) - Key Size 4mm				
M5 x 10	122243	200	**17.94**	6.69
12	121094	200	**16.94**	7.22
14	400513	200	**17.94**	7.74
15	400510	200	**17.94**	8.03
16	103024	200	**17.94**	8.29
18	400522	200	**20.30**	8.82
20	113970	200	**19.35**	9.35
22	400523	200	**23.10**	9.88
25	121096	200	**22.03**	10.67
30	103029	200	**24.54**	12.32
35	115292	200	**28.53**	13.95
40	103030	200	**29.12**	15.58
45	103031	200	**32.78**	17.20
50	103035	200	**35.62**	18.83
55	103038	200	**41.88**	20.48
60	103040	200	**45.38**	22.11
65	106225	200	**46.46**	23.74
70	106228	200	**48.89**	25.37
M6 (1) - Key Size 5mm				
M6 x 8	103042	200	**23.53**	9.57
10	122111	200	**18.81**	10.32
12	120872	200	**19.67**	11.07
14	400567	200	**20.53**	11.84
15	400512	200	**20.53**	11.84
16	103044	200	**20.53**	12.21
18	103045	200	**22.08**	13.35
20	119790	200	**21.44**	14.15
22	103046	200	**24.36**	14.85
25	119937	200	**24.36**	16.04
30	122121	200	**27.19**	17.93
35	121090	200	**31.04**	20.61
40	121075	200	**32.46**	22.99
45	122087	200	**33.21**	25.37
50	112624	200	**36.28**	27.74
55	113128	200	**47.64**	30.10
60	122088	200	**51.05**	32.47
65	103047	200	**55.72**	34.85
70	103048	200	**61.15**	37.20
75	103049	200	**68.24**	39.58
80	103051	200	**72.17**	41.95
90	103052	200	**80.01**	46.68
100	103053	200	**97.36**	51.41

Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
M6 (1) - Key Size 5mm				
M6 x 110	103054	200	**160.70**	55.73
120	103055	200	**211.94**	60.46
M8 (1.25) - Key Size 6mm				
M8 x 10	103056	200	**23.69**	22.31
12	114972	200	**24.03**	23.61
14	400524	200	**24.36**	24.99
15	400514	200	**24.36**	25.74
16	103058	200	**24.36**	26.42
18	400569	200	**26.43**	27.81
20	122086	200	**26.43**	29.19
22	120642	200	**29.12**	30.49
25	119351	200	**29.12**	32.63
30	119383	200	**31.20**	36.08
35	122113	200	**33.69**	39.51
40	113143	200	**35.07**	43.65
45	121076	200	**37.63**	48.55
50	121068	100	**41.46**	52.07
55	103063	100	**51.60**	56.30
60	121070	100	**54.81**	60.50
65	103064	100	**66.23**	65.45
70	103066	100	**75.65**	69.67
75	103069	100	**87.69**	73.90
80	103070	100	**99.69**	78.12
90	103073	100	**109.13**	86.55
100	103075	100	**128.55**	94.60
110	103076	100	**140.57**	103.44
120	103077	100	**187.04**	111.89
130	106230	100	**206.22**	120.34
140	106231	100	**230.41**	127.95
150	106232	100	**348.05**	143.00
160	106233	50	**540.32**	144.83
180	106234	50	**594.10**	162.56
200	106235	50	**786.92**	179.43
M10 (1.5) - Key Size 8mm				
M10 x 10	106236	200	**86.88**	39.34
12	106237	200	**84.90**	41.65
15	400525	200	**48.10**	44.75
16	103080	200	**36.42**	45.83
18	400526	200	**36.67**	48.00
20	113163	200	**36.67**	50.16
25	115060	200	**38.86**	55.57
30	122114	200	**42.32**	61.23
35	113257	200	**44.93**	86.37
40	100845	100	**47.04**	72.09
45	121088	100	**52.44**	78.45
50	125660	100	**54.20**	85.07

Pieces per Box

Sizes above the bold line are threaded to head.
Property Class: 12.9

Socket Head Cap Screws - Metric



HIGH-GRADE ALLOY STEEL

Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
M10 (1.5) - Key Size 8mm				
M10 x 55	103087	100	**66.01**	93.02
60	122217	100	**71.06**	98.32
65	103088	100	**83.37**	104.94
70	125786	100	**90.96**	112.90
75	103090	100	**102.76**	119.55
80	103091	100	**119.79**	126.17
90	103094	50	**137.07**	126.48
100	103095	50	**163.38**	137.35
110	103096	50	**174.58**	164.56
120	103097	50	**198.35**	179.26
130	106240	50	**219.82**	192.52
140	106241	50	**246.63**	212.08
150	106242	50	**288.98**	225.94
160	106243	50	**402.60**	239.80
180	106244	50	**602.02**	258.85
200	106245	50	**829.66**	285.38
220	400517	25	**1251.16**	311.92
M12 (1.75) - Key Size 10mm				
M12 x 12	106246	100	**157.52**	60.24
16	106247	100	**144.90**	66.53
20	112607	100	**76.24**	72.82
25	122250	100	**79.74**	80.67
30	122251	100	**88.77**	88.55
35	125530	100	**97.68**	96.40
40	114996	50	**99.02**	104.28
45	115075	50	**108.70**	112.13
50	112360	50	**114.88**	119.90
55	122255	50	**127.38**	129.58
60	122260	50	**130.47**	139.48
65	122261	50	**147.74**	152.13
70	103098	50	**153.08**	158.14
75	103099	50	**165.01**	171.23
80	103100	50	**177.02**	180.77
90	103103	50	**191.04**	196.26
100	122142	50	**218.15**	218.97
110	125791	50	**259.61**	238.06
120	103104	50	**273.55**	253.48
130	103107	50	**291.56**	272.54
140	103108	50	**314.33**	291.61
150	103110	50	**337.19**	310.68
160	107456	50	**354.05**	334.40
180	107458	50	**427.79**	367.88
200	107459	50	**590.17**	406.01
260	400572	25	**1470.46**	524.48
M14 (2) - Key Size 12mm				
M14 x 25	400528	50	**283.65**	118.82
30	400529	50	**283.65**	129.60

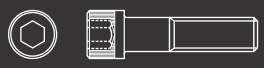
Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
M14 (2) - Key Size 12mm				
M14 x 35	400530	50	**283.65**	140.36
40	400531	50	**309.29**	151.14
45	400532	50	**338.50**	161.90
50	120863	50	**350.52**	172.68
55	400533	50	**395.20**	183.46
60	112000	50	**410.68**	196.48
65	400534	50	**451.05**	209.48
70	400535	50	**478.98**	227.46
75	400536	50	**562.74**	235.53
80	400537	50	**579.92**	248.56
90	400538	50	**591.08**	274.58
100	400539	50	**629.32**	300.63
110	400540	50	**781.81**	326.66
120	400508	50	**841.95**	352.10
M16 (2) - Key Size 14mm				
M16 x 25	106248	25	**159.75**	169.7
30	103112	25	**159.75**	184.1
35	103113	25	**168.22**	199.1
40	125751	25	**177.11**	213.6
45	103115	25	**185.25**	228.1
50	112474	25	**194.99**	242.0
55	103117	25	**208.32**	256.5
60	112594	25	**226.02**	271.0
65	103118	25	**242.30**	288.0
70	103119	25	**249.35**	305.0
75	103120	25	**262.78**	322.1
80	125658	25	**276.37**	339.2
90	103122	25	**310.77**	371.8
100	103123	25	**332.25**	407.3
110	103124	25	**366.14**	441.4
120	103126	25	**417.83**	475.5
130	103127	25	**470.51**	509.6
140	103128	25	**496.10**	541.2
150	103129	25	**521.94**	577.8
160	103364	25	**1444.67**	609.4
180	107460	25	**1452.47**	679.1
200	107448	25	**1640.78**	748.2
300	400578	5	**3024.16**	1096.5
M18 (2.5) - Key Size 14mm				
M18 x 35	400541	25	**512.55**	272.8
40	400542	25	**520.06**	290.8
45	400606	25	**540.62**	308.8
50	100844	25	**560.67**	326.0
60	400544	25	**619.01**	362.9
65	400545	25	**652.60**	380.9
70	400546	25	**676.40**	402.6
80	400549	25	**724.37**	445.7

Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
M18 (2.5) - Key Size 14mm				
M18 x 90	400550	25	**772.47**	486.6
100	400551	25	**1283.24**	532.2
120	400552	25	**2558.57**	618.6
M20 (2.5) - Key Size 17mm				
M20 x 30	107465	25	**326.63**	329.4
35	107466	25	**332.58**	352.1
40	103130	25	**337.44**	374.7
45	103131	25	**350.79**	397.3
50	103132	25	**363.80**	420.0
55	103136	25	**381.74**	442.7
60	103137	25	**401.47**	465.3
65	103138	25	**423.43**	487.9
70	103141	25	**438.88**	510.6
75	103142	25	**452.14**	537.3
80	103143	25	**470.01**	563.9
90	103144	25	**501.22**	617.2
100	103145	25	**832.63**	670.5
110	103146	25	**862.23**	723.8
120	103148	25	**1650.70**	777.1
130	103150	10	**1684.14**	826.8
140	103151	10	**1724.18**	880.0
150	103152	10	**1791.08**	934.3
160	107462	10	**1817.78**	990.2
180	107463	10	**1884.60**	1096.8
200	107464	5	**2085.23**	1203.3
220	400553	5	**3451.80**	1321.5
240	400554	5	**3745.40**	1428.2
260	400555	5	**4049.10**	1534.9
280	400556	5	**4302.17**	1641.9
300	400557	5	**4554.76**	1748.4
340	796973	5	**5167.80**	1960.30
M22 (2.5) - Key Size 17mm				
M22 x 80	180186	10	**1770.90**	739.2
90	180187	10	**1888.41**	805.2
100	180188	10	**3137.14**	871.2
110	180189	10	**3248.71**	937.2
140	180192	10	**6533.47**	1135.2
M24 (3) - Key Size 19mm				
M24 x 40	106249	10	**1691.09**	594.0
45	103153	10	**1565.62**	627.0
50	103155	10	**1458.69**	672.7
55	103157	10	**1714.78**	705.7
60	103158	10	**1483.67**	738.1
65	103159	10	**1503.70**	770.7
70	103160	10	**1523.80**	801.8
75	103161	10	**1585.25**	836.0
80	103162	10	**1563.85**	868.7

Pieces per Box

Sizes above the bold line are threaded to head.
Property Class: 12.9

Socket Head Cap Screws - Metric



Unbrako

HIGH-GRADE ALLOY STEEL

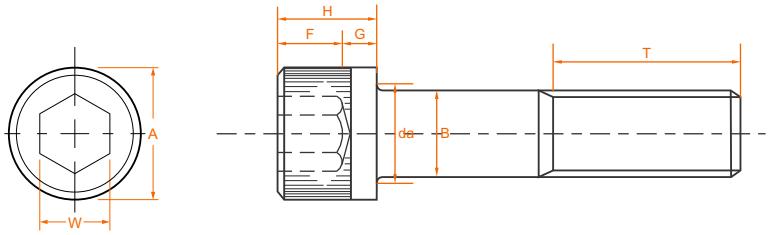
Size	Part No.		$Price /100	lbs. /1000
M24 (3) - Key Size 19mm				
M24 x 90	103163	10	**1791.08**	960.4
100	103165	10	**1844.57**	1034.0
110	103166	10	**1878.02**	1114.5
120	103167	10	**1938.08**	1188.0
130	103168	10	**1964.86**	1268.0
140	103170	10	**2004.90**	1353.0
150	103171	10	**2111.86**	1405.6
160	104143	10	**2125.28**	1482.6
180	104146	10	**2212.13**	1636.5
200	104147	5	**2305.64**	1808.1
220	400560	5	**4407.48**	1962.2
240	400561	5	**4744.99**	2116.3
260	400562	5	**5095.33**	2270.4
280	400563	1	**5710.42**	2578.6
300	400564	1	**6077.79**	2728.0
M30 (3.5) - Key Size 22mm				
M30 x 70	116464	1	**2495.11**	1419.8
80	140610	1	**2669.27**	1518.0
90	140611	1	**2710.49**	1621.7
100	140612	1	**2857.81**	1724.0
110	140613	1	**2928.48**	1881.0
120	140614	1	**3031.42**	2004.7
130	140615	1	**3270.26**	2125.5
140	140616	1	**3411.66**	2244.0
150	140617	1	**3835.95**	2366.0
160	140618	1	**4330.89**	2486.0
180	140620	1	**4634.53**	2728.0
200	140621	1	**4964.32**	2970.0
280	140625	1	**6927.48**	3936.5
300	400626	1	**7004.17**	4177.9
320	180848	1	**7152.51**	4419.8
M36 (4) - Key Size 27mm				
M36 x 80	140629	1	**3653.26**	2388.9
90	140630	1	**3929.70**	2530.0
100	140631	1	**4656.18**	2681.1
120	140633	1	**5001.46**	3055.0
130	400634	1	**5134.36**	3229.5
140	140635	1	**5239.70**	3351.3
150	140636	1	**5358.71**	3577.3
160	140637	1	**5477.83**	3751.3
180	140639	1	**5954.20**	4098.9
200	140640	1	**6549.59**	4466.0
220	180294	1	**7799.48**	4794.5
240	140641	1	**9050.36**	5142.3
260	140642	1	**9502.78**	5490.1
280	180411	1	**11506.30**	5837.9
300	140643	1	**12226.31**	6185.6
320	180490	1	**19988.58**	6533.4

Sizes above the bold line are threaded to head.
Property Class: 12.9

Threaded to Head

Size	Part No.		$Price /100	lbs. /1000
M5 (0.8) - Key Size 4mm				
M5 x 30	400583	200	**73.64**	12.32
35	400584	200	**85.58**	13.95
40	400585	200	**87.35**	15.58
50	400587	200	**106.91**	18.83
M6 (1) - Key Size 5mm				
M6 x 35	400589	200	**93.14**	20.68
40	400590	200	**97.37**	21.71
50	400591	200	**108.82**	25.50
60	400592	200	**153.14**	29.28
M8 (1.25) - Key Size 6mm				
M8 x 40	400593	100	**104.60**	42.97
50	400594	100	**124.37**	49.83
60	400595	100	**164.46**	56.72
70	406180	100	**226.92**	69.52
80	406181	100	**299.06**	70.49
M10 (1.5) - Key Size 8mm				
M10 x 50	400597	100	**160.92**	86.68
60	400598	100	**210.96**	99.88
70	400599	100	**270.01**	113.08
80	400600	100	**355.65**	115.59

Socket Head Cap Screws - 1960 series
#0 to 1/2 - UNRC/UNRF



Suitable for all high tensile applications. Up to 190,000 psi highest of any socket cap screw. Use Stainless for corrosive, cryogenic or elevated temperature environments.

Equivalent Standards

ASME B18.3

Mechanical Properties

Screw Size	≥ 1/2	<1/2
Heat Treatment	39-43 RC	39-43 RC
Tensile Strength	190 ksi	180 ksi
Yield Strength	170 ksi	162 ksi
Shear Strength	114 ksi	108 ksi

Material: Unbrako High Grade Alloy Steel
Elongation is 2 inches - 10% min.
Reduction of area - 35% min.

Length 'L' Tolerance (in)

Diameter	up to 1" incl.	over 1" to 2 1/2" incl.	over 2 1/2" to 6" incl.	over 6"
#0 thru 3/8 incl.	–.03	–.04	–.06	–.12
7/16 to 3/4 incl.	–.03	–.06	–.08	–.12
7/8 to 1-1/2 incl.	–.05	–.10	–.14	–.20
over 1 1/2		–.18	–.20	–.24

NOTES:

1. Thread Class: #0 to 1": 3A, over 1": 2A
2. Working Temperature: -50°C to +300°C
3. Torques calculated in accordance with VDI 2230 "Systematic calculation of high duty bolted joints" with σ 0.2 = 155 K.S.I. and μ = 0.125 for plain finish and μ = 0.094 for plated. Above 0.625" dia. σ 0.2 = 140 K.S.I.
4. The following diameters are fully interchangeable between 1936 and 1960 series:- No 10, 1/4", 3/8", 1/2" for both UNC and UNF

Head Marking

'X' represents Lot Traceability E-CODE

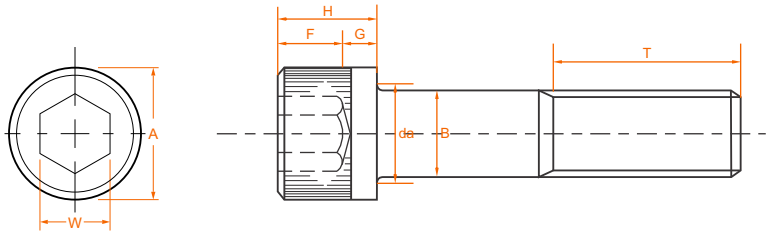
Product Dimensions

Thread Size nom.	Threads per Inch UNRC	UNRF	Head Diameter A max	min	Hex Socket Size W nom	Head Height H max	min	Key Depth F min	G min
#0	–	80	.096	.091	.050	.060	.057	.025	.020
#1	64	72	.118	.112	.062	.073	.070	.031	.025
#2	56	64	.140	.134	.078	.086	.083	.038	.029
#3	48	56	.161	.154	.078	.099	.095	.044	.034
#4	40	48	.183	.176	.094	.112	.108	.051	.038
#5	40	44	.205	.198	.094	.125	.121	.057	.043
#6	32	40	.226	.218	.109	.138	.134	.064	.047
#8	32	36	.270	.262	.141	.164	.159	.077	.056
#10	24	32	.312	.303	.156	.190	.185	.090	.065
1/4	20	28	.375	.365	.188	.250	.244	.120	.095
5/16	18	24	.469	.457	.250	.312	.306	.151	.119
3/8	16	24	.562	.550	.312	.375	.368	.182	.143
7/16	14	20	.656	.642	.375	.437	.430	.213	.166
1/2	13	20	.750	.735	.375	.500	.492	.245	.190

Thread Size nom	Body Diameter B max	min	Transition Diameter da max	min	Thread Length T min	Recommended seating torque (in-lbs) UNRC	UNRF
#0	.060	.0568	.074	.051	.500	–	3
#1	.073	.0695	.087	.061	.625	5	5
#2	.086	.0822	.102	.073	.625	7	8
#3	.099	.0949	.115	.084	.625	12	13
#4	.112	.1075	.130	.094	.750	18	19
#5	.125	.1202	.145	.107	.750	24	25
#6	.138	.1329	.158	.116	.750	34	36
#8	.164	.1585	.188	.142	.875	59	60
#10	.190	.1840	.218	.160	.875	77	91
1/4	.250	.2435	.278	.215	1.000	200	240
5/16	.3125	.3053	.347	.273	1.125	425	475
3/8	.375	.3678	.415	.331	1.250	750	850
7/16	.4375	.4294	.484	.388	1.375	1,200	1,350
1/2	.500	.4919	.552	.446	1.500	1,850	2,150

Socket Head Cap Screws - 1960 series
5/8 to 3 - UNRC/UNRF

Inch



Suitable for all high tensile applications. Up to 190,000 psi highest of any socket cap screw. Use Stainless for corrosive, cryogenic or elevated temperature environments.

Equivalent Standards

ASME B18.3

Mechanical Properties

Screw Size	≥ 1/2	<1/2
Heat Treatment	39-43 RC	39-43 RC
Tensile Strength	190 ksi	180 ksi
Yield Strength	170 ksi	162 ksi
Shear Strength	114 ksi	108 ksi

Material: Unbrako High Grade Alloy Steel
Elongation is 2 inches - 10% min.
Reduction of area - 35% min.

Length 'L' Tolerance (in)

Diameter	up to 1" incl.	over 1" to 2 1/2" incl.	over 2 1/2" to 6" incl.	over 6"
#0 thru 3/8 incl.	–.03	–.04	–.06	–.12
7/16 to 3/4 incl.	–.03	–.06	–.08	–.12
7/8 to 1-1/2 incl.	–.05	–.10	–.14	–.20
over 1 1/2		–.18	–.20	–.24

NOTES:

1. Thread Class: #0 to 1" - 3A, over 1" - 2A
2. Working Temperature: -50°C to +300°C
3. Torques calculated in accordance with VDI 2230 "Systematic calculation of high duty bolted joints" with σ 0.2 = 155 K.S.I. and μ = 0.125 for plain finish and μ = 0.094 for plated. Above 0.625" dia. σ 0.2 = 140 K.S.I.
4. The following diameters are fully interchangeable between 1936 and 1960 series:- No 10, 1/4", 3/8", 1/2" for both UNC and UNF

Head Marking

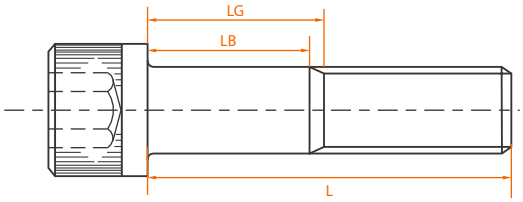
'X' represents Lot Traceability E-CODE

Product Dimensions

Thread Size nom.	Threads per Inch UNRC	UNRF	Head Diameter A max	min	Hex Socket Size W nom.	Head Height H max	min	Key Depth F min.	G min.
5/8	11	18	.938	.921	.500	.625	.616	.307	.238
3/4	10	16	1.125	1.107	.625	.750	.740	.370	.285
7/8	9	14	1.312	1.293	.750	.875	.864	.432	.333
1	8	12	1.500	1.479	.750	1.000	.988	.495	.380
1	–	14*	1.500	1.479	.750	1.000	.988	.495	.380
1 1/8	7	12	1.688	1.665	.875	1.125	1.111	.557	.428
1 1/4	7	12	1.875	1.852	.875	1.250	1.236	.620	.475
1 3/8	6	12	2.062	2.038	1.000	1.375	1.360	.682	.523
1 1/2	6	12	2.250	2.224	1.000	1.500	1.485	.745	.570
1 3/4	5	12	2.625	2.597	1.250	1.750	1.734	.870	.665
2	4 1/2	12	3.000	2.970	1.500	2.000	1.983	.995	.760
2 1/4	4 1/2	12	3.375	3.344	1.750	2.250	2.232	1.120	.855
2 1/2	4	12	3.750	3.717	1.750	2.500	2.481	1.245	.950
2 3/4	4	12	4.125	4.090	2.000	2.750	2.730	1.370	1.045
3	4	12	4.500	4.464	2.250	3.000	2.979	1.495	1.140

Thread Size nom.	Body Diameter B max	min	Transition Diameter da max	min	Thread Length T min	Recommended seating torque (in-lbs) UNRC	UNRF
5/8	.625	.6163	.689	.562	1.750	3,400	3,820
3/4	.750	.7406	.828	.681	2.000	6,000	6,800
7/8	.875	.8647	.963	.798	2.250	8,400	9,120
1	1.000	.9886	1.100	.914	2.500	12,500	13,200
1	1.000	.9886	1.100	.914	2.500	–	13,900
1 1/8	1.125	1.1086	1.235	1.023	2.812	14,900	16,600
1 1/4	1.250	1.2336	1.370	1.148	3.125	25,000	27,000
1 3/8	1.375	1.3568	1.505	1.256	3.437	33,000	35,000
1 1/2	1.500	1.4818	1.640	1.381	3.750	43,500	47,000
1 3/4	1.750	1.7295	1.910	1.609	4.375	71,500	82,500
2	2.000	1.9780	2.180	1.843	5.000	108,000	125,000
2 1/4	2.250	2.2280	2.450	2.093	5.625	155,000	186,000
2 1/2	2.500	2.4762	2.720	2.324	6.250	215,000	248,000
2 3/4	2.750	2.7262	2.990	2.574	6.875	290,000	330,000
3	3.000	2.9762	3.260	2.824	7.500	375,000	430,000

Socket Head Cap Screws - 1960 series
Body and Grip Lengths



Length	#0		#1		#2		#3		#4		#5		#6		#8		#10		#1/4	
L Nom.	L_G	L_B	L_G	L_B	L_G	L_B	L_G	L_B	L_G	L_B	L_G	L_B	L_G	L_B	L_G	L_B	L_G	L_B	L_G	L_B
3/4	.250	.187																		
7/8	.250	.187	.250	.172	.250	.161	.250	.146												
1	.500	.437	.250	.172	.250	.161	.250	.146	.250	.125	.250	.125								
1 1/4	.750	.687	.625	.547	.625	.536	.625	.521	.250	.125	.250	.125	.500	.344	.375	.219	.375	.167		
1 1/2			.875	.797	.875	.786	.875	.771	.750	.625	.750	.625	.500	.344	.375	.219	.375	.167	.500	.250
1 3/4					1.125	1.036	1.125	1.021	.750	.625	.750	.625	1.000	.844	.875	.719	.875	.667	.500	.250
2							1.375	1.271	1.250	1.125	1.250	1.125	1.000	.844	.875	.719	.875	.667	1.000	.750
2 1/4									1.250	1.125	1.250	1.125	1.500	1.344	1.375	1.219	1.375	1.167	1.000	.750
2 1/2											1.750	1.625	1.500	1.344	1.375	1.219	1.375	1.167	1.500	1.250
2 3/4													2.000	1.844	1.875	1.719	1.875	1.667	1.500	1.250
3															1.875	1.719	1.875	1.667	2.000	1.750
3 1/4															2.375	2.219	2.375	2.167	2.000	1.750
3 1/2																	2.375	2.167	2.500	2.250
3 3/4																	2.875	2.667	2.500	2.250
4																	2.875	2.667	3.000	2.750
4 1/4																			3.000	2.750
4 1/2																			3.500	3.250
4 3/4																			3.500	3.250
5																			4.000	3.750
5 1/4																				
5 1/2																				
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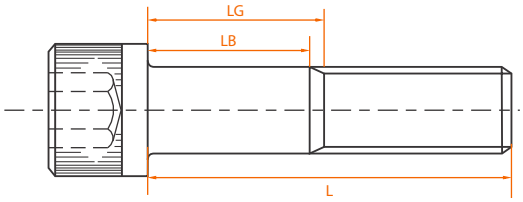
Length Tolerance

Diameter	up to 1" incl.	over 1" to 2 1/2" incl.	over 2 1/2" to 6" incl.	over 6"
#0 thru 3/8 incl.	–.03	–.04	–.06	–.12
7/16 to 3/4 incl.	–.03	–.06	–.08	–.12
7/8 to 1-1/2 incl.	–.05	–.10	–.14	–.20
over 1 1/2		–.18	–.20	–.24

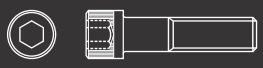
LG is the maximum grip length and is the distance from the bearing surface to the first complete thread. LB is the minimum body length and is the length of the unthreaded cylindrical portion of the shank. Thread length for the sizes up to and including 1" diameter shall be controlled by the grip length and body length as shown in the table. For sizes larger than 1" the minimum complete thread length shall be equal to the basic thread length, and the total thread length including imperfect threads shall be basic thread length plus five pitches. Lengths too short to apply formula shall be threaded to head. Complete threads shall extend within two pitches of the head lengths above the heavy line on sizes up to and including 5/8" dia. Larger diameters shall be threaded as close to the head as practicable. Screws of longer lengths than those tabulated shall have a thread length conforming to the formula for sizes larger than 1".

Socket Head Cap Screws - 1960 series
Body and Grip Lengths



Length	5/16		3/8		7/16		1/2		5/8		3/4		7/8		1	
L Nom.	L_G	L_B	L_G	L_B	L_G	L_B	L_G	L_B	L_G	L_B	L_G	L_B	L_G	L_B	L_G	L_B
3/4																
7/8																
1																
1 1/4																
1 1/2																
1 3/4	.625	.347	.500	.187												
2	.625	.347	.500	.187	.625	.268										
2 1/4	1.125	.847	1.000	.687	.625	.268	.750	.365								
2 1/2	1.125	.847	1.000	.687	1.125	.768	.750	.365	.750	.295						
2 3/4	1.625	1.187	1.500	1.187	1.125	.768	.750	.365	.750	.295						
3	1.625	1.347	1.500	1.187	1.625	1.268	1.500	1.115	.750	.295	1.000	.500				
3 1/4	2.125	1.847	2.000	1.687	1.625	1.268	1.500	1.115	1.500	1.045	1.000	.500	1.000	.444		
3 1/2	2.125	1.847	2.000	1.687	2.125	1.768	1.500	1.115	1.500	1.045	1.000	.500	1.000	.444	1.000	.375
3 3/4	2.625	2.347	2.500	2.187	2.125	1.768	2.250	1.865	1.500	1.045	1.000	.500	1.000	.444	1.000	.375
4	2.625	2.347	2.500	2.187	2.625	2.268	2.250	1.865	2.250	1.795	2.000	1.500	1.000	.444	1.000	.375
4 1/4	3.125	2.847	3.000	2.687	2.625	2.268	2.250	1.865	2.250	1.795	2.000	1.500	2.000	1.444	1.000	.375
4 1/2	3.125	2.847	3.000	2.687	3.125	2.768	3.000	2.615	2.250	1.795	2.000	1.500	2.000	1.444	2.000	1.375
4 3/4	3.625	3.347	3.500	3.187	3.125	2.768	3.000	2.615	3.000	2.545	2.000	1.500	2.000	1.444	2.000	1.375
5	3.625	3.347	3.500	3.187	3.625	3.268	3.000	2.615	3.000	2.545	3.000	2.500	2.000	1.444	2.000	1.375
5 1/4	4.125	3.847	4.000	3.687	3.625	3.268	3.750	3.365	3.000	2.545	3.000	2.500	3.000	2.444	2.000	1.375
5 1/2	4.125	3.847	4.000	3.687	4.125	3.768	3.750	3.365	3.750	3.295	3.000	2.500	3.000	2.444	3.000	2.375
5 3/4	4.625	4.347	4.500	4.187	4.125	3.768	3.750	3.365	3.750	3.295	3.000	2.500	3.000	2.444	3.000	2.375
6	4.625	4.347	4.500	4.187	4.625	4.268	4.500	4.115	3.750	3.295	4.000	3.500	3.000	2.444	3.000	2.375
6 1/4	5.125	4.847	5.000	4.687	4.625	4.268	4.500	4.115	4.500	4.045	4.000	3.500	4.000	3.444	3.000	2.375
6 1/2			5.000	4.687	5.125	4.768	4.500	4.115	4.500	4.045	4.000	3.500	4.000	3.444	4.000	3.375
6 3/4			5.500	5.187	5.125	4.768	5.250	4.865	4.500	4.045	4.000	3.500	4.000	3.444	4.000	3.375
7			5.500	5.187	5.625	5.268	5.250	4.865	5.250	4.795	5.000	4.500	4.000	3.444	4.000	3.375
7 1/4			6.000	5.687	5.625	5.268	5.250	4.865	5.250	4.795	5.000	4.500	5.000	4.444	4.000	4.375
7 1/2			6.000	5.687	6.125	5.768	6.000	5.615	5.250	4.795	5.000	4.500	5.000	4.444	5.000	4.375
7 3/4					6.125	5.768	6.000	5.615	6.000	5.545	5.000	4.500	5.000	4.444	5.000	4.375
8					6.625	6.268	6.000	5.615	6.000	5.545	6.000	5.500	5.000	4.444	5.000	4.375
8 1/2					7.125	6.768	7.000	6.615	6.750	6.295	6.000	5.500	6.000	5.444	6.000	5.375
9					7.625	7.268	7.000	6.615	6.750	6.295	7.000	6.500	6.000	5.444	6.000	5.375
9 1/2							8.000	7.615	7.750	7.295	7.000	6.500	7.000	6.444	7.000	6.375
10							8.000	7.615	7.750	7.295	8.000	7.500	7.000	6.444	7.000	6.375
11									9.250	8.795	9.000	8.500	8.000	7.444	8.000	7.375
12									10.250	9.795	10.000	9.000	9.000	8.444	9.000	8.375
13											11.000	10.500	10.000	9.444	10.000	9.375
14											12.000	11.500	11.000	10.444	11.000	10.375
15											13.000	12.500	12.000	11.444	12.000	11.375
16													13.000	12.444	13.000	12.375
17													14.000	13.444	14.000	13.375
18													15.000	14.444	15.000	14.375
19															16.000	15.375
20															17.000	16.375

Socket Head Cap Screws - 1960 Series



HIGH-GRADE ALLOY STEEL

Size	Part No.		$Price /100	lbs. /1000
#0-80 UNF - Key Size 0.05"				
#0 x 3/16	117137	100	**43.13**	0.17
1/4	117153	100	**43.38**	0.18
3/8	121059	100	**43.54**	0.22
#1-72 UNF - Key Size 1/16"				
#1 x 1/4	117202	100	**40.38**	0.36
3/8	102704	100	**40.38**	0.45
#2-56 UNC - Key Size 5/64"				
#2 x 3/16	105493	100	**30.28**	0.47
1/4	105509	100	**31.71**	0.58
3/8	113307	100	**31.78**	0.75
1/2	113323	100	**32.87**	0.93
5/8	700572	100	**41.00**	1.05
3/4	700573	100	**49.30**	1.18
1	700574	100	**65.74**	1.44
#3-48 UNC - Key Size 5/64"				
#3 x 1/4	113374	100	**16.91**	0.80
3/8	107750	100	**17.14**	0.98
1/2	107766	100	**17.50**	1.22
5/8	700581	100	**17.89**	1.47
3/4	700582	100	**21.38**	1.71
#4-40 UNC - Key Size 3/32"				
#4 x 1/4	107783	100	**16.60**	1.21
3/8	107799	100	**16.77**	1.50
1/2	107816	100	**17.35**	1.72
5/8	107832	100	**17.60**	1.96
3/4	107849	100	**18.44**	2.27
1	109394	100	**25.10**	2.88
1 1/4	120922	100	**59.88**	3.43
1 1/2	109070	100	**59.88**	4.20
#5-40 UNC - Key Size 3/32"				
#5 x 1/4	107865	100	**16.51**	1.61
5/16	112658	100	**17.18**	1.76
3/8	107881	100	**17.18**	1.94
1/2	107897	100	**17.18**	2.27
5/8	113390	100	**17.35**	2.60
3/4	113407	100	**18.68**	2.97
1	112049	100	**28.56**	3.83
#6-32 UNC - Key Size 7/64"				
#6 x 1/4	113423	100	**17.18**	1.98
5/16	109328	100	**17.44**	2.29

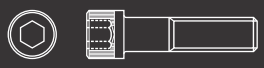
Size	Part No.		$Price /100	lbs. /1000
#6-32 UNC - Key Size 7/64"				
#6 x 3/8	113440	100	**17.44**	2.42
1/2	118792	100	**17.79**	2.86
5/8	118808	100	**18.20**	3.30
3/4	118824	100	**18.87**	3.61
7/8	118840	100	**20.97**	4.00
1	118856	100	**22.58**	4.38
1 1/4	112179	100	**31.06**	5.68
1 1/2	114328	100	**34.12**	6.45
#6-40 UNF - Key Size 7/64"				
#6 x 1/4	102720	100	**19.07**	2.09
3/8	111564	100	**18.27**	2.53
1/2	111581	100	**18.86**	2.79
5/8	111597	100	**19.19**	3.19
3/4	114012	100	**21.36**	3.56
1	700842	100	**37.72**	4.22
#8-32 UNC - Key Size 9/64"				
#8 x 1/4	118872	100	**14.70**	3.08
5/16	117320	100	**39.87**	3.63
3/8	118888	100	**14.27**	3.96
1/2	118904	100	**15.01**	4.53
5/8	118920	100	**15.51**	4.84
3/4	118936	100	**16.51**	5.50
7/8	103140	100	**17.77**	6.20
1	103156	100	**19.44**	6.69
1 1/4	103174	100	**22.68**	8.12
1 1/2	103190	100	**24.20**	9.66
1 3/4	117451	100	**37.77**	11.18
2	117516	100	**31.78**	12.39
2 1/4	120791	100	**115.71**	15.29
#8-36 UNF - Key Size 9/64"				
#8 x 3/8	700845	100	**21.58**	3.51
1/2	117699	100	**24.70**	4.40
5/8	700847	100	**30.00**	4.78
3/4	117715	100	**36.00**	5.54
1	700849	100	**48.00**	6.16
#10-24 UNC - Key Size 5/32"				
#10 x 1/4	109734	100	**25.54**	4.80
3/8	103206	100	**15.74**	5.50
1/2	112492	100	**15.74**	6.25
5/8	112508	100	**16.36**	7.00
3/4	112524	100	**17.68**	7.70
7/8	112540	100	**18.72**	8.45
1	112557	100	**20.56**	9.20
1 1/4	103215	100	**23.54**	11.13
1 1/2	103232	100	**24.93**	13.07

Size	Part No.		$Price /100	lbs. /1000
#10-24 UNC - Key Size 5/32"				
#10 x 1 3/4	103248	100	**27.82**	14.96
2	103264	100	**30.09**	16.94
2 1/4	108823	100	**39.46**	19.12
2 1/2	106226	100	**41.72**	20.83
2 3/4	103477	100	**136.99**	23.01
3	106355	100	**140.76**	24.46
3 1/2	116278	100	**159.93**	28.38
4	116279	100	**181.76**	32.34
#10-32 UNF - Key Size 5/32"				
#10 x 1/4	111756	100	**25.54**	4.80
5/16	116280	100	**25.54**	5.30
3/8	117733	100	**16.10**	5.50
1/2	117749	100	**16.45**	6.25
5/8	117765	100	**17.68**	7.00
3/4	117781	100	**18.63**	7.70
7/8	117798	100	**19.87**	8.45
1	117814	100	**21.78**	9.20
1 1/4	117830	100	**23.63**	11.79
1 1/2	117847	100	**26.07**	13.07
1 3/4	117863	100	**29.04**	14.96
2	117879	100	**32.02**	16.94
2 1/4	107085	100	**44.00**	19.54
2 1/2	107150	100	**47.94**	21.12
3	107182	100	**57.92**	25.01
1/4-20 UNC - Key Size 3/16"				
1/4 x 1/4	120048	100	**19.07**	9.00
3/8	105232	100	**15.18**	10.30
1/2	105248	100	**16.60**	11.59
5/8	108937	100	**17.69**	12.89
3/4	108954	100	**18.01**	14.19
7/8	108969	100	**19.10**	15.49
1	105256	100	**21.44**	16.72
1 1/4	105272	100	**23.12**	19.36
1 3/8	117409	100	**111.46**	20.72
1 1/2	105288	100	**25.53**	22.77
1 3/4	105304	100	**27.62**	26.16
2	105320	100	**30.03**	29.48
2 1/4	105336	100	**37.63**	32.91
2 1/2	118338	100	**41.80**	36.30
2 3/4	118355	100	**50.31**	39.67
3	118371	100	**55.40**	43.05
3 1/4	117539	100	**62.41**	46.46
3 1/2	117573	100	**70.83**	49.81
3 3/4	117605	100	**84.27**	53.20
4	109434	100	**92.94**	57.35
4 1/2	109499	100	**140.57**	64.11
5	114978	100	**220.94**	70.86

Sizes above the bold line are threaded to head.

Pieces per Box

Socket Head Cap Screws - 1960 Series



Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
1/4-20 UNC - Key Size 3/16"				
1/4 x 5 1/2	105637	100	**242.04**	77.64
6	115042	100	**263.12**	84.39
1/4-28 UNF - Key Size 3/16"				
1/4 x 1/4	114545	100	**26.41**	9.00
3/8	117896	100	**16.86**	10.30
1/2	117913	100	**17.77**	11.59
5/8	111454	100	**18.01**	12.89
3/4	111471	100	**19.86**	14.19
7/8	111487	100	**21.19**	15.49
1	111503	100	**22.53**	16.72
1 1/4	111519	100	**24.69**	19.36
1 1/2	111535	100	**27.69**	22.77
1 3/4	108026	100	**29.87**	26.16
2	108042	100	**32.54**	29.48
2 1/4	108057	100	**40.22**	32.91
2 1/2	118427	100	**49.64**	36.30
2 3/4	118460	100	**90.51**	40.70
3	118476	100	**71.99**	43.05
3 1/2	116281	100	**82.24**	51.44
4	116283	100	**110.63**	58.19
5/16-18 UNC - Key Size 1/4"				
5/16 x 3/8	118387	100	**26.72**	18.79
1/2	118403	100	**19.94**	20.68
5/8	118419	100	**20.53**	22.88
3/4	118436	100	**22.10**	25.30
7/8	104055	100	**23.36**	27.24
1	104071	100	**24.95**	29.70
1 1/4	104088	100	**27.11**	33.99
1 1/2	104104	100	**29.70**	38.50
1 3/4	104121	100	**31.95**	45.01
2	104137	100	**34.95**	48.84
2 1/4	104153	100	**42.96**	55.86
2 1/2	109900	100	**47.05**	59.62
2 3/4	109916	100	**64.23**	66.73
3	109932	100	**74.00**	70.40
3 1/4	109950	50	**89.09**	74.71
3 1/2	109966	50	**99.69**	81.80
4	109833	100	**110.12**	92.64
4 1/2	109866	100	**257.99**	100.85
5	103652	100	**266.18**	110.68
5 1/2	121215	100	**279.83**	125.20
6	103684	100	**356.00**	136.07
5/16-24 UNF - Key Size 5/32"				
5/16 x 1/2	108073	100	**21.86**	20.90
5/8	104516	100	**22.27**	22.04
3/4	104532	100	**24.54**	24.29

Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
5/16-24 UNF - Key Size 1/4"				
5/16 x 7/8	104548	100	**25.45**	26.53
1	110752	100	**27.54**	30.51
1 1/4	110769	100	**28.78**	35.00
1 1/2	110786	100	**32.04**	39.53
1 3/4	110802	100	**35.62**	46.33
2	110818	100	**38.80**	50.84
2 1/4	110834	100	**45.79**	57.16
2 1/2	110850	100	**51.81**	61.67
2 3/4	105606	100	**114.17**	65.45
3	105344	100	**123.38**	70.95
3 1/2	106016	100	**307.59**	83.40
4	120995	100	**375.98**	94.23
3/8-16 UNC - Key Size 5/16"				
3/8 x 1/2	109982	100	**33.87**	33.22
5/8	109999	100	**29.73**	36.30
3/4	110015	100	**26.04**	39.38
7/8	110031	100	**27.86**	42.46
1	110048	100	**30.11**	45.54
1 1/8	103784	100	**70.26**	48.33
1 1/4	110065	100	**33.37**	51.68
1 3/8	103816	100	**83.47**	54.76
1 1/2	115710	100	**36.51**	57.84
1 3/4	115727	50	**40.73**	65.49
2	115743	50	**43.67**	73.04
2 1/4	115760	50	**54.20**	80.81
2 1/2	115776	50	**59.60**	88.44
2 3/4	115792	50	**78.76**	95.92
3	115808	50	**85.77**	103.75
3 1/4	115824	50	**102.45**	111.32
3 1/2	122480	50	**117.54**	119.06
3 3/4	105003	50	**166.59**	128.22
4	115857	50	**137.31**	134.42
4 1/2	115873	50	**160.75**	149.69
5	115889	50	**193.29**	165.00
5 1/2	105035	50	**217.41**	180.29
5 3/4	113866	50	**247.87**	189.46
6	112859	50	**285.56**	195.60
6 1/2	111241	50	**275.92**	210.91
8	112990	25	**480.48**	256.85
3/8-24 UNF - Key Size 3/16"				
3/8 x 1/2	110867	100	**43.05**	33.22
5/8	110883	100	**30.62**	36.30
3/4	110900	100	**30.78**	39.38
7/8	110917	100	**32.19**	42.46
1	110934	100	**34.87**	47.52
1 1/4	110950	100	**37.78**	51.68
1 1/2	110966	100	**41.56**	57.84

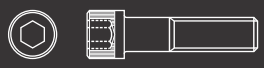
Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
3/8-24 UNF - Key Size 5/16"				
3/8 x 1 3/4	116440	50	**47.21**	65.49
2	116456	50	**51.17**	73.04
2 1/4	116472	50	**63.39**	80.81
2 1/2	116488	50	**69.96**	88.44
2 3/4	112246	50	**96.18**	100.10
3	116504	50	**96.78**	106.74
3 1/4	400467	50	**116.80**	111.41
3 1/2	112278	50	**141.46**	119.06
4	119090	50	**158.74**	137.37
4 1/2	108318	50	**253.32**	152.68
7/16-14 UNC - Key Size 3/8"				
7/16 x 3/4	107385	100	**53.47**	58.19
7/8	107417	100	**56.73**	61.01
1	107449	100	**60.64**	66.59
1 1/4	118520	50	**67.41**	75.02
1 1/2	118554	50	**73.74**	81.84
1 3/4	118586	50	**80.84**	91.89
2	118619	50	**87.27**	105.34
2 1/4	116299	50	**94.01**	113.78
2 1/2	116332	50	**100.27**	126.21
2 3/4	116364	25	**113.87**	134.66
3	116396	25	**120.79**	147.09
3 1/2	110568	25	**139.15**	167.97
4	115611	25	**158.00**	188.85
4 1/2	104743	25	**200.22**	209.73
5	110554	25	**232.33**	230.58
7/16-20 UNF - Key Size 3/8"				
7/16 x 1	116520	100	**62.73**	69.15
1 1/4	104561	50	**70.08**	78.23
1 1/2	104577	50	**76.91**	87.32
2	104593	50	**89.76**	108.86
2 1/2	105615	50	**383.66**	130.39
3	122789	25	**413.61**	150.61
3 1/2	116284	25	**437.72**	171.47
1/2-13 UNC - Key Size 3/8"				
1/2 x 1/2	115644	50	**135.87**	74.36
5/8	115677	50	**101.56**	79.95
3/4	102603	50	**62.29**	85.51
7/8	102636	50	**64.91**	91.08
1	102670	50	**67.52**	96.69
1 1/4	102703	50	**71.83**	107.80
1 1/2	107950	50	**82.02**	118.80
1 3/4	108016	50	**88.68**	130.17
2	102464	50	**95.51**	141.24
2 1/4	110772	25	**105.28**	154.88
2 1/2	110837	25	**112.20**	168.63

Pieces per Box

Sizes above the bold line are threaded to head.

HIGH-GRADE ALLOY STEEL

Socket Head Cap Screws - 1960 Series



Unbrako

HIGH-GRADE ALLOY STEEL

Size	Part No.		$Price /100	lbs. /1000
1/2-13 UNC - Key Size 3/8″				
1/2 x 2 3/4	110903	25	**129.47**	182.16
3	120761	25	**137.65**	195.91
3 1/4	111303	25	**148.24**	212.08
3 1/2	111575	25	**158.92**	223.23
3 3/4	103111	25	**175.36**	241.87
4	111608	25	**192.46**	257.51
4 1/4	107772	25	**314.68**	264.18
4 1/2	111641	25	**223.00**	287.98
4 3/4	119162	25	**492.02**	293.99
5	111673	25	**246.27**	305.76
5 1/4	107805	25	**518.14**	316.29
5 1/2	115511	25	**269.54**	340.78
5 3/4	107839	25	**603.90**	346.08
6	115544	25	**307.13**	371.36
6 1/4	105005	10	**935.23**	375.98
6 1/2	115576	10	**460.13**	393.73
7	109736	10	**524.35**	416.83
7 1/2	107937	10	**1001.63**	446.62
8	109768	10	**1193.54**	468.95
8 1/2	108003	10	**1700.41**	501.16
9	102417	10	**1737.53**	523.60
10	102451	10	**1861.49**	578.16
11	108275	10	**2428.52**	637.78
12	105569	10	**2802.38**	692.34
1/2-20 UNF - Key Size 3/8″				
1/2 x 3/4	116247	50	**127.29**	88.11
1	104609	50	**84.99**	100.12
1 1/4	104625	50	**93.34**	107.80
1 1/2	109763	50	**102.59**	118.80
1 3/4	109780	50	**109.75**	130.17
2	109796	50	**120.99**	141.24
2 1/4	122870	25	**130.81**	154.88
2 1/2	107220	25	**140.36**	168.63
2 3/4	111047	25	**180.63**	182.16
3	107237	25	**174.96**	195.91
3 1/2	116617	25	**227.65**	223.21
4	119272	25	**242.35**	257.51
4 1/2	700928	25	**269.00**	287.98
5	116285	25	**296.24**	317.31
5 1/2	700930	25	**323.68**	346.92
6	116286	25	**351.11**	364.76
7	700932	25	**600.21**	430.28
8	700933	25	**814.00**	484.00
5/8-11 UNC - Key Size 1/2″				
5/8 x 1	109802	25	**134.28**	170.32
1 1/4	109593	25	**145.75**	188.08
1 1/2	109626	25	**157.20**	205.81

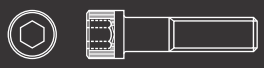
Size	Part No.		$Price /100	lbs. /1000
5/8-11 UNC - Key Size 1/2″				
5/8 x 1 3/4	116335	25	**167.61**	225.39
2	111036	25	**170.51**	241.30
2 1/4	111069	25	**179.11**	255.82
2 1/2	111101	25	**188.79**	287.76
2 3/4	116639	25	**213.39**	305.49
3	116673	25	**222.24**	323.09
3 1/4	116705	25	**231.42**	351.74
3 1/2	116737	25	**243.18**	369.69
4	102196	25	**268.46**	408.58
4 1/2	102047	25	**345.37**	451.64
5	120714	25	**373.65**	498.10
5 ½	120746	10	**393.43**	544.50
6	120778	10	**430.17**	580.14
6 ½	111320	10	**615.70**	626.56
7	111354	10	**763.23**	672.98
7 1/2	122898	10	**2209.44**	708.47
8	104175	10	**906.80**	755.04
8 1/2	109197	10	**2219.99**	801.46
9	118276	5	**2278.90**	836.88
10	106599	5	**2441.08**	922.46
11	107003	5	**2850.44**	1015.52
12	115134	5	**3051.99**	1110.12
5/8-18 UNF - Key Size 1/2″				
5/8 x 1	117868	25	**161.14**	170.32
1 1/4	117884	25	**200.60**	188.10
1 1/2	117901	25	**200.60**	205.81
1 3/4	117918	25	**230.64**	223.52
2	117935	25	**287.92**	241.34
2 1/4	105032	25	**287.92**	258.94
2 1/2	117951	25	**287.92**	287.76
3	105894	25	**352.71**	323.18
3 1/2	121385	25	**417.50**	369.60
4	117038	25	**447.50**	416.24
4 1/2	700946	25	**457.56**	462.00
5	119030	25	**467.51**	498.08
5 1/2	700948	10	**535.00**	544.50
6	107467	25	**602.93**	580.14
3/4-10 UNC - Key Size 5/8″				
3/4 x 1 1/4	104210	25	**242.63**	298.54
1 1/2	104244	25	**259.58**	324.96
1 3/4	113859	25	**276.45**	350.46
2	113892	25	**292.31**	376.64
2 1/4	113924	25	**306.33**	402.16
2 1/2	113957	25	**319.24**	428.34
2 3/4	113990	25	**374.45**	453.93
3	111623	25	**399.37**	499.64
3 1/4	111656	25	**423.35**	525.54

Size	Part No.		$Price /100	lbs. /1000
3/4-10 UNC - Key Size 5/8″				
3/4 x 3 1/2	111689	25	**447.69**	550.00
3 3/4	111246	25	**455.00**	577.30
4	111722	25	**475.54**	623.02
4 1/2	104539	25	**521.69**	674.78
5	110759	25	**568.42**	746.46
5 1/2	110793	10	**614.15**	798.16
6	121562	10	**660.29**	869.66
6 1/2	110858	10	**859.97**	921.58
7	110891	10	**969.88**	993.08
8	110924	10	**1212.94**	1116.28
8 1/2	103863	10	**2602.08**	1168.20
9	107374	10	**2613.90**	1239.92
9 1/2	107438	10	**2637.15**	1291.62
10	118545	10	**2780.79**	1363.12
11	121572	10	**2887.93**	1486.54
12	118610	10	**2965.95**	1609.96
13	108283	10	**4093.48**	1733.38
3/4-16 UNF - Key Size 5/8″				
3/4 x1 1/4	700952	25	**361.00**	298.54
1 1/2	120615	25	**378.55**	324.50
2	120376	25	**411.55**	376.29
2 1/2	138871	25	**449.33**	428.12
3	102344	25	**471.84**	499.64
3 1/2	117976	25	**528.90**	551.41
4	118041	25	**561.78**	623.04
4 1/2	114043	25	**664.22**	674.78
5	116293	25	**913.98**	746.46
6	700962	10	**1096.77**	869.66
7/8-9 UNC - Key Size 3/4″				
7/8 x 2	110957	10	**508.26**	559.37
2 1/4	116447	10	**528.81**	594.88
2 1/2	116479	10	**566.51**	630.52
2 3/4	116511	10	**639.12**	665.94
3	104568	10	**678.22**	701.36
3 1/4	104600	10	**706.74**	765.16
3 1/2	104632	10	**761.42**	800.58
4	104665	10	**854.23**	899.80
4 1/2	104697	10	**941.97**	968.00
5	104729	10	**1030.41**	1041.79
5 1/2	104761	10	**1118.84**	1140.92
6	104793	10	**1206.59**	1210.00
6 1/2	110251	10	**1451.10**	1311.20
7	115937	10	**1696.21**	1382.26
8	115970	10	**1974.58**	1552.32

Pieces per Box

Sizes above the bold line are threaded to head.

Socket Head Cap Screws - 1960 Series



Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
7/8-14 UNF - Key Size 3/4"				
7/8 X 2 1/2	106327	10	**1716.91**	563.20
3 1/2	105086	10	**2440.57**	800.58
1-8 UNC - Key Size 3/4"				
1 X 1 1/2	102584	10	**1534.20**	698.72
2	116002	10	**595.39**	809.29
2 1/4	116035	10	**637.02**	836.00
2 1/2	115091	10	**676.91**	887.04
2 3/4	115123	10	**716.80**	932.80
3	104702	10	**751.88**	887.13
3 1/4	115189	10	**786.17**	1026.34
3 1/2	114821	10	**831.74**	1113.66
4	114853	10	**994.47**	1160.52
4 1/2	114888	10	**1162.84**	1301.39
5	114920	10	**1250.77**	1424.08
5 1/2	103572	10	**1370.80**	1520.82
6	103589	10	**1491.07**	1646.35
6 1/2	103606	10	**1868.37**	1775.18
7	103623	10	**2106.21**	1868.68
7 1/2	100398	10	**3022.73**	1997.27
8	122961	10	**2587.27**	2090.88
8 1/2	105063	10	**3133.93**	2219.58
9	116867	10	**3334.08**	2313.08
9 1/2	121557	10	**3346.23**	2441.78
10	116899	10	**3362.78**	2535.50
11	102035	5	**4476.29**	2757.70
12	104168	5	**4559.30**	2979.90
14	121558	5	**5325.79**	3424.52
1-12 UNF Key Size 3/4"				
1 X 2 3/4	117604	10	**1706.19**	964.06
3 1/2	109908	10	**2027.03**	1108.21
5 1/2	105362	10	**2840.95**	1520.20
6	116289	10	**3011.18**	1646.26
8	105350	10	**3824.44**	2090.88
1 1/4-7 UNC - Key Size 7/8"				
1 1/4 X 2 1/2	115451	1	**2437.41**	1596.98
3	115468	1	**2587.20**	1745.57
3 1/2	121587	1	**2597.88**	1893.98
4	104842	1	**2672.86**	2086.48
4 1/2	104857	1	**3000.06**	2136.29
5	112918	1	**3014.65**	2433.86
5 1/2	104887	1	**3232.72**	2596.00
6	110103	1	**3477.15**	2781.13
6 1/2	110118	1	**3552.16**	2954.82
7	110136	1	**3828.62**	3124.00
8	110152	1	**4142.20**	3475.78
9	110168	1	**5248.29**	3822.94

Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
1 1/4-7 UNC - Key Size 7/8"				
1 1/4 X 10	110184	1	**6037.99**	4170.32
12	110201	1	**7071.47**	4864.86
1 1/4-12 UNF - Key Size 7/8"				
1 1/4X 3 1/2	106603	1	**5506.11**	1912.90
4	116291	1	**6065.74**	2086.48
4 1/2	108258	1	**6571.00**	2260.06
5	109017	1	**7075.63**	2433.86
5 1/2	116292	1	**7580.25**	2607.44
6	107644	1	**8085.51**	2781.24
1 1/2-6 UNC - Key Size 1"				
1 1/2 X 3	110217	1	**3506.35**	2772.66
3 1/2	110234	1	**3767.29**	2984.30
4	110250	1	**4003.88**	3195.94
4 1/2	115919	1	**4129.51**	3407.58
5	115936	1	**4393.38**	3715.36
5 1/2	115953	1	**4469.38**	3965.39
6	115969	1	**4757.61**	4215.42
6 1/2	115985	1	**4884.16**	4465.34
7	116001	1	**5185.06**	4323.00
8	116017	1	**5662.17**	4816.02
9	116033	1	**6646.47**	5715.60
10	116050	1	**7228.23**	6215.88
12	116068	1	**8390.97**	7215.78
1 1/2-12 UNF Key Size 1"				
1 1/2 X 3	103034	1	**8060.57**	2772.66
3 1/2	116143	1	**8675.85**	2984.30
4	110258	1	**9291.11**	3195.94
4 1/2	110290	1	**9906.38**	3407.58
5	110697	1	**10801.14**	3715.36
5 1/2	109136	1	**11527.41**	3965.28
6	106106	1	**12254.90**	4215.42
8	100447	1	**14000.94**	4816.02
10	114786	1	**18070.57**	6215.88

Note:

- Sizes above the bold line are threaded to head.
- The following diameters are fully interchangeable between 1936 and 1960 series:-
  No 10, 1/4", 3/8", 1/2" both UNC and UNF

Pieces per Box

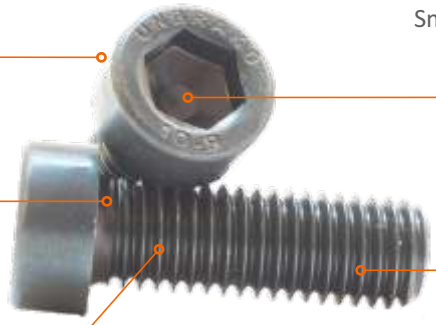
SOCKET LOW HEAD CAP SCREWS

Unbrako
THE WORLD LEADER

Low Head Socket Cap Screws are High Strength, precision fasteners designed for applications where head height clearance is a problem.

Low Head Socket Head Cap Screws cannot be pre-loaded as high as a standard socket head cap screw because of their reduced head height and smaller socket size.

Low Head Socket Head Cap Screws are manufactured from High Strength Alloy Steel and have a Black Oxide finish.



Low head height for thin parts and limited space.

Fillet under head increases fatigue life of head-to-shank junction.

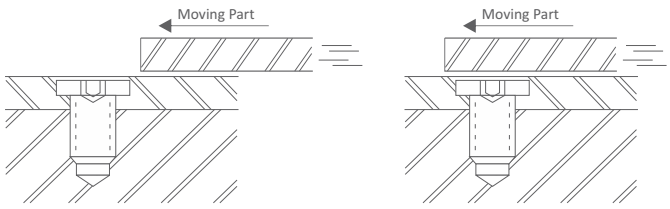
Class 3A rolled threads with radiused root to increase fatigue life of threads by reducing stress concentrations and avoiding sharp corners where failures start.

Smooth, burr-free sockets, uniformly concentric and usable to full depth for correct wrench engagement.

Highest standards of quality, material, manufacture and performance.

Hardness : 40 - 43 HRC
33 - 39 HRC

Tensile Strength : 1040 N/mm^2
Yield Strength : 940 N/mm^2



High Strength Fasteners for applications with limited clearance.

Suitable for use in parts too thin for standard Socket Head Cap Screw and for applications with limited clearance.

Equivalent Standards

DIN 7984 + 6912
(Except for Head & Socket Dims)

Mechanical Properties

Material: Unbrako High Grade Alloy Steel
Property Class: 10.9
Heat Treatment: Rc 33-39
Tensile Strength: 1040 N/mm²
Yield Strength: 940 N/mm²
Shear Strength: 624 N/mm²
Min. Elongation: 9%

NOTES:

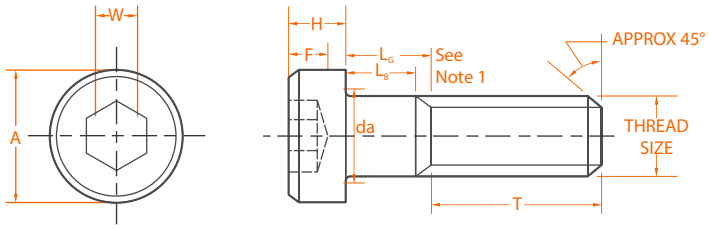
1. Body and Grip Lengths are same as metric Socket Head Cap Screws. (see page no.16)
2. Thread Class: 6g
3. Working Temperature: -50°C to +300°C
4. Sizes M5 and larger are stamped U 10.9. Torques calculated in accordance with VDI 2230 "Systematic calculation of high duty bolted joints" with σ 0.2 = 900 N/mm2 and μ = 0.125 for plain finish and μ = 0.094 for plated.

Length 'L' Tolerance (mm)

Screws Over	Up to and including	Tolerance
-	50	±0.25
50	80	±0.50
80	120	±0.70
120	250	±0.80
250	-	±1.00

Head Marking

Head markings may vary slightly depending on manufacturing practice. UNBRAKO and UNB are recognized identifications for M5 diameter & larger.



Product Dimensions

Thread size nom.	Pitch	Head Diameter A max	Hex Socket Size W nom.	Head Height H max	Key Depth F min.	Transition Diameter da max.	Thread Length T ref
M4	0.70	7	3	2.8	1.48	4.7	20
M5	0.80	8.5	4	3.5	1.85	5.7	22
M6	1.00	10	5	4.0	2.09	6.8	24
M8	1.25	13	6	5.0	2.48	9.2	28
M10	1.50	16	8	6.5	3.36	11.2	32
M12	1.75	18	10	8.0	4.26	13.7	36
M16	2.00	24	12	10.0	4.76	17.7	44
M20	2.50	30	14	12.5	6.07	22.4	52

Thread size nom.	Recommended Seating Torque				Induced Load	
	Unplated		Plated			
	N-m	lbf.ln.	N-m	lbf.ln.	kN	lbf.
M4	3.8	33.6	2.9	25.7	5.65	1,270
M5	8.0	70.8	6.0	53.1	9.20	2,068
M6	13.0	115.0	9.8	86.7	13.00	2,920
M8	32.0	283.0	24.0	212.0	23.90	5,370
M10	64.0	566.0	48.0	425.0	38.00	8,540
M12	110.0	974.0	83.0	735.0	55.50	12,470
M16	275.0	2,434.0	206.0	1,820.0	105.00	23,600
M20	550.0	4,870.0	405.0	3,585.0	164.00	36,800

as per Unbrako standard

Suitable for use in parts too thin for standard Socket Head Cap Screw and for applications with limited clearance.

Equivalent Standards

ASME B18.3

Mechanical Properties

Hardness	RC 38-43
Tensile Stress	170,000 psi min.
Yield Strength	150,000 psi min.

Length 'L' Tolerance (in)

Screw Over	upto & incl	Tolerance
-	1	-.030
1	2 1/2	-.040
2 1/2	-	-.060

Tensile and Shear Strength

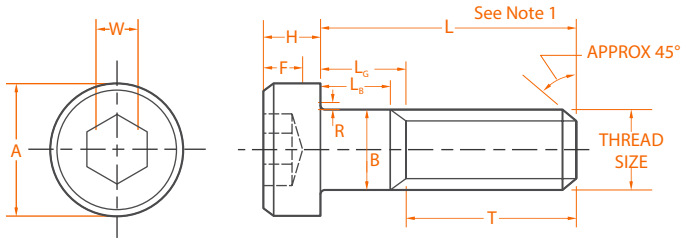
Thread size nom.	Tensile Strength – lbs. min.		Shear strength in threads (calculated lbs.)	
	UNRC	UNRF	UNRC	UNRF
#8	2,380	2,500	1,450	1,570
#10	2,980	3,400	1,700	2,140
1/4	5,410	6,180	3,090	3,900
5/16	8,910	9,870	4,930	6,210
3/8	13,200	14,900	7,450	9,400
1/2	24,100	27,200	13,600	17,100

NOTES:

1. Body and Grip lengths are same as UNC/UNF Socket Head Cap Screws. (see pageno. 24)
2. Thread Class: 3A UNRC and UNRF

Head Marking

Head markings may vary slightly depending on manufacturing practice. UNBRAKO and UNB are recognized identifications for 1/4" diameter & larger.



Product Dimensions

Thread size nom.	Thread per Inch		Body Diameter B	Head Diameter A		Hex Socket Size W	Head Height H		Fillet Extension R	
	UNRC	UNRF	max	max	min	nom.	max	min	max	min
#8	32	36	0.1640	.270	.265	.0781	.085	.079	.012	.007
#10	24	32	0.1900	.312	.307	.0938	.098	.092	.014	.009
1/4	20	28	0.2500	.375	.369	.1250	.127	.121	.014	.009
5/16	18	24	0.3125	.437	.431	.1562	.158	.152	.017	.012
3/8	16	24	0.3750	.562	.556	.1875	.192	.182	.020	.015
1/2	13	20	0.5000	.750	.743	.2500	.254	.244	.026	.020

Thread size nom.	Socket Depth F min.	Thread Length T ref.	Recommended seating torque in-lbs.
#8	.060	.875	25
#10	.072	.875	35
1/4	.094	1.000	80
5/16	.110	1.125	157
3/8	.115	1.250	278
1/2	.151	1.500	667

Low Head Cap Screws

Unbrako

HIGH-GRADE ALLOY STEEL

10.9 Metric

Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
M4 (0.7) - Key Size 3MM				
M4 x 8	106250	200	**40.88**	2.86
10	106251	200	**41.46**	3.30
12	106255	200	**41.46**	3.74
16	106256	200	**48.76**	4.40
20	106257	200	**56.05**	5.06
25	106260	200	**68.19**	6.16
30	406185	200	**77.87**	7.04
M5 (0.8) - Key Size 4MM				
M5 x 8	106262	200	**44.37**	4.84
10	103500	200	**42.04**	5.50
12	103501	200	**43.22**	6.38
15	400790	200	**44.37**	7.26
16	103502	200	**44.37**	7.48
20	103597	200	**51.00**	8.80
25	103503	200	**61.91**	10.56
30	103505	200	**70.91**	11.26
M6 (1) - Key Size 5MM				
M6 x 8	106263	200	**43.22**	6.60
10	103508	200	**43.22**	8.14
12	103509	200	**44.37**	8.89
15	400792	200	**44.96**	10.56
16	103511	200	**44.96**	10.41
20	103512	200	**46.14**	12.76
25	103515	200	**47.31**	15.18
30	103516	200	**47.88**	17.38
35	103517	200	**54.72**	19.80
40	103518	200	**62.94**	22.00
45	106264	200	**72.28**	24.42
M8 (1.25) - Key Size 6MM				
M8 x 12	103519	200	**47.19**	18.04
15	400791	200	**47.64**	20.46
16	103520	200	**47.64**	21.34
20	103521	200	**47.88**	24.64
25	103525	200	**48.46**	28.82
30	103526	200	**57.56**	33.00
35	103528	200	**66.21**	36.96
40	103529	200	**76.09**	41.14
M10 (1.5) - Key Size 8MM				
M10 x 16	103532	200	**289.10**	35.86
20	103533	200	**154.83**	40.19
25	103534	200	**145.06**	45.65
30	103535	200	**141.60**	54.12

Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
M10 (1.5) - Key Size 8MM				
M10 x 35	103536	200	**150.01**	56.52
40	103538	100	**161.84**	61.95
45	106271	100	**203.54**	73.70
50	103541	100	**221.33**	80.08
55	106272	100	**270.01**	86.68
M12 (1.75) - Key Size 10MM				
M12 x 20	103549	100	**250.69**	50.60
25	103550	100	**250.69**	56.10
30	103551	100	**271.83**	74.80
35	103552	100	**255.94**	84.48
40	103553	50	**209.78**	90.57
50	103554	50	**281.19**	113.08
60	103555	50	**328.52**	132.22
M16 (2) - Key Size 12MM				
M16 x 30	103562	25	**840.58**	149.60
35	103563	25	**686.24**	166.32
40	103564	25	**768.10**	183.04
45	106277	25	**846.09**	199.76
50	103565	25	**923.47**	216.48
60	103566	25	**1078.84**	249.92
90	103574	25	**1523.65**	356.40
100	103575	25	**1646.71**	383.68
M20 (2.5) - Key Size 14MM				
M20 x 40	103578	25	**1355.40**	301.4
50	103580	25	**1616.26**	354.2
60	103581	25	**1849.41**	407.0
100	103599	25	**3001.28**	631.4

Sizes above the bold line are threaded to head.

Inch

Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
#8-32 UNC - Key Size 5/64"				
#8 x 3/8	100598	100	**36.39**	2.95
1/2	100619	100	**35.90**	3.52
5/8	100671	100	**42.06**	4.05
3/4	100573	100	**49.86**	4.62
#10-24 UNC - Key Size 3/32"				
#10 x 3/8	100556	100	**34.71**	4.18
1/2	100579	100	**34.59**	4.75
5/8	100505	100	**35.88**	5.48
3/4	100717	100	**38.54**	6.18
1	100623	100	**46.92**	8.36
#10-32 UNF - Key Size 3/32"				
#10 x 3/8	100575	100	**34.71**	4.40
1/2	100541	100	**34.59**	5.06
5/8	100542	100	**37.46**	5.79
3/4	100718	100	**38.54**	6.82
1/4-20 UNC - Key Size 1/8"				
1/4 x 3/8	100506	100	**37.82**	7.70
1/2	100607	100	**38.18**	9.02
5/8	100507	100	**39.96**	9.94
3/4	100508	100	**40.80**	11.66
1	100719	100	**43.67**	14.08
5/16-18 UNC - Key Size 5/32"				
5/16 x 1/2	100720	100	**42.24**	14.74
3/4	100543	100	**45.09**	18.92
1	100620	100	**49.98**	23.10
1 1/4	100686	100	**62.27**	26.60
1 1/2	100544	100	**74.21**	31.68
3/8-16 UNC - Key Size 3/16"				
3/8 x 1/2	100608	100	**55.34**	25.08
3/4	100609	100	**60.84**	30.58
1	100509	100	**67.77**	36.70
1 1/4	100613	100	**74.55**	43.56
1 1/2	100565	100	**80.40**	48.93

All inch sizes are threaded to head.

Pieces per Box

SOCKET HEAD SHOULDER SCREWS

Unbrako shoulder screws are hardened shafts with a knurled head and threaded portion. The shoulder formed where the threads meet the larger diameter body acts as a stop when the screw is threaded into a tapped hole, permitting the screw to be used as a pivot, shaft, or stationary guide.

Unbrako shoulder screws are used to operate stripper plates and in pressure pads a wide variety of tool and die work. They are also used as shafts or pivots, holding pulleys, gears, cams and cam followers, ratchets and circular form tools. Stationary guide applications including locating pins in fixtures, latch stops, alignment of stationary members, linkage blocks, and stock guides in dies. Unbrako shoulder screws are especially advantageous in applications where the fastened part must be removed frequently. For instance, when the shoulder screw is used as a shaft for circular form tools, the screw can be removed to permit sharpening of the tool in a matter of seconds. Assembly is equally as fast.

Unbrako shoulder screws are made of high grade alloy steel the precision tolerance on the shoulder provides close and accurate mating with the fastened components. Unbrako manufactures to a tolerance position closer than that required by international standards.

FEATURES

Precision hex socket for maximum wrenching strength permits full tightening without cracking or reaming socket, yet provides ample metal in the crucial fillet area for maximum head strength.

Controlled root radius doubles fatigue life of threads by reducing stress concentrations and avoiding sharp corners where failures may start. Contour following flow lines of rolled threads provide extra strength, prevent stripping.

Neck allows assembly with no chamfering or other hole preparation.

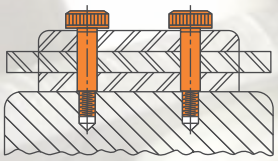
Finished threads close to body for maximum holding power

Knurled head for sure finger grip and fast assembly

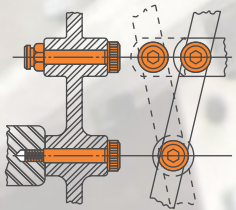
Controlled concentricity between head and body for easier, more accurate assembly

Shoulder diameter held to close tolerance

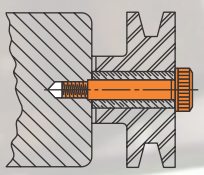
Applications



Stationary Guide



Moving Shaft or Pivot



Pulley Shaft Uses

Replaces costly special parts – shafts, pivots, pins, guides, linkages and trunnion mountings. Also standard for tool and die industries.

Equivalent Standard

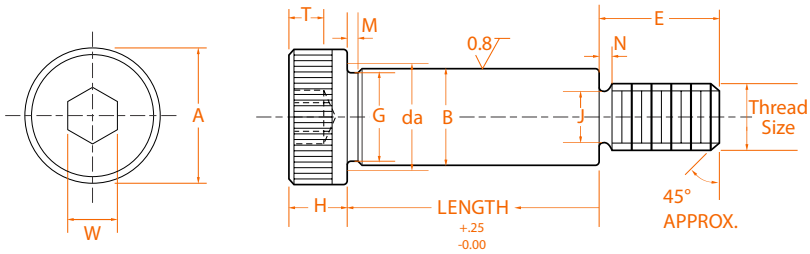
Specification: Generally conforming to ISO 7379, ASME B18.3.3M, BS 4168-7

Mechanical Properties

Material: Unbrako High Grade Alloy Steel
Thread Class: 5g6g
Hardness: Rc 39-43
Shear Strength: 730 N/mm2
Working Temperatures: -50°C to 300°C

Note

Because of their configuration, these screws cannot be tensile tested.



Product Dimensions

Body size nom.	Thread size	Pitch	Head Diameter A max	Hex Socket Size W nom	Head Height H max	Socket Depth T min	Shoulder diameter B max	B min	J max
6	M5	0.80	10.00	3	4.50	2.4	6	5.96	3.84
8	M6	1.00	13.00	4	5.50	3.3	8	7.95	4.56
10	M8	1.25	16.00	5	7.00	4.2	10	9.95	6.23
12	M10	1.50	18.00	6	8.00	4.9	12	11.95	7.89
16	M12	1.75	24.00	8	10.00	6.6	16	15.95	9.54
20	M16	2.00	30.00	10	14.00	8.8	20	19.95	13.20
24	M20	2.50	36.00	12	16.00	10.0	24	23.95	16.54

Body size nom.	da max	N max	G max	M max	Thread Length E max	Recommended seating torque N-m	in-lbs.
6	6.80	2.00	5.62	1.85	9.75	7	60
8	9.20	2.50	7.62	1.85	11.25	12	105
10	11.20	3.00	9.62	1.85	13.25	29	255
12	14.20	3.50	11.62	1.85	16.40	57	500
16	18.20	4.00	15.62	1.85	18.40	100	885
20	22.40	4.50	19.62	2.50	22.40	240	2,125
24	26.40	5.60	23.62	2.65	27.40	470	4,160

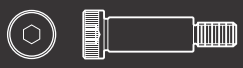
CONCENTRICITY - Body to head O.D. within 0.002 TIR when checked in a 'V' block. Body to thread P.D. within 0.004 TIR when checked at a distance of 0.188 from the shoulder at the threaded end. Squareness, concentricity, parallelism and bow of body to thread P.D. shall be within 0.005 TIR per inch of body length with a maximum of 0.020 when seated against the shoulder in a threaded bush and checked on the body at a distance of 2M from the underside of the head.

Head Marking

Head markings may vary slightly depending on manufacturing practice. UNBRAKO and UNB are recognized identifications for M6 diameter & larger.

Unbrako

Socket Head Shoulder Screws - Metric



Unbrako

HIGH-GRADE ALLOY STEEL

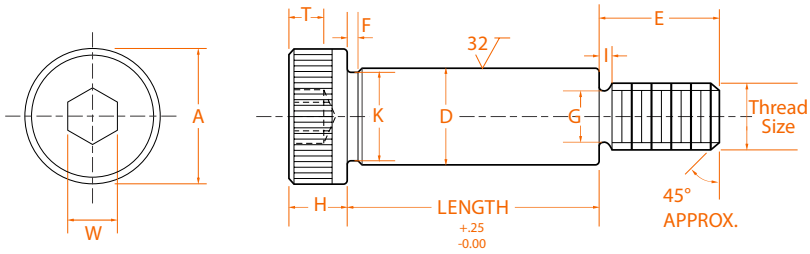
Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
6mm (M5-0.8) - Key Size 3mm				
6 x 10	105364	50	**251.69**	12.43
12	105365	50	**234.50**	13.49
16	105366	50	**237.50**	15.58
20	105368	50	**244.43**	17.93
25	105370	50	**280.10**	20.28
30	105372	50	**316.25**	22.90
40	105373	50	**376.49**	28.14
8mm (M6-1) - Key Size 4mm				
8 x 12	105375	50	**282.38**	26.00
16	105377	50	**285.39**	29.63
20	105379	50	**291.39**	33.29
25	105380	50	**296.32**	37.84
30	105381	50	**302.32**	42.39
40	105383	50	**308.33**	51.50
50	105386	50	**369.89**	60.59
10mm (M8-1.25) - Key Size 5mm				
10 x 16	105388	50	**339.28**	51.04
20	105390	50	**345.20**	56.72
25	105392	50	**353.21**	63.82
30	105393	50	**362.23**	70.91
40	105394	50	**370.23**	85.07
50	105395	50	**379.16**	99.26
60	105396	50	**387.16**	113.30
70	105402	50	**396.17**	127.60
80	106422	50	**410.11**	141.79
12mm (M10-1.5) - Key Size 6mm				
12 x 15	401485	25	**384.16**	78.56
16	105404	25	**384.16**	80.61
20	105406	25	**425.71**	88.70
25	105407	25	**480.94**	98.85
30	105410	25	**494.94**	109.01
40	105411	25	**508.88**	129.29
50	105412	25	**523.89**	149.58
60	105416	25	**539.84**	169.86
70	105417	25	**554.76**	190.15
80	105420	25	**611.76**	210.43
90	105427	25	**670.79**	230.74
100	105433	25	**729.76**	251.02
16mm (M12-1.75) - Key Size 8mm				
16 x 30	105434	25	**689.49**	203.02
40	105435	25	**728.64**	238.70
50	105436	25	**802.28**	274.38
60	105437	25	**856.28**	310.05
70	105438	25	**920.99**	345.73

Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
16mm (M12-1.75) - Key Size 8mm				
16 x 80	105440	25	**997.89**	381.39
90	106343	25	**1073.65**	417.08
100	106344	25	**1271.69**	452.76
120	106346	25	**2057.77**	524.11
20mm (M16-2) - Key Size 10mm				
20 x 40	105441	10	**1555.52**	423.61
50	105442	10	**1642.96**	479.14
60	105444	10	**1727.65**	534.64
70	105448	10	**1812.21**	590.17
80	105449	10	**1896.77**	645.68
90	105450	10	**2098.76**	701.21
100	106347	10	**2000.67**	756.71
120	106348	10	**2294.22**	867.75
24mm (M20-2.5) - Key Size 12mm				
24 x 50	401488	5	**4450.16**	828.50
60	401489	5	**4869.08**	906.49
70	401490	5	**5287.97**	984.48
80	401491	5	**5707.02**	1062.49
90	401492	5	**6125.91**	1140.48
100	401493	5	**6544.82**	1218.47
120	401494	5	**9291.94**	1372.80

Note:

- Precision ground to h8 Tolerance on the shoulder.
- The Nominal Diameter of a shoulder screw is the diameter of the shoulder and not the thread diameter, but it is recommended that both are quoted when ordering Eg. 16mm x M12 x 70

Pieces per Box



Replaces costly special parts – shafts, pivots, pins, guides, linkages and trunnion mountings. Also standard for tool and die industries.

Equivalent Standard

ASME B18.3, BS 2470

Mechanical Properties

Hardness: Rockwell C 39-43;
Shear Strength: 108,000 lbf/in²
Working temperature: -50° to +300° C
Thread class: 3A

Seating Torques and Strength

Thread size nom.	seating torque in-lbs.	ult. tensile strength lbs. (min)	single shear strength of body lbs. (min)
1/4	45	2,220	4,710
5/16	112	4,160	7,360
3/8	230	7,060	10,500
1/2	388	10,600	18,850
5/8	990	19,810	29,450
3/4	1,975	31,670	42,410
1	3,490	47,680	75,400
1-1/4	5,610	66,230	117,800
1-1/2	12,000	110,000	169,500
1-3/4	16,000	141,000	231,000
2	30,000	205,000	301,500

Note

Because of their configuration, these screws cannot be tensile tested.

Head Marking

Head markings may vary slightly depending on manufacturing practice. UNBRAKO and UNB are recognized identifications for 1/4" diameter & larger.

Unbrako

Product Dimensions

Body size nom.	Thread size	Threads per Inch UNRC	Head Diameter A max.	Hex Socket Size W nom	Head Height H max	Socket Depth T min.	Shoulder diameter D max.	Shoulder diameter D min.
1/4	#10	24	.375	.125	.188	.094	.248	.246
5/16	1/4	20	.438	.156	.219	.117	.311	.309
3/8	5/16	18	.562	.188	.250	.141	.373	.371
1/2	3/8	16	.750	.250	.312	.188	.498	.496
5/8	1/2	13	.875	.312	.375	.234	.623	.621
3/4	5/8	11	1.000	.375	.500	.281	.748	.746
1	3/4	10	1.312	.500	.625	.375	.998	.996
1 1/4	7/8	9	1.750	.625	.750	.469	1.248	1.246
1 1/2	1 1/8	7	2.125	.875	1.000	.656	1.498	1.496
1 3/4	1 1/4	7	2.375	1.000	1.125	.750	1.748	1.746
2	1 1/2	6	2.750	1.250	1.250	.937	1.998	1.996

Body size nom.	G max.	K min	I max	F max	Thread Length E max
1/4	.142	.227	.083	.093	.375
5/16	.193	.289	.100	.093	.438
3/8	.249	.352	.111	.093	.500
1/2	.304	.477	.125	.093	.625
5/8	.414	.602	.154	.093	.750
3/4	.521	.727	.182	.093	.875
1	.638	.977	.200	.125	1.000
1-1/4	.750	1.227	.222	.125	1.125
1-1/2	.964	1.478	.286	.125	1.500
1-3/4	1.089	1.728	.286	.125	1.750
2	1.307	1.978	.333	.125	2.000

NOTES

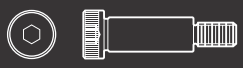
Concentricity: Head to body – within .005 T.I.R. when checked in "V" block equal to or longer than body length. Pitch diameter to body – within .004 T.I.R. when held in threaded bushing and checked at a distance of 3/16" from shoulder at threaded end.

Shoulder must rest against face of shoulder of standard "GO" ring gage.
Bearing surface of head – perpendicular to axis of body within 2° maximum deviation.

Tensile strength based on minimum neck area "G." Shear strength based on shoulder diameter "D."

Screw point chamfer: The point shall be flat or slightly concave, and chamfered. The plane of the point shall be approximately normal to the axis of the screw. The chamfer shall extend slightly below the root of the thread, and the edge between flat and chamfer may be slightly rounded. The included angle of the point should be approximately 90°.

Socket Head Shoulder Screws - Inch



Unbrako

HIGH-GRADE ALLOY STEEL

Size	Part No.		$Price /100	lbs. /1000
1/4" (#10-24) UNC - Key Size 1/8"				
1/4" x 3/8	103614	25	**124.38**	11.84
1/2	115475	25	**126.23**	13.55
5/8	115729	25	**128.40**	15.82
3/4	115859	25	**130.97**	16.96
1	102352	25	**138.90**	21.34
1 1/4	111469	25	**148.74**	23.80
1 1/2	117980	25	**154.59**	27.21
5/16" (1/4-20) UNC - Key Size 5/32"				
5/16" x 3/8	118045	25	**149.49**	19.51
1/2	114047	25	**145.65**	22.20
5/8	117628	25	**148.74**	24.88
3/4	106137	25	**151.17**	27.54
1	106201	25	**162.76**	32.91
1 1/4	106266	25	**170.60**	38.26
1 1/2	106331	25	**176.52**	43.63
1 3/4	106395	25	**194.38**	48.97
2	106459	25	**194.70**	54.34
3/8" (5/16-18) UNC - Key Size 3/16"				
3/8" x 3/8	106524	25	**171.69**	33.77
1/2	111791	25	**172.02**	37.64
5/8	116768	25	**172.60**	41.49
3/4	116800	25	**175.69**	45.36
1	110993	25	**176.78**	53.09
1 1/4	111025	25	**188.37**	60.83
1 1/2	118465	25	**194.38**	68.55
1 3/4	114133	25	**227.70**	76.30
2	114166	25	**240.96**	84.02
2 1/4	114200	25	**258.14**	91.74
2 1/2	114233	25	**249.19**	99.48
2 3/4	119970	25	**267.26**	107.21
3	120003	25	**281.60**	114.95
3 1/4	120036	25	**358.56**	122.67
3 1/2	120069	25	**347.64**	130.39
3 3/4	120101	25	**379.01**	138.14
4	118103	25	**400.65**	145.86
1/2" (3/8-16) UNC - Key Size 1/4"				
1/2" x 1/2	119560	25	**273.30**	74.36
5/8	107602	25	**277.14**	81.25
3/4	107634	25	**277.29**	88.13
1	113288	25	**279.38**	101.90
1 1/4	106400	25	**293.32**	115.70
1 1/2	106432	25	**301.16**	129.47
1 3/4	106465	25	**320.09**	143.26
2	106497	25	**342.91**	157.04
2 1/4	113444	25	**346.46**	170.81
2 1/2	113476	25	**378.77**	184.60

Size	Part No.		$Price /100	lbs. /1000
1/2" (3/8-16) UNC - Key Size 1/4"				
1/2" x 2 3/4	113509	25	**393.59**	198.37
3	102884	25	**405.44**	212.17
3 1/4	111946	25	**435.71**	225.94
3 ½	111978	25	**479.02**	239.71
3 3/4	112011	25	**496.62**	253.51
4	108444	25	**518.30**	267.28
4 1/4	108477	25	**602.65**	281.07
4 1/2	108510	10	**630.02**	294.84
4 3/4	108544	10	**700.75**	308.62
5	102921	10	**718.11**	322.41
5 1/2	116309	10	**788.52**	349.98
6	116311	10	**850.57**	377.52
5/8" (1/2-13) UNC - Key Size 5/16"				
5/8" x 1	115741	25	**381.80**	169.47
1 1/4	102954	25	**447.15**	191.03
1 1/2	107083	25	**486.35**	212.61
1 3/4	107114	25	**499.96**	234.17
2	107147	25	**517.73**	255.73
2 1/4	104292	25	**553.67**	277.31
2 1/2	104359	25	**611.58**	298.87
2 3/4	110484	25	**640.03**	320.43
3	109843	25	**702.41**	342.01
3 1/4	103662	25	**791.60**	363.57
3 1/2	103728	25	**915.90**	385.13
3 3/4	117089	10	**1010.92**	406.71
4	119174	10	**1042.54**	428.27
4 1/4	114672	10	**1316.83**	449.83
4 1/2	114737	10	**1448.39**	471.39
4 3/4	119201	10	**1570.27**	492.98
5	106617	10	**1593.63**	514.54
5 1/2	119573	10	**1982.79**	557.68
6	119605	10	**2240.33**	600.80
6 1/2	116312	10	**2453.81**	643.94
7	116313	10	**2618.22**	687.08
3/4" (5/8-11) UNC - Key Size 3/8"				
3/4" x 3/4	102298	25	**701.16**	241.18
1	102365	25	**791.53**	272.27
1 1/4	102397	25	**881.98**	303.38
1 1/2	108998	10	**843.14**	334.47
1 3/4	125809	10	**844.49**	365.55
2	113145	10	**851.33**	396.00
2 1/4	107658	10	**880.53**	427.72
2 1/2	107690	10	**909.22**	458.83
2 3/4	107722	10	**944.01**	489.92
3	113244	10	**998.24**	521.00
3 1/4	107461	10	**1085.49**	552.09
3 1/2	107493	10	**1171.42**	583.18

Size	Part No.		$Price /100	lbs. /1000
3/4" (5/8-11) UNC - Key Size 3/8"				
3/4" x 3 3/4	107525	10	**1260.18**	614.26
4	107557	10	**1300.64**	645.37
4 1/4	107590	10	**1333.26**	676.46
4 1/2	107622	10	**1449.56**	707.54
4 3/4	113276	10	**1523.47**	738.63
5	113308	10	**1598.30**	769.71
5 1/2	106420	10	**2166.74**	831.91
6	106452	10	**2440.04**	894.08
6 1/2	117921	10	**2779.99**	956.25
7	117938	10	**2960.72**	1018.45

Note:
The nominal diameter of a shoulder screw is the diameter of the shoulder, and not the thread diameter, but it is recommended that both are quoted when ordering. Eg 1/2 x 5/8 UNC x 1

Pieces per Box

FLAT HEAD COUNTERSUNK SOCKET SCREWS

Unbrako
THE WORLD LEADER

Modern equipment and machinery requires stronger more reliable joints to hold their parts together - and stronger more reliable fasteners.

That's why Unbrako countersunk screws are so widely used for fastening of plates, strips, mouldings, and other thin section parts. Unbrako countersunk screws provide reliable fastening and a smooth, attractive, flush mounting that enhances the appearance of the product on which they are used.

Unbrako countersunk screws provide more clamping force because they are manufactured from high grade alloy steel, and held to exacting tolerances to ensure the highest degree of dimensional uniformity. The closely controlled head angle assures flush seating, and close all-round head contact by initially contacting at the upper portion of the head bearing area in the counter-sunk hole. Closely controlled threads mean tighter and more secure fits, and stronger assemblies. Deep accurate non-slip sockets provide maximum key engagement for full tightening without marring the surrounding surface.

Unbrako countersunk screws are available with either plain or plated finish. Stainless steel screws are also available.

FEATURES

Precision forged head for continuous grain flow and maximum strength

Fully formed radiused threads rolled to maintain continuous grain flow for greater tensile and fatigue strength.

Heat treatment in a controlled atmosphere for maximum uniform strength and surface integrity without brittleness or decarburisation.

Uniform under-head angle gives maximum contact with side walls.

Radiused-root runout increases fatigue life.

Deep, accurate socket for uniform wrenching power and high maximum torques.

HIGH-GRADE ALLOY STEEL

Controlled angle under the head ensures maximum flushness and side wall contact. Non-slip Hex socket prevents marring of material.

Equivalent Standards

ISO 10642, ASME B18.3.5M, DIN 7991, BS 4168-8

Mechanical Properties

Material: Unbrako High Grade Alloy Steel
Property Class: 012.9
Heat Treatment: Rc 39-44
Shear Strength: 630 N/mm^2
Min. Elongation: 9%
Tensile Strength: 1040 Mpa
Shear Strength: 630 Mpa
Yield Strength: 945 Mpa

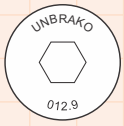
Notes

1. Thread Class: 5g6g
2. Working Temperature: -50°C to +300°C
3. For sizes up to and including M20 Head Angle shall be 92°/90°, over M20 Head Angle be 62°/60°.
4. Torque calculated in accordance with VDI2230 -"Systematic calculation of high duty bolted joints" with σ 0.2= 720N/mm^2 and μ = .125 for plain finish and μ = 0.094 for plated.

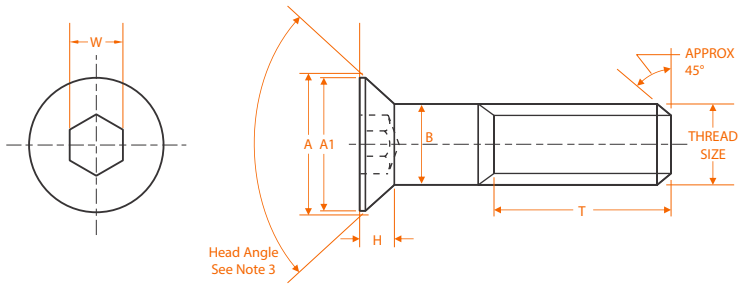
Length 'L' Tolerance (mm)

Screws Over	Up to and including	Tolerance
-	50	±0.25
50	80	±0.50
80	120	±0.70
120	250	±0.80
250	-	±1.02

Head Marking



Head markings may vary slightly depending on manufacturing practice. UNBRAKO and UNB are recognized identifications for M5 diameter & larger.



Product Dimensions

Thread size nom.	Pitch	Theoretical Diameter A max	Head Diameter A1 min	Body Dia B max	Hex Socket Size W nom.	Head Height H ref.	Thread Length T ref.
M3	0.50	6.72	5.82	2.98	2.0	1.86	18
M4	0.70	8.96	7.80	3.98	2.5	2.48	20
M5	0.80	11.2	9.78	4.98	3.0	3.10	22
M6	1.00	13.44	11.73	5.97	4.0	3.72	24
M8	1.25	17.92	15.73	7.97	5.0	4.96	28
M10	1.50	22.40	19.67	9.97	6.0	6.20	32
M12	1.75	26.88	23.67	11.97	8.0	7.44	36
(M14)	2.00	30.24	26.67	13.96	10.0	8.12	40
M16	2.00	33.60	29.67	15.96	10.0	8.80	44
(M18)	2.50	36.96	32.61	17.96	12.0	9.48	48
M20	2.50	40.32	35.61	19.96	12.0	10.11	52
(M22)	2.50	37.38	35.61	21.96	14.0	13.32	56
M24	3.00	40.42	38.61	23.96	14.0	14.22	60

Recommended Seating Torques				Tensile Load
Unplated		Plated		
N-m	lbf.In.	N-m	lbf.In.	kN
1.4	12	1.1	9	5.28
3.4	30	2.6	22	9.22
6.8	60	5.1	45	14.90
11.0	97	8.3	73	21.10
28.0	248	21.0	186	38.40
55.0	486	41.0	365	60.90
95.0	840	71.0	630	88.50
150.0	1,330	112.0	990	121.00
237.0	2,100	177.0	1,570	165.00
340.0	3,000	255.0	2,250	202.00
480.0	4,250	360.0	3,190	257.00
637.0	5,640	477.0	4,220	318.00
746.0	6,600	585.0	5,180	371.00

General Note: Flat, countersunk head cap screws and button head cap screws are designed and recommended for moderate fastening applications: machine guards, hinges, covers, etc. They are not suggested for use in critical high load strength applications where socket head cap screws should be used. Also due to their head configuration they may not meet the minimum ultimate tensile requirements for property class 12.9 as specified in EN ISO 898-1. They are nevertheless required to meet the other material and property requirements for property class 12.9.

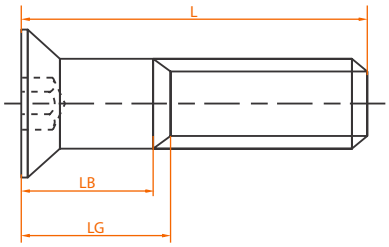
Body and Grip Length Dimensions

- LG is the maximum grip length and is the distance from the bearing surface to the first complete thread.
- LB is the minimum body length and is the length of the unthreaded cylindrical portion of the shank.
- Dimensions for LB and LG are calculated from the following formula:

  T Ref = (2x Nominal Dia) plus 12mm.

  LG max = Nominal length "L" minus "T"

  LB min = Nominal length "L" minus (T + 5 pitches)



Length	M3		M4		M5		M6		M8		M10		M12	
L Nom.	L_B (min)	L_G (max)	L_B (min)	L_G (max)	L_B (min)	L_G (max)	L_B (min)	L_G (max)	L_B (min)	L_G (max)	L_B (min)	L_G (max)	L_B (min)	L_G (max)
30														
35	14.5	17.0	11.5	15.0										
40	19.5	22.0	16.5	20.0	14.0	18.0								
45	24.5	27.0	21.5	25.0	19.0	23.0	16.0	21.0						
50	29.5	32.0	26.5	30.0	24.0	28.0	21.0	26.0	15.75	22.0				
55	34.5	37.0	31.5	35.0	29.0	33.0	26.0	31.0	20.75	27.0				
60			36.5	40.0	34.0	38.0	31.0	36.0	25.75	32.0	20.5	28.0		
65			41.5	45.0	39.0	43.0	36.0	41.0	30.75	37.0	25.5	33.0	20.2	29.0
70			46.5	50.0	44.0	48.0	41.0	46.0	35.75	42.0	30.5	38.0	25.2	34.0
80			56.5	60.0	54.0	58.0	51.0	56.0	45.75	52.0	40.5	48.0	35.2	44.0
90					64.0	68.0	61.0	66.0	55.70	62.0	50.5	58.0	45.2	54.0
100					74.0	78.0	71.0	76.0	65.70	72.0	60.5	68.0	55.2	64.0
110							81.0	86.0	75.70	82.0	70.5	78.0	65.2	74.0
120							91.0	96.0	85.70	92.0	80.5	88.0	75.2	84.0
130									95.70	102.0	90.5	98.0	85.2	94.0
140									105.70	112.0	100.5	108.0	95.2	104.0
150									115.70	122.0	110.5	118.0	105.2	114.0

Length	M14		M16		M18		M20		M22		M24	
L Nom.	L_B (Max.)	L_G (Max.)	L_B (Max.)	L_G (Max.)	L_B (Max.)	L_G (Max.)	L_B (Max.)	L_G (Max.)	L_B (Max.)	L_G (Max.)	L_B (Max.)	L_G (Max.)
70	20.0	30.0										
80	30.0	40.0	26.0	36.0								
90	40.0	50.0	36.0	46.0	29.5	42.0						
100	50.0	60.0	46.0	56.0	39.5	52.0						
110	60.0	70.0	56.0	66.0	49.5	62.0	45.5	58.0				
120	70.0	80.0	66.0	76.0	59.5	72.0	55.5	68.0	51.5	64.0		
130	80.0	90.0	76.0	86.0	69.5	82.0	65.5	78.0	61.5	74.0	55.0	70.0
140	90.0	100.0	86.0	96.0	79.5	92.0	75.5	88.0	71.5	84.0	65.0	80.0
150	100.0	110.0	96.0	106.0	89.5	102.0	85.5	98.0	81.5	94.0	75.0	90.0
160			106.0	116.0	99.5	112.0	95.5	108.0	91.5	104.0	85.0	100.0
180			126.0	136.0	119.5	132.0	115.5	128.0	111.5	124.0	105.0	120.0
200					139.5	156.0	135.5	148.0	131.5	144.0	125.0	140.0
220									151.5	164.0	145.0	160.0
240											165.0	180.0

Countersunk Socket Head Screws- Metric

Unbrako

HIGH-GRADE ALLOY STEEL

Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
M3 (0.5) - Key Size 2mm				
M3 x 6	106283	200	**22.53**	0.84
8	103303	200	**22.77**	1.06
10	103304	200	**22.94**	1.25
12	103305	200	**23.45**	1.45
15	401672	200	**26.70**	1.76
16	103306	200	**26.70**	1.87
20	103308	200	**29.04**	2.27
25	106284	200	**33.79**	2.79
30	106285	200	**34.06**	3.30
M4 (0.7) - Key Size 2.5mm				
M4 x 8	103309	200	**26.04**	1.96
10	103311	200	**26.19**	2.33
12	103312	200	**26.45**	2.68
15	401674	200	**26.04**	3.23
16	103313	200	**28.61**	3.41
18	401675	200	**30.37**	3.76
20	103315	200	**30.37**	4.11
25	103316	200	**34.20**	5.02
30	103317	200	**39.04**	5.92
35	106287	200	**47.22**	7.44
40	106288	200	**49.05**	8.56
M5 (0.8) - Key Size 3mm				
M5 x 8	103318	200	**26.70**	3.30
10	103319	200	**27.62**	3.87
12	103320	200	**27.69**	4.44
14	401676	200	**28.61**	5.04
15	401660	200	**28.61**	5.32
16	103321	200	**28.61**	5.61
18	401677	200	**29.95**	6.18
20	103322	200	**29.95**	6.75
25	103323	200	**35.21**	8.18
30	103324	200	**42.87**	9.61
35	106289	200	**51.22**	11.04
40	106290	200	**56.47**	13.51
45	106293	200	**57.54**	15.22
50	106294	200	**62.32**	17.16
M6 (1) - Key Size 4mm				
M6 x 8	103325	200	**29.55**	5.08
10	103328	200	**31.78**	5.90
12	103329	200	**32.12**	6.71
14	401678	200	**29.95**	7.55
15	401661	200	**29.95**	7.94
16	103330	200	**29.95**	8.36
18	401679	200	**31.28**	9.17
20	103331	200	**31.28**	9.99
25	103332	200	**34.95**	12.03

Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
M6 (1) - Key Size 4mm				
M6 x 30	103333	200	**44.96**	14.08
35	103334	200	**48.38**	16.13
40	103335	200	**49.81**	18.17
45	106295	200	**72.82**	20.04
50	106296	200	**79.50**	24.53
M8 (1.25) - Key Size 5mm				
M8 x 10	103336	200	**38.33**	11.70
12	103337	200	**38.31**	13.18
15	401680	200	**37.46**	15.40
16	103338	200	**37.46**	16.15
18	401681	200	**37.95**	17.62
20	103340	200	**37.95**	19.10
25	103341	200	**39.13**	22.77
30	103342	200	**42.21**	26.47
35	103343	200	**45.14**	30.16
40	103344	200	**45.04**	33.86
45	106297	200	**76.59**	37.53
50	106298	200	**83.42**	44.62
55	106299	100	**89.23**	49.66
60	106300	100	**94.86**	53.53
70	106301	100	**106.09**	62.44
M10 (1.5) - Key Size 6mm				
M10 x 12	103345	200	**47.73**	23.41
16	103347	200	**43.88**	28.05
20	103348	200	**45.79**	32.71
25	103349	200	**47.22**	38.52
30	103350	200	**51.56**	44.35
35	103351	200	**56.97**	50.16
40	103352	100	**63.74**	55.99
45	106302	100	**74.24**	61.80
50	106303	100	**79.34**	67.63
55	106304	100	**100.49**	73.44
60	106305	100	**118.29**	85.93
70	106306	50	**132.81**	99.57
80	106308	50	**149.13**	113.98
90	106309	50	**193.86**	128.00
100	106310	50	**215.19**	142.03
M12 (1.75) - Key Size 8mm				
M12 x 20	103353	100	**87.35**	48.07
25	103354	100	**97.11**	56.50
30	103355	100	**106.78**	64.92
35	103356	100	**106.78**	73.37
40	103357	100	**117.29**	81.80
45	106311	100	**127.55**	90.22
50	103358	50	**138.56**	98.65
55	106312	50	**161.88**	107.07

Size	Part No.	Pieces per Box	$Price /100	lbs. /1000
M12 (1.75) - Key Size 8mm				
M12 x 60	106313	50	**174.55**	115.50
70	106314	50	**217.66**	143.99
80	106315	50	**248.33**	163.68
90	106316	50	**318.88**	184.56
100	106330	50	**353.88**	204.82
M16 (2) - Key Size 10mm				
M16 x 30	103359	50	**206.47**	118.60
35	103360	50	**210.23**	134.05
40	103361	50	**214.32**	149.47
45	106318	50	**252.78**	164.91
50	103362	50	**257.11**	180.36
55	106320	25	**275.81**	195.78
60	103363	25	**298.14**	211.22
70	106321	25	**341.85**	242.09
80	106322	25	**412.11**	291.87
M20 (2.5) - Key Size 12mm				
M20 x 35	106328	25	**336.00**	211.97
40	106332	25	**374.23**	236.10
45	106334	25	**412.24**	260.22
50	106335	25	**450.68**	284.35
60	106337	25	**527.10**	332.60
70	106338	25	**603.66**	380.82
80	106339	25	**680.11**	429.07
100	106342	25	**833.06**	525.56
120	401685	10	**1319.55**	676.37
140	401686	10	**1538.96**	788.83
160	401687	10	**1965.90**	901.30
M24 (3) - Key Size 14mm				
M24 x 50	220032	10	**666.00**	407.00
100	401693	10	**1180.80**	721.60
120	183179	10	**1636.74**	857.34

Sizes above the bold line are threaded to head.

Pieces per Box

Countersunk Socket Head Screws
UNC/UNF

Inch

Controlled angle under the head ensures maximum flushness and side wall contact. Non-slip Hex socket prevents marring of material.

Equivalent Standards

BS 2470, ANSI B18.3

Mechanical Properties

Thread Class: 3A
Material: ASTM F835
Hardness: Rc 39–43
Tensile Strength: 160,000 PSI

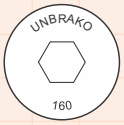
Length Tolerance

Diameter	to 1″	over 1″ to 2 1/2″	over 2 1/2″ to 6″
#0 to 3/8″ incl.	–.03	–.04	–.06
7/16 to 3/4″ incl.	–.03	–.06	–.08
7/8 to 1″ incl.	–.05	–.10	–.14

Application Data

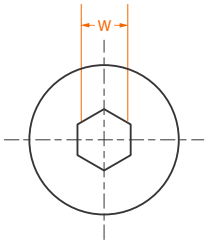
Thread size nom.	Maximum Tightening Torques Unplated UNC	Unplated UNF	Plated UNC	Plated UNF
#0	-	1.6	-	1.2
#1	2.6	2.9	1.9	2.1
#2	4.4	4.8	3.3	3.6
#3	6.7	8.5	5.0	6.3
#4	8.9	10.0	6.6	7.5
#5	13.0	14.0	9.0	10.0
#6	16.0	19.0	12.0	14.0
#8	30.0	32.0	22.0	24.0
#10	44.0	51.0	33.0	38.0
1/4	100.0	120.0	75.0	90.0
5/16	210.0	240.0	157.0	180.0
3/8	380.0	430.0	285.0	322.0
7/16	600.0	680.0	450.0	510.0
1/2	930.0	1,050.0	697.0	787.0
5/8	1,800.0	2,000.0	1,350.0	1,500.0
3/4	3,200.0	3,560.0	2,400.0	2,670.0
7/8	5,400.0	6,000.0	4,050.0	4,500.0
1	8,200.0	8,900.0	6,150.0	6,675.0

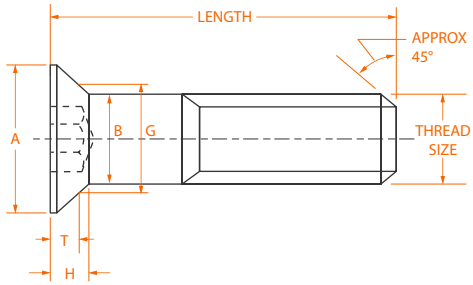
Head Marking



Head markings may vary slightly depending on manufacturing practice. UNBRAKO, and UNB are recognized identifications for #10 diameter & larger.

Unbrako





Product Dimensions

Thread size nom.	Thread per Inch UNC	Thread per Inch UNF	Head Diameter A max*	Head Diameter A min**	Hex Socket Size W nom.	Head Height H max ref.	Socket Depth T min.
#0	–	80	.138	.117	.035	.044	.025
#1	64	72	.168	.143	.050	.054	.031
#2	56	64	.197	.168	.050	.064	.038
#3	48	56	.226	.193	.0625	.073	.044
#4	40	48	.255	.218	.0625	.083	.055
#5	40	44	.281	.240	.0781	.090	.061
#6	32	40	.307	.263	.0781	.097	.066
#8	32	36	.359	.311	.0937	.112	.076
#10	24	32	.411	.359	.1250	.127	.087
1/4	20	28	.531	.480	.1562	.161	.111
5/16	18	24	.656	.600	.1875	.198	.135
3/8	16	24	.781	.720	.2187	.234	.159
7/16	14	20	.844	.781	.2500	.234	.159
1/2	13	20	.938	.872	.3125	.251	.172
5/8	11	18	1.188	1.112	.3750	.324	.220
3/4	10	16	1.438	1.355	.5000	.396	.220
7/8	9	14	1.688	1.604	.5625	.468	.248
1	8	12	1.938	1.841	.6250	.540	.297

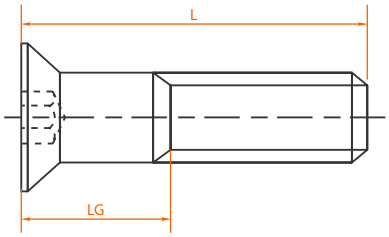
* maximum – to theoretical sharp corners
**minimum – absolute with A flat

Thread size nom.	thd-to-hd max ref	Body Diameter B max	Body Diameter B min	Protrusion gage diameter G max	Protrusion gage diameter G min	Tensile Load lbf UNC	Tensile Load lbf UNF
#0	.500	.060	.0568	.078	.077	-	265
#1	.750	.073	.0695	.101	.100	390	390
#2	.750	.086	.0822	.124	.123	555	555
#3	.750	.099	.0949	.148	.147	725	725
#4	.875	.112	.1075	.172	.171	960	1,040
#5	.875	.125	.1202	.196	.195	1,260	1,310
#6	.875	.138	.1329	.220	.219	1,440	1,620
#8	1.000	.164	.1585	.267	.266	2,220	2,240
#10	1.250	.190	.1840	.313	.312	2,780	3,180
1/4	1.250	.250	.2435	.424	.423	5,070	5,790
5/16	1.500	.3125	.3053	.539	.538	8,350	9,250
3/8	1.750	.375	.3678	.653	.652	12,400	14,000
7/16	2.000	.4375	.4294	.690	.689	16,900	18,900
1/2	2.250	.500	.4919	.739	.738	22,800	25,600
5/8	2.500	.625	.6163	.962	.961	36,000	40,800
3/4	3.000	.750	.7406	1.186	1.185	53,200	59,300
7/8	3.250	.875	.8647	1.411	1.410	73,500	81,000
1	3.750	1.000	.9886	1.635	1.634	96,300	106,000

GENERAL NOTE: Flat, countersunk head cap screws and button head cap screws are designed and recommended for moderate fastening applications: machine guards, hinges, covers, etc. They are not suggested for use in critical high load strength applications where socket head cap screws should be used.

Maximum Lengths

- LG is the maximum grip length and is the distance from the bearing surface to the first complete thread.



Thread Size	Length 'L'																		
	3/4	7/8	1	11/4	11/2	13/4	2	21/4	21/2	23/4	3	31/4	31/2	33/4	4	41/4	41/2	43/4	5
# 0	0.25	0.25	0.50	0.75															
# 1		0.25	0.25	0.62	0.88														
# 2		0.25	0.25	0.62	0.88	1.12													
# 3		0.25	0.25	0.62	0.88	1.12	1.38												
# 4				0.50	0.50	1.00	1.00	1.50											
# 5				0.50	0.50	1.00	1.00	1.50											
# 6				0.50	0.50	1.00	1.00	1.50	1.50	2.00									
# 8				0.38	0.38	0.88	0.88	1.38	1.38	1.88	1.88	2.38							
# 10					0.62	0.62	1.12	1.12	1.62	1.62	2.12	2.12	2.62	2.62	3.12				
1/4						0.75	0.75	1.25	1.25	1.75	1.75	2.25	2.25	2.75	2.75	3.25	3.25	3.75	3.75
5/16							0.88	0.88	1.38	1.38	1.88	1.88	2.38	2.38	2.88	2.88	3.38	3.38	3.88
3/8								1.00	1.00	1.50	1.50	2.00	2.00	2.50	2.50	3.00	3.00	3.50	3.50
7/16									1.12	1.12	1.62	1.62	2.12	2.12	2.62	2.62	3.12	3.12	3.62
1/2									1.00	1.00	1.00	1.75	1.75	1.75	2.50	2.50	2.50	3.25	3.25
5/8												1.50	1.50	1.50	2.25	2.25	2.25	3.00	3.00
3/4													1.50	1.50	1.50	1.50	2.50	2.50	2.50
7/8														1.50	1.50	1.50	1.50	2.50	2.50
1															1.50	1.50	1.50	1.50	2.50

Countersunk Socket Head Screws
UNC/UNF

Unbrako

HIGH-GRADE ALLOY STEEL

Size	Part No.		$Price /100	lbs. /1000
#4-40 UNC - Key Size 1/16″				
#4 x 1/4	104414	100	**15.79**	0.84
3/8	104447	100	**20.85**	1.10
1/2	104480	100	**21.78**	1.36
5/8	103424	100	**22.10**	1.61
3/4	103457	100	**25.53**	1.89
#5-40 UNC - Key Size 5/64″				
#5 x 1/4	121026	100	**20.85**	1.06
3/8	107506	100	**21.27**	1.39
1/2	107615	100	**22.35**	1.74
5/8	113269	100	**22.86**	1.94
3/4	119592	100	**26.28**	2.40
#6-32 UNC - Key Size 5/64″				
#6 x 1/4	119626	100	**21.86**	1.32
3/8	119658	100	**22.77**	1.72
1/2	119691	100	**23.69**	2.13
5/8	119725	100	**24.19**	2.51
3/4	119759	100	**25.86**	2.93
1	105351	100	**29.36**	3.37
#8-32 UNC - Key Size 3/32″				
#8 x 3/8	106645	100	**22.10**	2.60
1/2	106677	100	**22.53**	3.19
5/8	106709	100	**23.02**	3.78
3/4	106741	100	**24.03**	4.38
1	106773	100	**26.04**	5.59
#10-24 UNC - Key Size 1/8″				
#10 x 3/8	106805	100	**20.60**	3.43
1/2	113654	100	**22.86**	4.20
5/8	113687	100	**25.19**	4.97
3/4	113719	100	**25.77**	5.74
1	120686	100	**30.28**	7.26
1 1/4	118712	100	**37.71**	8.80
1 1/2	108955	100	**38.80**	11.62
#10-32 UNF- Key Size 1/8″				
#10 x 3/8	111890	100	**20.60**	3.59
1/2	111889	100	**22.86**	4.42
5/8	113158	100	**25.19**	5.26
3/4	107655	100	**25.77**	6.09
1	107671	100	**30.28**	7.77
1 1/4	107687	100	**37.71**	9.44
1 ½	111818	100	**38.80**	12.03
1/4-20 UNC - Key Size 5/32″				
1/4 x 3/8	105257	100	**21.95**	6.93
1/2	105289	100	**20.94**	8.32
5/8	105321	100	**22.45**	9.70

Size	Part No.		$Price /100	lbs. /1000
1/4-20 UNC - Key Size 5/32″				
1/4 x 3/4	105352	100	**23.45**	11.09
1	118658	100	**25.45**	13.86
1 1/4	120514	100	**34.04**	16.63
1 1/2	120581	100	**37.71**	19.40
1 3/4	120645	100	**49.14**	23.21
2	118672	100	**51.73**	27.26
1/4-28 UNF - Key Size 5/32″				
1/4 x 3/8	111834	100	**21.95**	7.19
1/2	108107	100	**20.94**	8.71
5/8	104289	100	**22.45**	10.21
3/4	104322	100	**23.45**	11.73
1	104356	100	**25.45**	14.72
1 1/4	115174	100	**34.04**	17.73
1 1/2	107581	100	**37.71**	20.75
5/16-18 UNC - Key Size 3/16″				
5/16 x 1/2	120341	100	**28.45**	14.23
5/8	119485	100	**29.95**	16.41
3/4	119517	100	**30.19**	18.59
7/8	106770	100	**25.53**	19.51
1	105918	100	**29.45**	22.95
1 1/4	105951	100	**36.72**	27.32
1 1/2	105983	100	**41.13**	31.68
1 3/4	106015	100	**60.64**	36.04
2	106046	100	**65.15**	44.73
2 1/4	106079	100	**77.08**	47.76
2 1/2	117115	100	**85.34**	50.80
5/16-24 UNF - Key Size 3/16″				
5/16 x 1/2	114970	100	**33.90**	14.83
5/8	103930	100	**35.69**	17.20
3/4	103326	100	**35.98**	18.59
1	115218	100	**35.09**	24.35
1 1/4	115282	100	**43.75**	29.13
1 1/2	115345	100	**52.44**	33.90
3/8-16 UNC - Key Size 7/32″				
3/8 x 1/2	117147	100	**37.38**	22.40
5/8	117179	100	**37.54**	23.85
3/4	107104	100	**38.05**	28.91
7/8	118253	100	**40.32**	32.12
1	107136	100	**40.12**	35.40
1 1/4	104272	100	**43.47**	41.80
1 ½	104338	100	**47.94**	48.38
1 3/4	110464	100	**71.30**	54.87
2	108160	100	**72.65**	65.74
2 1/4	109890	50	**86.18**	73.17
2 1/2	103706	50	**92.68**	80.61
3	104929	50	**111.29**	96.73

Size	Part No.		$Price /100	lbs. /1000
3/8-24 UNF - Key Size 7/32″				
3/8 x 5/8	115416	100	**44.74**	23.85
3/4	103388	100	**45.34**	30.32
1	103420	100	**47.81**	37.40
1 1/4	106866	100	**59.28**	44.48
1 ½	106896	100	**65.37**	51.57
7/16-14 UNC - Key Size 7/32″				
7/16 x 3/4	104993	100	**78.99**	35.22
1	116833	100	**85.20**	43.63
1 1/4	116897	50	**92.91**	35.42
1 1/2	102033	50	**100.34**	63.40
1 3/4	105097	50	**209.92**	68.86
2	116228	50	**220.92**	72.47
1/2-13 UNC- Key Size 5/16″				
1/2 x 3/4	115671	100	**79.74**	45.06
1	102630	100	**85.85**	60.85
1 1/4	107321	50	**99.52**	72.71
1 1/2	107353	50	**101.86**	84.57
1 3/4	120801	50	**114.70**	96.40
2	106977	50	**122.29**	108.26
2 1/4	106992	50	**147.08**	112.11
2 1/2	107007	25	**153.83**	142.16
3	107038	25	**179.11**	165.88
1/2-20 UNF- Key Size 5/16″				
1/2 x 3/4	106925	100	**83.62**	51.19
1	106955	100	**90.02**	64.00
1 1/4	106985	50	**104.36**	76.78
1 1/2	107015	50	**106.81**	89.58
1 3/4	107046	50	**120.27**	102.37
2	107076	50	**128.24**	115.17
5/8-11 UNC - Key Size 3/8″				
5/8 x 1 1/4	107053	25	**178.45**	122.94
1 1/2	107923	25	**197.97**	141.70
1 3/4	120818	25	**222.73**	160.45
2	107955	25	**230.83**	179.21
2 1/4	107971	25	**280.72**	197.96
2 1/2	107989	25	**289.31**	208.53
3	120848	25	**340.53**	254.21
3/4-10 UNC - Key Size 1/2″				
3/4 x 1 1/4	102419	25	**557.20**	262.37
1 1/2	102436	25	**321.31**	219.14
1 3/4	102453	25	**350.35**	226.03
2	102469	25	**372.23**	251.50
2 1/4	102486	25	**919.22**	283.49
2 1/2	102502	25	**457.07**	329.01
3	102535	25	**518.57**	383.94
4	701531	25	**712.80**	475.20

Pieces per Box

Sizes above the bold line are threaded to head.

Unbrako®
THE WORLD LEADER

WHAT YOU BUILD IS ONLY AS GOOD AS WHAT HOLDS IT TOGETHER

High Strength Structural Bolts
Tension Control Structural Bolts
A325 / A490
BS EN 14399, 15048
Arc Welding Studs
Rebar Couplers

Special Orders Only

Your application demands a fastener which outperforms all others. At Unbrako, our fasteners incorporate fully formed radiused heads, rolled to maintain continuous grain flow for increased fatigue strength. It is part of our commitment to giving you the very best in every way.

It's what makes us number one in the world of fasteners with unparalleled engineering knowledge, design ingenuity and manufacturing ability.

Build with Strength

BUTTON HEAD CAP SCREWS

Unbrako THE WORLD LEADER

Unbrako button head screws are ideally suited for use in materials too thin to countersink and in non-critical loading applications. Their low head profile gives them smooth, aesthetic appearance, and their deep accurate sockets ensure non-slip wrench engagement to prevent marring of the surface in which they are installed.

Unbrako button head screws are made from high grade alloy steel and every manufacturing operation is closely controlled. Heads are forged for greater strength and full formed radius-root rolled threads assure close tolerances, maximum strength and superior fatigue resistance. Deep accurate sockets allow full tightening, and customized heat treatment of each heat of steel ensures maximum strength and hardness without brittleness.

FEATURES & BENEFITS

GENERAL NOTE

Flat, countersunk head cap screws and button head cap screws are designed and recommended for moderate fastening applications: machine guards, hinges, covers, etc. These are not suggested for use in critical high strength applications where socket head cap screws should be used.

HIGH-GRADE ALLOY STEEL

Low head streamline design. Use them in materials too thin to countersink; also for non-critical loading requiring heat treated screws

Equivalent Standards

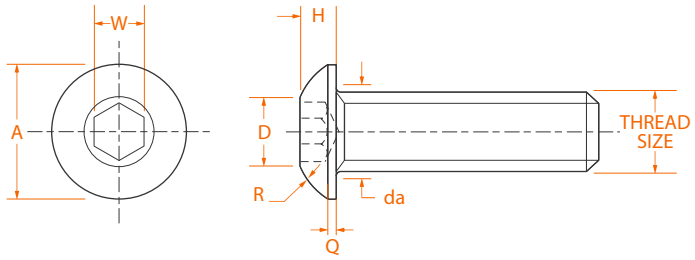
ISO 7380, ASME B18.3.4M, BS 4168-4

Mechanical Properties

1. Material: ASTM F835M, EN ISO 898-1
2. Dimensions: B18.3.4M
3. Property Class: 12.9
4. Hardness: Rc 39-44
5. Tensile Stress: 1040MPa
6. Shear Stress: 630 Mpa
7. Yield Stress: 945 Mpa
8. Working temperature: -50°C to +300°C
9. Bearing surface: To be square with body within 2°.
10. Thread Class: 5g 6g
11. Min Elongation 9%
12. Length Tolrence +/- 0.25MM
13. Torques Calculated In Accordance With VDI 2230

Head Marking

Head markings may vary slightly depending on manufacturing practice. UNBRAKO, and UNB are recognized identifications for M5 diameter & larger.



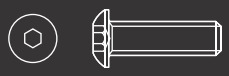
Product Dimensions

Thread size nom.	Pitch	Head Diameter A max	Transition dia da max	D max	Head Height H max.	Q max	R ref.	Hex Socket Size W nom.
M3	0.50	5.70	3.60	3.31	1.65	.38	3.00	2.0
M4	0.70	7.60	4.70	3.93	2.20	.38	4.20	2.5
M5	0.80	9.50	5.70	4.50	2.75	.50	5.20	3.0
M6	1.00	10.50	6.80	5.90	3.30	.80	5.60	4.0
M8	1.25	14.00	9.20	7.00	4.40	.80	7.50	5.0
M10	1.50	17.50	11.20	8.20	5.50	.80	10.00	6.0
M12	1.75	21.00	13.70	10.50	6.60	.80	11.00	8.0

Recommended Tightening Torque				Tensile Load
Unplated		Plated		
Nm	lbf.in	Nm	lbf.in	kN
1.4	12	1.1	9	5.28
3.4	30	2.6	22	9.22
6.8	60	5.1	45	14.90
11.0	97	8.3	73	21.10
28.0	248	21.0	186	38.40
55.0	486	41.0	363	60.90
95.0	840	71.0	630	88.50

General Note: Flat, countersunk head cap screws and button head cap screws are designed and recommended for moderate fastening applications: machine guards, hinges, covers, etc. They are not suggested for use in critical high strength applications where socket head cap screws should be used. Also due to their head configuration they may not meet the minimum ultimate tensile requirements for property class 12.9 as specified in EN ISO 898-1. They are nevertheless required to meet the other material and property requirements for property class 12.9.

Button Head Socket Screws - Metric



Unbrako

HIGH-GRADE ALLOY STEEL

Black / Plain

Size	Part No.		$Price /100	lbs. /1000
M3 (0.5) - Key Size 2mm				
M3 x 5	180248	200	**16.94**	0.97
6	106353	200	**16.94**	1.06
8	106354	200	**16.44**	1.25
10	106357	200	**16.60**	1.45
12	106358	200	**17.77**	1.65
16	106359	200	**23.19**	2.02
M4 (0.7) - Key Size 2.5mm				
M4 x 6	180200	200	**18.94**	2.16
8	106360	200	**18.94**	2.49
10	106361	200	**19.03**	2.84
12	106363	200	**19.61**	3.17
15	401218	200	**21.51**	3.67
16	106364	200	**21.51**	3.85
M5 (0.8) - Key Size 3mm				
M5 x 6	180398	200	**26.46**	3.83
8	180175	200	**26.46**	4.38
10	106365	200	**19.03**	4.93
12	106366	200	**19.86**	5.48
15	401219	200	**21.51**	6.29
16	106367	200	**21.51**	6.56
18	406269	200	**22.69**	7.11
20	106368	200	**22.69**	7.63
22	401220	200	**26.19**	8.18
25	106369	200	**26.19**	9.00
30	106370	200	**27.95**	10.36
M6 (1) - Key Size 4mm				
M6 x 8	180249	200	**40.37**	5.74
10	106372	200	**20.18**	7.15
12	106373	200	**21.51**	7.92
15	401222	200	**21.78**	9.09
16	106374	200	**21.78**	9.48
18	401223	200	**23.86**	10.25
20	106375	200	**23.86**	11.02
25	106376	200	**27.37**	12.96
30	106378	200	**29.45**	14.92
M8 (1.25) - Key Size 5mm				
M8 x 10	106379	200	**29.78**	14.74
12	106380	200	**29.96**	16.13
15	401226	200	**31.31**	18.24
16	106382	200	**31.31**	18.94
20	106384	200	**31.78**	21.74
25	106385	200	**33.21**	25.23

Size	Part No.		$Price /100	lbs. /1000
M8 (1.25) - Key Size 5mm				
M8 x 30	106386	200	**36.79**	28.73
35	106389	200	**41.22**	32.23
40	106390	200	**41.72**	35.73
M10 (1.5) - Key Size 6mm				
M10 x 16	106392	200	**57.26**	32.82
20	106393	200	**60.12**	37.25
25	106396	200	**69.18**	42.75
30	106399	200	**53.90**	48.27
35	106401	200	**60.64**	53.79
40	106402	100	**70.24**	59.29
M12 (1.75) - Key Size 8mm				
M12 x 16	106403	100	**83.80**	52.47
20	106404	100	**86.34**	58.85
25	106405	100	**94.91**	66.84
30	106406	100	**108.65**	74.84
35	106407	100	**111.10**	82.83
40	106408	50	**143.47**	84.66
50	106413	50	**165.68**	106.79

Note:
- All button head socket screws are supplied with full thread.

Pieces per Box

Low heads streamline design. Use them in materials too thin to countersink; also for non-critical loading requiring heat treated screws

Equivalent Standard

ASME B18.3, BS 2470

Mechanical Properties

Material: Unbrako High Grade Alloy Steel
Thread Class: 3A
Max working temperature: -50°C to +300°C
Heat Treatment: Rc 39-44
Tensile Strength: 160,000 PSI
Min. Elongation: 9%

Length Tolerance

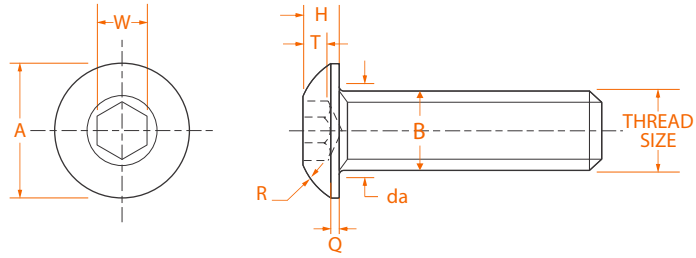
Diameter	to 1" Incl.	over 1" to 2" Incl.
To 1" incl.	–.03	–.04
Over 1" to 2"	–.03	–.06

Maximum Tightening Torques

Thread size nom.	Unplated UNF	Unplated UNC	Plated UNF	Plated UNC
	Maximum Tightening Torques (lbf. in.)			
#4	8.9	10	6.6	7.5
#5	13.0	14	9.7	10.0
#6	16.0	19	12.0	14.0
#8	30.0	32	22.0	24.0
#10	44.0	51	33.0	38.0
1/4	100.0	120	75.0	90.0
5/16	210.0	240	157.0	180.0
	Maximum Tightening Torques (lbf. ft.)			
3/8	380.0	430	285.0	322.0
7/16	600.0	680	450.0	510.0
1/2	930.0	1050	697.0	787.0
5/8	1800.0	2000	1350.0	1500.0
3/4	3200.0	3560	2400.0	2670.0

Head Marking

Head markings may vary slightly depending on manufacturing practice. UNBRAKO and UNB are recognized identifications for #10 diameter & larger.



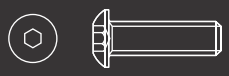
Product Dimensions

Thread size nom.	Threads per Inch UNC	Threads per Inch UNF	Head Diameter A max	Head Diameter A min	Hex Socket Size W min.	Head Height H max	Head Height H min	Socket Depth T min
#0	–	80	.114	.104	.035	.032	.026	.020
#1	64	72	.139	.129	.050	.039	.033	.028
#2	56	64	.164	.154	.050	.046	.038	.028
#3	48	56	.188	.176	.0625	.052	.044	.035
#4	40	48	.213	.201	.0625	.059	.051	.035
#5	40	44	.238	.226	.0781	.066	.058	.044
#6	32	40	.262	.250	.0781	.073	.063	.044
#8	32	36	.312	.298	.0937	.087	.077	.052
#10	24	32	.361	.347	.1250	.101	.091	.070
1/4	20	28	.437	.419	.1562	.132	.122	.087
5/16	18	24	.547	.527	.1875	.166	.152	.105
3/8	16	24	.656	.636	.2187	.199	.185	.122
7/16	14	20	.750	.730	.2500	.232	.212	.138
1/2	13	20	.875	.851	.3125	.265	.245	.175
5/8	11	18	1.000	.970	.3750	.331	.311	.210
3/4	10	16	1.218	1.198	.5000	.398	.378	.272

Thread size nom.	thd. to hd max ref	Body Dia B max	Body Dia B min	Transition Dia. Q max	Transition Dia. da max	R ref	Tensile Load lbs. UNC	Tensile Load lbs. UNF
#0	.500	.060	.0568	.010	.080	.070		
#1	.500	.073	.0695	.010	.093	.080		
#2	.500	.086	.0822	.010	.106	.099		
#3	.500	.099	.0949	.010	.119	.110		
#4	.500	.112	.1075	.015	.132	.135	960	1,040
#5	.500	.125	.1202	.015	.145	.141	1,260	1,310
#6	.625	.138	.1329	.015	.158	.158	1,440	1,620
#8	.750	.164	.1585	.015	.194	.185	2,220	2,240
#10	1.000	.190	.1840	.020	.220	.213	2,780	3,180
1/4	1.000	.250	.2435	.031	.290	.249	5,070	5,790
5/16	1.000	.3125	. 3053	.031	.353	.309	8,350	9,250
3/8	1.250	.375	.3678	.031	.415	.368	12,400	14,000
7/16	1.500	.437	.4294	0.31	.478	.417	16,900	18,900
1/2	2.000	.500	.4919	.046	.560	.481	22,800	25,600
5/8	2.000	.625	.6163	.062	.685	.523	36,000	40,800
3/4	2.000	.750	.7406	0.78	.810	.670	53,200	59,300

N.B. Because of their head configurations, Button head screw tensile loads, are based on 160,000 lbf/in2.

Button Head Socket Screws - Inch



Size	Part No.		$Price /100	lbs. /1000
#4-40 UNC - Key Size 1/16″				
#4 x 1/4	104704	100	**15.85**	0.90
5/16	107146	100	**14.54**	0.99
3/8	104720	100	**16.36**	1.14
1/2	104736	100	**17.45**	1.21
#6-32 UNC - Key Size 5/64″				
#6 x 1/4	104752	100	**16.09**	1.54
5/16	105496	100	**14.34**	1.63
3/8	104768	100	**16.36**	1.94
1/2	104784	100	**17.45**	2.31
5/8	104800	100	**19.06**	2.68
1	106565	100	**24.57**	3.72
#8-32 UNC - Key Size 3/32″				
#8 x 1/4	116546	100	**16.03**	2.44
3/8	116562	100	**17.01**	2.99
1/2	116579	100	**17.18**	3.56
5/8	116595	100	**19.61**	4.00
3/4	116611	100	**20.69**	4.69
#10-24 UNC - Key Size 1/8″				
#10 x 1/4	116932	100	**17.60**	3.34
3/8	116948	100	**17.85**	3.89
1/2	116964	100	**18.60**	4.80
5/8	109705	100	**19.61**	5.50
3/4	109722	100	**20.28**	6.25
7/8	103523	100	**20.94**	6.84
1	103539	100	**22.19**	7.72
#10-32 UNF - Key Size 1/8″				
#10 x 1/4	105400	100	**17.60**	3.48
3/8	102042	100	**17.85**	4.27
1/2	102058	100	**18.60**	5.06
5/8	120709	100	**19.61**	5.85
3/4	120725	100	**20.28**	6.47
7/8	120741	100	**29.94**	7.22
1	118647	100	**26.44**	8.23
1/4-20 UNC - Key Size 5/32″				
1/4 x 3/8	103556	100	**19.35**	7.04
1/2	110416	100	**19.35**	8.34
5/8	104174	100	**20.60**	9.64
3/4	104191	100	**21.51**	10.93
7/8	104209	100	**23.10**	12.25
1	103943	100	**24.78**	13.55
1 1/4	120415	100	**28.17**	16.15
1 1/2	120447	100	**32.73**	18.77

Size	Part No.		$Price /100	lbs. /1000
1/4-28 UNF - Key Size 5/32″				
1/4 x 1/4	114974	100	**19.61**	5.96
3/8	118664	100	**23.06**	7.37
1/2	120494	100	**23.06**	8.78
5/8	120527	100	**24.55**	10.19
3/4	120561	100	**25.64**	11.59
7/8	120593	100	**33.79**	13.00
1	120625	100	**29.53**	14.41
5/16-18 UNC - Key Size 3/16″				
5/16 x 3/8	103959	100	**25.61**	12.58
1/2	103975	100	**25.61**	14.70
5/8	103991	100	**27.90**	16.79
3/4	104007	100	**29.16**	18.90
7/8	104023	100	**30.36**	20.99
1	104040	100	**30.91**	23.10
1 1/4	119263	100	**34.80**	27.30
5/16-24 UNF - Key Size 3/16″				
5/16 x 3/8	701879	100	**25.61**	13.02
1/2	120690	100	**25.61**	15.27
5/8	118684	100	**27.90**	17.51
3/4	118716	100	**29.16**	19.78
1	120320	100	**30.91**	24.27
3/8-16 UNC - Key Size 7/32″				
3/8 x 1/2	104056	100	**34.16**	23.41
5/8	104072	100	**38.36**	26.49
3/4	108180	100	**42.28**	29.57
7/8	108197	100	**43.52**	32.65
1	108213	100	**43.99**	35.73
1 1/4	108229	100	**48.19**	41.91
1 1/2	113752	100	**55.96**	48.07
2	701845	100	**67.98**	60.41
3/8-24 UNF - Key Size 7/32″				
3/8 x 1/2	120353	100	**34.16**	24.42
3/4	119491	100	**42.28**	31.06
1	119523	100	**43.99**	37.73
1 1/4	183934	100	**48.19**	41.91
1/2-13 UNC - Key Size 5/16″				
1/2 x 3/4	106017	100	**106.66**	59.20
1	111721	50	**93.53**	70.38
1 1/4	111737	50	**81.02**	81.55
1 1/2	111753	50	**88.96**	92.40
2	111769	50	**116.17**	115.08

Size	Part No.		$Price /100	lbs. /1000
1/2-20 UNF - Key Size 5/16″				
1/2 x 1	108196	100	**73.15**	73.83
5/8-11 UNC - Key Size 3/8″				
5/8 x1 1/4	111802	25	**203.48**	122.28
1 1/2	111819	25	**212.84**	148.83
2	111906	25	**339.94**	184.25

Note:
- All button head socket screws are supplied with full thread.

HIGH-GRADE ALLOY STEEL

Pieces per Box

FLANGE BUTTON HEAD CAP SCREWS

Unbrako THE WORLD LEADER

Unbrako flange button head screws allow the covering of large diameter holes in sheet metal. As the large under head surface pressure by area is low, this fastener can also be used with softer materials without harm or damage. Flange button heads are ideal to fix strips, cover plates and sheet metal housings.

The radius on the button head presents a streamlined profile, virtually eliminating the sharp edges which could occur with a bolt and washer assembly.

Unbrako flange button head screws are available with metric threads and are made from high grade alloy steel.

FEATURES & BENEFITS

Precision forged head for continuous grain flow and maximum strength

Deep, accurate socket for uniform wrenching power and high maximum torques.

Heat treated in a controlled atmosphere for maximum uniform strength and surface integrity without brittleness or decarburisation

Flange facilitates greater load spread and streamlined appearance

Radiused root runout increases fatigue life

Fully formed radiused threads rolled to maintain continuous grain flow for greater tensile & fatigue strength

Allow covering of large diameter holes in sheet metal. Ideal to fix strips, cover plates and sheet metal housings.

Mechanical Properties

Material: Unbrako High Grade Alloy Steel
Heat Treatment: Rc 39-44

Notes

1. Thread Class: 5g 6g
2. Full thread length to within 2½ pitches of head.
3. Working Temperature: -50°C +300°C
4. Length tolerance = ±0.25mm.

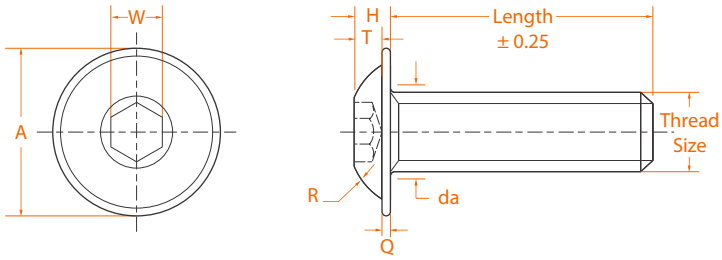
5. Torques calculated in accordance with VDI 2230 "Systematic calculation of high duty bolted joints with σ 0.2 = 720 N/mm^2 and μ = 0.125 for plain finish.

Length Tolerance

Screws Over	Up to and including	Tolerance
-	1"	± 0.16"
1"	2"	+ 0.031" - 0.016"
2"	6"	± 0.031"
6"	-	± 0.062"

Head Marking

Head markings may vary slightly depending on manufacturing practice. UNBRAKO and UNB are recognized identifications for M5 diameter & larger.



Product Dimensions

Thread Size nom.	Pitch	Head Diameter A max.	Hex Socket Size W nom	Head Height H max.	Socket Depth T min	Transition Dia da max	Q max	R ref
M3	0.50	7.12	2.0	1.65	1.05	3.60	0.70	3.00
M4	0.70	9.29	2.5	2.20	1.35	4.70	0.80	4.20
M5	0.80	11.40	3.0	2.75	1.92	5.70	0.90	5.20
M6	1.00	13.59	4.0	3.30	2.08	6.80	1.20	5.60
M8	1.25	17.00	5.0	4.40	2.75	9.20	1.30	7.50
M10	1.50	20.80	6.0	5.50	3.35	11.20	1.75	10.00
M12	1.75	24.69	8.0	6.60	4.16	13.70	2.40	11.00

Thread Size nom.	Recommended Tightening Torques Unplated		Tensile Loads kN
	N-m	lbf.in	
M3	1.96	18	5.23
M4	4.52	40	9.13
M5	9.08	80	14.77
M6	15.40	138	20.90
M8	36.80	330	38.06
M10	72.30	650	60.32
M12	126.00	1134	87.67

Allow covering of large diameter holes in sheet metal. Ideal to fix strips, cover plates and sheet metal housings.

Mechanical Properties

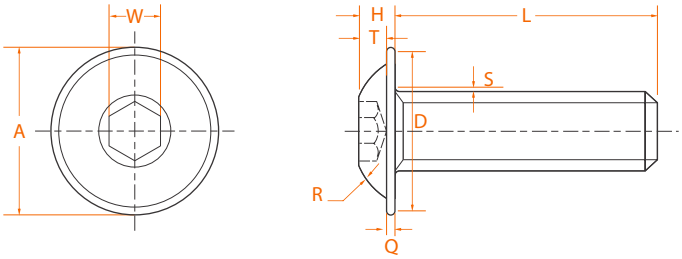
Heat Treatment: 40 - 43 HRC
Thread Class: 3A

Length Tolerance

Up to 1″	-0.03
Over 1″ to 2 1/2″	-0.04
Over 2 1/2″	-0.06

Notes

*Thread Length: Screw lengths equal to or shorter than listed in column 'L' will be threaded to head

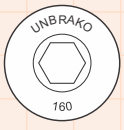


Product Dimensions

Thread Size nom.	Threads per Inch UNC	UNF	Head Diameter A max	Hex Socket Size W max	W min	Head Height H max	Socket Depth T min.
#4	40	48	0.240	0.0635	0.0625	0.059	0.035
#6	32	40	0.292	0.0791	0.0781	0.073	0.044
#8	32	36	0.357	0.0952	0.0937	0.087	0.052
#10	24	32	0.407	0.1270	0.1250	0.101	0.070
1/4	20	28	0.560	0.1587	0.1562	0.132	0.087
5/16	18	24	0.680	0.1900	0.1875	0.166	0.105
3/8	16	24	0.810	0.2217	0.2187	0.199	0.122
1/2	13	20	1.070	0.3160	0.3125	0.265	0.175

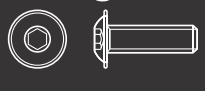
Thread Size nom.	Bearing Face D min	Q max	R nom	Fillet Extension S max	Thread Length* L min
#4	0.203	0.025	0.140	0.010	0.500
#6	0.252	0.028	0.163	0.010	0.625
#8	0.312	0.031	0.190	0.015	0.750
#10	0.357	0.036	0.218	0.015	1.000
1/4	0.496	0.046	0.254	0.020	1.000
5/16	0.603	0.058	0.314	0.020	1.000
3/8	0.721	0.069	0.373	0.020	1.250
1/2	0.960	0.094	0.486	0.030	2.000

Head Marking



Head markings may vary slightly depending on manufacturing practice. UNBRAKO and UNB are recognized identifications for 1/4″ diameter & larger.

Flange Button Head Socket Screws - Metric

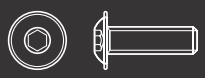


Size	Part No.		$ Price /100	lbs /1000
M3 (0.5) - Key Size 2mm				
M3 x 6	404977	200	**33.13**	1.23
M4 (0.7) - Key Size 2.5mm				
M4 x 8	404982	200	**29.08**	2.79
10	404983	200	**33.76**	3.15
12	404984	200	**37.42**	3.48
16	404986	200	**44.77**	4.16
M5 (0.8) - Key Size 3mm				
M5 x 10	404988	200	**30.07**	5.41
12	404989	200	**32.82**	5.96
16	404991	200	**39.42**	7.04
20	404992	200	**41.43**	8.12
25	404994	200	**44.10**	9.48
M6 (1) - Key Size 4mm				
M6 x 10	180079	200	**43.10**	8.36
12	404997	200	**42.44**	9.13
16	404999	200	**49.79**	10.69
20	405001	200	**56.87**	12.23

Size	Part No.		$ Price /100	lbs /1000
M6 (1) - Key Size 4mm				
M6 x 25	405003	200	**65.82**	14.17
30	405004	200	**74.84**	16.13
M8 (1.25) - Key Size 5mm				
M8 x 10	405005	200	**91.55**	16.37
12	405007	200	**41.43**	17.78
16	405009	200	**50.45**	20.57
20	405011	200	**54.13**	23.36
25	405012	200	**62.49**	26.86
30	405013	200	**70.83**	30.36
40	405015	200	**86.87**	37.36
M10 (1.5) - Key Size 6mm				
M10 x 16	405016	200	**83.53**	35.82
20	405017	200	**93.55**	40.24
25	405018	200	**106.24**	45.76
30	405019	200	**119.28**	51.26

HIGH-GRADE ALLOY STEEL

Flange Button Head Socket Screw - Inch



Size	Part No.		$ Price /100	lbs /1000
#8-32 UNC - Key Size 3/32"				
#8 x 1/4	116376	100	**14.56**	3.04
3/8	116379	100	**17.31**	3.61
1/2	116381	100	**20.05**	4.18
#10-24 UNC - Key Size 1/8"				
#10 x 3/8	116391	100	**21.91**	4.86
1/2	116393	100	**21.92**	5.59
5/8	116395	100	**22.10**	6.34
3/4	116398	100	**22.58**	7.06
#10-32 UNF - Key Size 1/8"				
#10 x 3/8	116392	100	**22.98**	4.86
1/2	116394	100	**22.99**	5.59
3/4	116400	100	**32.30**	7.06

Size	Part No.		$ Price /100	lbs /1000
1/4-20 UNC - Key Size 5/32"				
1/4" x 3/8	116406	100	**26.13**	9.46
1/2	116408	100	**23.46**	10.76
3/4	116413	100	**29.12**	13.35
1	116418	100	**34.83**	15.97
5/16-18 UNC - Key Size 3/16"				
5/16" x 3/8	116421	100	**29.78**	17.91
1/2	116423	100	**33.29**	20.02
5/8	116425	100	**36.77**	22.11
3/4	116427	100	**40.28**	24.22
1	116432	100	**49.24**	28.42
3/8-16 UNC - Key Size 7/32"				
3/8" x 1/2	116434	100	**49.39**	31.68
3/4	116439	100	**94.38**	37.84
1	116444	100	**97.56**	44.00
1 1/4	116446	100	**111.20**	50.16

Pieces per Box

All flange button head socket screws are supplied with full thread

Unbrako

NABL ISO/IEC 17025:2005
CERTIFIED LAB

PRECISION
in Every Fastener

Unbrako Lab is equipped state-of-the-art equipment for testing of both physical and metallurgical aspects of fasteners for the most demanding industries:

- Tensile testing
- Hardness testing
- Salt spray testing
- Digital profile analysis
- X-ray analysis of coating thickness
- Impact Testing
- Chemical composition analysis (Spectrometer)
- Metallurgical Microscope with Image Analyzer
- Dynamic fatigue testing
- Torque tension and friction testing
- Eddy current Testing
- MCD Testing

SOCKET SET SCREWS

Unbrako
THE WORLD LEADER

If you know set screws, you know that the tighter you can tighten them, the better they hold and the more they resist loosening from vibration. But there's a limit to how much you can tighten the average socket set screw. If you're not care-ful, you can ream or crack the socket, and in some cases, even strip the threads. So you're never quite sure whether or not it will actually stay tight. With UNBRAKO set screws it's a different story. A unique combination of design and carefully controlled manufacturing and heat treating gives these screws extra strength that permits you to tighten them appreciably tighter than ordinary screws with minimal fear of reaming or cracking the socket. this extra strength represents a substantial bonus of extra holding power and the additional safety and reliability that goes with it.

Design – Deeper UNBRAKO sockets give more key engagement to let you seat the screws tighter. Corners are radiused to safeguard against reaming or cracking the socket when the extra tightening torque is applied. The sharp corners of other set screws create high stress

concentrations and can cause can cause cracking, even at lower tightening torques. By eliminating the corners, the radii distribute tightening stresses to reduce the chance of splitting to a minimum.

Controlled Manufacturing – The fully-formed threads of UNBRAKO set screws are rolled under extreme pressure to minimize stripping and handle the higher tightening torques. Also, with rolled threads, tolerances can be more closely maintained. Unbrako set screws have Class 3A threads, closest interchangeable fit, giving maximum cross-section with smooth assembly. The thread form itself has the radiused root that increases the strength of the threads and resistance to shear.

Controlled Heat Treatment – This is the third element of the combination. Too little carbon in the furnace atmosphere (decarburization) makes screws soft, causing reamed sockets, stripped threads and sheared points when screws are tightened. Too much carbon (carburization) makes screws brittle and liable to crack or fracture. The heat treatment is literally tailored to each "heat" of UNBRAKO screws, maintaining the necessary controlled Rc 45-53 hardness for maximum strength. Finally, point style affects holding power. As much as 15% more can contributed, depending on the depth of penetration. The cone point (when used without a spotting hole in the shaft) gives greatest increase because of its greater penetration. The plain cup point by far the most commonly used, because of the wide range of applications to which it is adaptable.

However, there is one cup point that can give you both a maximum holding power and of resistance to vibration. It is the exclusive UNBRAKO knurled cup point, whose locking knurls bite into the shaft and resist the tendency of the screw to back out of the tapped hole. The chart on this page shows clearly how much better the UNBRAKO set screws resist vibration in comparison with plain cup point set screws. UNBRAKO knurled cup point self-locking set screws give you excellent per-formance under conditions of extreme vibration.

SOCKET SET SCREWS

Unbrako
THE WORLD LEADER

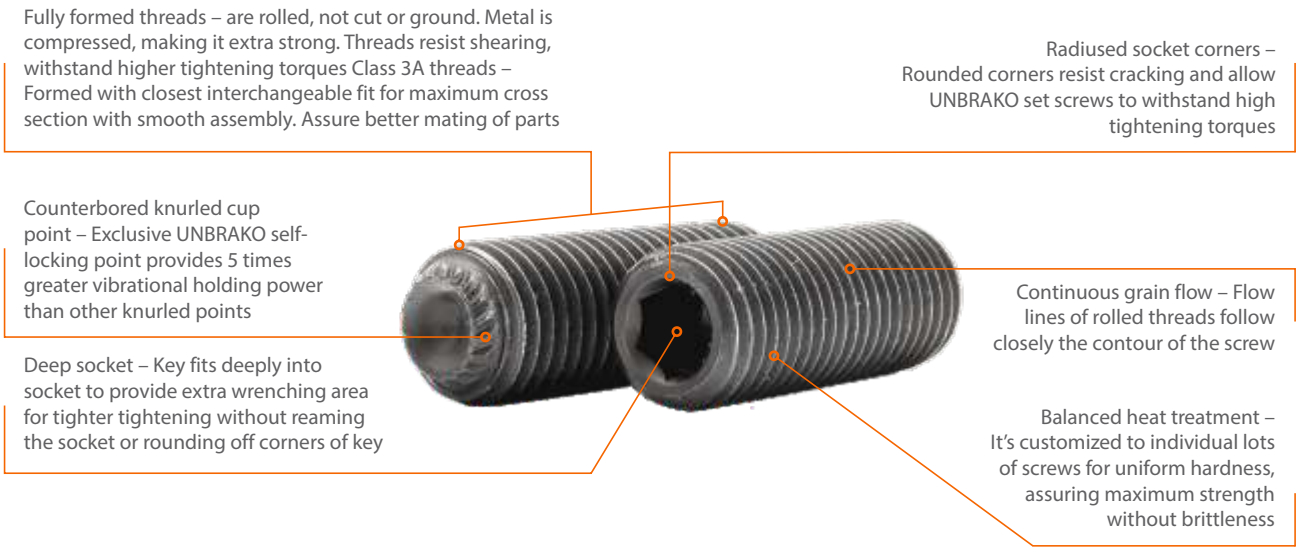
In contrast to other types of fasteners, set screws are primarily used in compression. They must hold fast against three types of forces, torsional (rotational), axial (lateral movement) and vibrational. To be effective, socket set screws should produce a strong clamping action which resists the relative motion between the assembled parts, because of the compression developed by tightening the set screw. Since holding power is proportional to seating torque, the tighter you can seat the screw, the higher the compression force will be.

But there is a limit to how much you can tighten the average set screw. If you're not careful, you'll ream or crack the socket, or strip the threads. So you're never sure if the screw is tight enough, and whether it will stay tight.

But you can be sure that Unbrako set screws will 'stay put' because you can tighten them until the key twists off, with no damage to the screws. Unbrako recommend tightening torques as much as 40% higher than other set screws, giving you extra holding power and additional safety and reliability.
Unbrako socket set screws hold tighter because they are stronger than other set screws. The superior strength and dimensional uniformity of Unbrako set screws permit use of consistently higher seating torques than with other set screws. Consequently you can often save money because you can reduce the size or the number of set screws you require in your assembly.

Here are some of the reasons why Unbrako set screws are so strong and stay tight. Unbrako set screws are made of high grade alloy steel and heat treated to a minimum hardness of Rc 45.
Deep accurate sockets give more key engagement for extra wrenching areas. Radiused socket corners minimize points of weakness where cracks may start. Distribute stresses. Fully formed rolled threads provide greater strength and resistance to stripping. Controlled heat treatment assures uniform hardness without brittleness.

Unbrako socket set screws are available in knurled cup, cone, half dog, flat and plain cup point styles in plain or plated finishes. Stainless steel set screws are available in plain cup points only.



SOCKET SET SCREWS

Point Selection According To Application

Point selection is normally determined by the nature of the application – materials, their relative hardness, frequency of assembly and re-assembly and other factors. Reviewed here are standard point types, their general features and most frequent areas of application of each type.

KNURLED CUP

For quick and permanent location of gears, collars, pulleys or knobs on shafts. Exclusive counterclockwise locking knurls resist screw loosening, even in poorly tapped holes. Resists most severe vibration.

PLAIN CUP

Use against hardened shafts, in zinc, die castings and other soft materials where high tightening torques are impractical.

CONE POINT

For permanent location of parts. Deep penetration gives highest axial and holding power. In material over Rockwell C15 point is spotted to half its length to develop shear strength across point. Used for pivots and fine adjustment.

HALF DOG POINT

Used for permanent location of one part to another. Point is spotted in hole drilled in shaft or against flat (milled). Often replaces dowel pins. Works well against hardened members or hollow tubing.

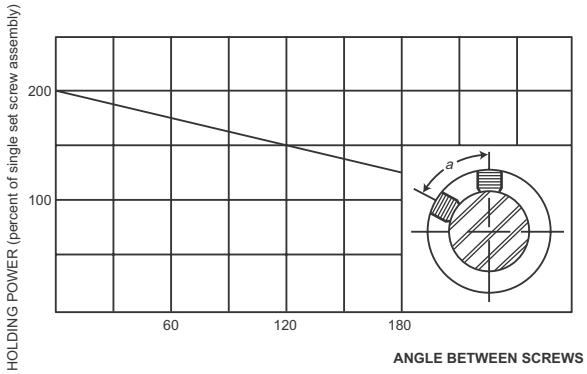
FLAT POINT

Use where parts must be frequently re-set, as it causes little or no damage to part it bears against. Can be used against hardened shafts (usually with ground flat for better contact) and as adjusting screw. Preferred for thin wall thickness and on soft plugs.

Torsional And Axial Holding Power

Size selection of socket set screws

The user of a set-screw-fastened assembly is primarily buying static holding power. The data in this chart offers a simplified means for selecting diameter and seating torque of a set screw on a given dia-meter shaft. Torsional holding power in inch-pounds and axial holding power in pounds are tabulated for various cup point socket screws, seated at recommended installation torques. Shafting used was hardened to Rockwell C15. Test involved Class 3A screw threads in Class 2B tapped holes. Data was determined experimentally in a long series of tests in which holding power was defined as the minimum load to produce 0.010 inch relative movement of shaft and collar. From this basic chart, values can be modified by percentage factors to yield suitable design data for almost any standard set screw application.



Socket Set Screws
Knurled, Plain, Flat and Cone Point

Fasten collars, sheaves, gears, knobs on shafts. Locate machine parts. Self-locking knurled cup point is standard. Special Points like Flat, Dog, Cone & Plain Cup are also available.

Mechanical Properties

Unbrako High Grade Alloy Steel
Hardness: Rc 45 Minimum

Notes

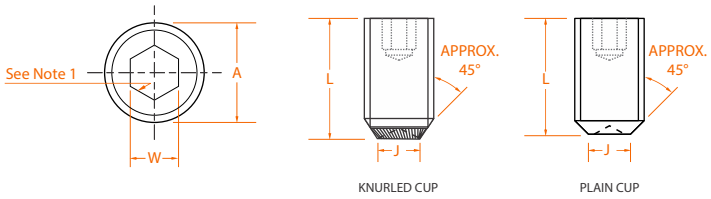
1. Corner of recess must have fillets to minimise stress concentrations.
2. Thread Class: 6g
3. Working Temperature: -50°C to +300°C
4. Angle: The cup angle is 135 max for screw lengths equal to or smaller than screw diameter. For longer lengths, the cup angle will be 124 max.
5. Torques calculated at 75% of the torsional shear strength of the respective Unbrako wrenches.

Maximum Tightening Torque

Thread size	Nm	lbf.in.
M3	0.87	7.7
M4	2.20	19.5
M5	4.60	41.0
M6	7.80	69.0
M8	18.00	160.0
M10	36.00	320.0
M12	62.00	550.0
(M14)	62.00	550.0
M16	150.00	1330.0
(M18)	290.00	2570.0
M20	290.00	2570.0
(M22)	475.00	4200.0
M24	475.00	4200.0

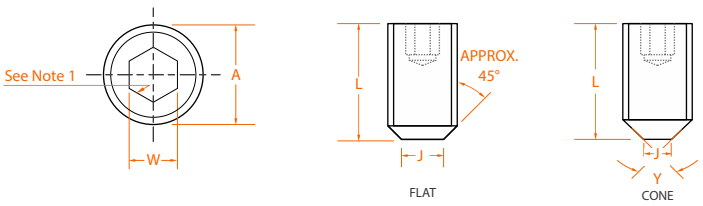
Length Tolerance

Screws Over	Up to and including	Tolerance
-	Screw Dia	+0.25 - 0.00
Screw Dia	50	±0.25
50	80	±0.50
80	120	±0.70
120	250	±0.80



Product Dimensions

Thread size A nom.	Pitch	Hex Socket Size W nom.	Knurled Cup Point J max	Knurled Cup Point L - min preferred	Plain Cup Point J max	Plain Cup Point L - min preferred
M2.5	0.45	1.27	-	-	1.2	3.0
M3	0.50	1.5	1.30	3.0	1.4	3.0
M4	0.70	2.0	2.10	3.0	2.0	3.0
M5	0.80	2.5	2.40	4.0	2.5	4.0
M6	1.00	3.0	3.30	5.0	3.0	4.0
M8	1.25	4.0	4.30	6.0	5.0	5.0
M10	1.50	5.0	5.25	8.0	6.0	6.0
M12	1.75	6.0	6.60	10.0	8.0	8.0
(M14)	2.00	6.0	8.10	12.0	9.0	10.0
M16	2.00	8.0	9.10	14.0	10.0	12.0
(M18)	2.50	10.0	10.30	16.0	12.0	14.0
M20	2.50	10.0	11.50	18.0	14.0	16.0
(M22)	2.50	12.0	12.65	20.0	16.0	18.0
M24	3.00	12.0	14.65	20.0	16.0	20.0



Thread size A nom.	Pitch	Hex Socket Size W nom.	Flat Point J max.	Flat Point L - min Preferred	Cone Point J max.	Cone Point L - min Preferred	Cone Point y° ± 2° 90° for these Lengths & Over; and 120° Under
M3	0.50	1.5	2.0	3.0	Sharp	4.0	4.0
M4	0.70	2.0	2.5	3.0	Sharp	4.0	5.0
M5	0.80	2.5	3.5	4.0	Sharp	5.0	6.0
M6	1.00	3.0	4.0	4.0	1.5	6.0	8.0
M8	1.25	4.0	5.5	5.0	2.0	6.0	10.0
M10	1.50	5.0	7.0	6.0	2.5	8.0	12.0
M12	1.75	6.0	8.5	8.0	3.0	10.0	14.0
(M14)	2.00	6.0	10.0	10.0	4.0	12.0	14.0
M16	2.00	8.0	12.0	12.0	4.0	14.0	18.0
(M18)	2.50	10.0	13.0	12.0	5.0	16.0	20.0
M20	2.50	10.0	15.0	14.0	5.0	18.0	22.0
(M22)	2.50	12.0	17.0	16.0	6.0	20.0	28.0
M24	3.00	12.0	18.0	20.0	6.0	20.0	28.0

All Dimensions In Millimetres.
Sizes In Brackets Are Non-preferred Standards.

Fasten collars, sheaves, gears, knobs on shafts. Locate machine parts. Self-locking knurled cup point is standard. Special Points like Flat, Dog, Cone & Plain Cup are also available.

Equivalent Standards

	BS 4168, ASME B18.3.6M
Flat Point	DIN 913, ISO 4026
Cone Point	DIN 914, ISO 4027
Dog Point	DIN 915, ISO 4028
Plain Cup	DIN 916, ISO 4028
	ISO 898-5

Mechanical Properties

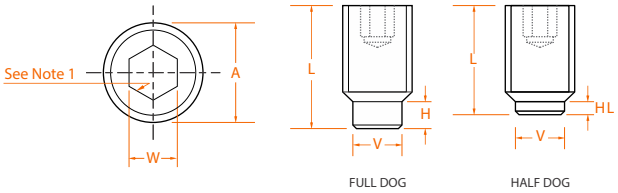
Unbrako High Grade Alloy Steel
Hardness: Rc 45 Minimum

Notes

1. Corner of recess must have fillets to minimise stress concentrations.
2. Thread Class: 6g
3. Working Temperature: -50°C to +300°C
4. Screws with lengths L or smaller will have half dog point H. Screws with lengths larger than L will have full dog point HL.
5. Torques calculated at 75% of the torsional shear strength of the respective Unbrako wrenches.

Length Tolerance

Screws Over	Up to and including	Tolerance
-	Screw Dia	+0.25 - 0.00
Screw Dia	50	±0.25
50	80	±0.50
80	120	±0.70
120	250	±0.80



Product Dimensions

Thread size A nom.	Pitch	Hex Socket Size W nom.	Dog Point L (See Note 4)	Dog Point H-Full Dog max	Dog Point HL-Half Dog max	Dog Point V max
M3	0.50	1.5	5.00	1.75	1.00	2.00
M4	0.70	2.0	6.00	2.25	1.25	2.50
M5	0.80	2.5	6.00	2.75	1.50	3.50
M6	1.00	3.0	8.00	3.25	1.75	4.00
M8	1.25	4.0	10.00	4.30	2.25	5.50
M10	1.50	5.0	12.00	5.30	2.75	7.00
M12	1.75	6.0	16.00	6.30	3.25	8.50
(M14)	2.00	6.0	20.00	7.36	3.80	10.00
M16	2.00	8.0	20.00	8.36	4.30	12.00
(M18)	2.50	10.0	25.00	9.36	4.80	13.00
M20	2.50	10.0	25.00	10.36	5.30	15.00
(M22)	2.50	12.0	30.00	11.43	5.80	17.00
M24	3.00	12.0	30.00	12.43	6.30	18.00

Application Data

Thread size	Maximum Tightening Torque Nm	Maximum Tightening Torque lbf.in.
M3	0.87	7.7
M4	2.20	19.5
M5	4.60	41.0
M6	7.80	69.0
M8	18.00	160.0
M10	36.00	320.0
M12	62.00	550.0
(M14)	62.00	550.0
M16	150.00	1,330.0
(M18)	290.00	2,570.0
M20	290.00	2,570.0
(M22)	475.00	4,200.0
M24	475.00	4,200.0

Sizes in brackets are non-preferred standards.

Torsional and axial holding power

Tabulated axial and torsional holding powers are typical strengths and should be used accordingly, with specific safety factors appropriate to the given application and load conditions.

Thread Size	Seating Torque Nm	Axial Holding Power (kN)	Shaft diameter (shaft hardness Rc 15 to Rc 35) Torsional holding power Nm 1.4	1.6	1.8	2.0	3.0	4.0	5.0	6.0	8.0	10	12	14
M1.4	.10	.19	.13	.15	.17	.19	.29	.38	.48					
M1.6	.10	.22	.15	.18	.20	.22	.33	.44	.55	.66				
M1.8	.10	.25	.18	.20	.23	.25	.38	.50	.63	.75	1.0			
M2.0	.21	.29	.20	.23	.26	.29	.44	.58	.73	.87	1.2	1.5		
M2.5	.60	.53		.42	.48	.53	.80	1.10	1.30	1.60	2.1	2.7	3.2	
M2.6	.60	.56			.50	.56	.84	1.10	1.40	1.70	2.2	2.8	3.4	3.9
M3	.87	.71				.71	1.07	1.40	1.80	2.10	2.8	3.6	4.3	5.0
M4	2.20	1.70				1.70	2.60	3.40	4.30	5.10	6.8	8.5	10.0	12.0
M5	4.60	2.50					3.80	5.00	6.30	7.50	10.0	13.0	15.0	18.0
M6	7.80	4.20							11.00	13.00	17.0	21.0	25.0	29.0
M8	18.00	6.70								20.00	27.0	34.0	40.0	47.0
M10	36.00	9.30									37.0	47.0	56.0	65.0
M12	62.00	12.00										60.0	72.0	84.0
M14	62.00	15.00											90.0	105.0
M16	150.00	18.00												126.0

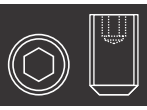
Thread Size	Seating Torque Nm	Axial Holding Power (kN)	Shaft diameter (shaft hardness Rc 15 to Rc 35) Torsional holding power Nm 16	18	20	25	30	40	50	60	70	80	90	100
M2.6	.60	.56	4.5											
M3	.87	.71	5.7	6.4	7.1									
M4	2.20	1.70	14.0	15.0	17.0	21								
M5	4.60	2.50	20.0	23.0	25.0	31	38							
M6	7.80	4.20	34.0	38.0	42.0	53	63	84						
M8	18.00	6.70	54.0	60.0	67.0	84	101	134	168	201				
M10	36.00	9.30	74.0	84.0	93.0	116	140	186	233	279				
M12	62.00	12.00	96.0	108.0	120.0	150	180	240	300	360	420			
M14	62.00	15.00	120.0	135.0	150.0	188	225	300	375	450	525	600		
M16	150.00	18.00	144.0	162.0	180.0	225	270	360	450	540	630	720	810	
M18	290.00	21.00	168.0	189.0	210.0	263	315	420	525	630	735	840	945	1050
M20	290.00	23.00		207.0	230.0	288	345	460	575	690	805	920	1040	1150
M22	475.00	26.00			260.0	325	390	520	650	780	910	1040	1170	1300
M24	475.00	29.00				363	435	580	725	870	1020	1160	1310	1450

HIGH-GRADE ALLOY STEEL

Knurled Cup Point

Size	Part No.	Pieces per Box	$ Price /100	lbs /1000
M3(0.5) - Key Size 1.5mm				
M3 x 3	104076	200	**7.73**	0.18
4	103172	200	**6.19**	0.24
5	103175	200	**6.23**	0.29
6	103176	200	**7.44**	0.40
8	103177	200	**8.56**	0.57
10	103178	200	**8.97**	0.73
12	103179	200	**9.18**	0.90
16	103180	200	**12.36**	1.30
M4 (0.7) - Key Size 2mm				
M4 x 4	103182	200	**9.08**	0.44
5	103185	200	**9.83**	0.55
6	103186	200	**12.15**	0.84
8	103187	200	**11.47**	1.01
10	103188	200	**12.79**	1.28
12	103189	200	**11.81**	1.56
15	401084	200	**14.62**	2.00
16	103191	200	**14.90**	2.13
20	103193	200	**17.05**	2.73
M5 (0.8) - Key Size 2.5mm				
M5 x 5	103194	200	**15.74**	0.88
6	103195	200	**15.03**	1.03
8	103196	200	**17.46**	1.54
10	103197	200	**20.08**	2.00
12	103198	200	**18.63**	2.46
15	401099	200	**23.63**	3.17
16	103199	200	**23.63**	3.39
20	103202	200	**28.20**	4.31
25	103203	200	**35.83**	5.48
30	103204	200	**43.46**	6.64
M6 (1) - Key Size 3mm				
M6 x 6	103207	200	**12.07**	1.41
8	103208	200	**16.04**	2.40
10	103209	200	**13.88**	2.73
12	103211	200	**14.74**	3.50
15	401087	200	**21.79**	4.36
16	103212	200	**21.79**	5.17
20	103214	200	**22.69**	6.01
25	103217	200	**30.14**	7.68
30	103218	200	**36.62**	9.33
35	103219	200	**46.27**	10.98
40	103220	200	**53.32**	12.65
45	103221	200	**60.28**	15.55
50	103222	200	**67.23**	15.95
M8 (1.25) - Key Size 4mm				
M8 x 8	103224	200	**17.08**	3.92
10	103227	200	**16.82**	4.82
12	103228	200	**17.19**	6.23
15	401091	200	**24.49**	7.70
16	103229	200	**24.49**	8.43
20	103230	200	**28.38**	10.85
25	103231	200	**36.26**	13.86
30	103235	200	**46.54**	16.85
35	103236	200	**54.86**	19.87
40	103237	200	**63.19**	25.34
50	103240	200	**79.85**	28.91
M10 (1.5) - Key Size 5mm				
M10 x 10	103241	200	**21.56**	7.41
12	103244	200	**18.40**	9.04
15	401094	200	**24.27**	11.90
16	103245	200	**24.27**	12.85
20	103246	200	**29.05**	16.65
25	103247	200	**37.33**	21.41
30	103249	200	**57.03**	26.16
35	103251	200	**67.40**	34.54
40	103252	200	**77.80**	35.68
45	103253	100	**81.28**	40.44
50	103254	100	**85.40**	45.19
M12 (1.75) - Key Size 6mm				
M12 x 12	103256	100	**49.87**	12.25
16	103258	100	**54.26**	17.78
20	103259	100	**64.41**	23.32
25	103260	100	**65.96**	30.25
30	103261	100	**81.01**	37.16
35	103262	100	**96.13**	44.09
40	103263	50	**111.19**	51.00
45	103269	50	**134.63**	57.93
50	103270	50	**179.05**	64.83
60	103272	50	**205.13**	78.67
M16 (2) - Key Size 8mm				
M16 x 16	106352	50	**92.82**	30.40
20	103274	50	**100.31**	40.59
25	103276	50	**116.27**	53.33
30	103277	50	**134.41**	66.04
35	103278	50	**137.42**	78.78
40	103279	50	**172.95**	91.52
50	103282	50	**204.04**	116.97
55	103283	25	**238.92**	129.69
60	103284	25	**315.70**	142.43
M20 (2.5) - Key Size 10mm				
M20 x 25	103286	50	**208.37**	79.64
30	103287	50	**260.52**	99.57
35	103288	25	**312.74**	119.53
40	103289	25	**364.94**	139.48
50	103292	25	**469.30**	179.37
60	103294	25	**573.66**	219.25

Flat Point



Size	Part No.	Pieces per Box	$ Price /100	lbs /1000
M3 (0.5) - Key Size 1.5mm				
M3 x 3	120000	200	**12.41**	0.22
4	120001	200	**9.35**	0.22
5	104024	200	**13.03**	0.33
6	108106	200	**13.64**	0.44
8	108108	200	**18.62**	0.66
10	108109	200	**20.12**	0.66
12	104025	200	**22.36**	0.88
16	120004	200	**24.58**	1.32
M4 (0.7) - Key Size 2mm				
M4 x 4	121084	200	**9.35**	0.44
5	104027	200	**10.71**	0.59
6	111691	200	**12.28**	0.66
8	108110	200	**13.61**	0.88
10	104028	200	**14.90**	1.32
12	104029	200	**19.86**	1.76
16	108101	200	**27.31**	2.42
20	120005	200	**29.78**	2.64
M5 (0.8) - Key Size 2.5mm				
M5 x 5	121109	200	**11.23**	0.88
6	104031	200	**9.82**	1.10
8	104033	200	**15.21**	1.54
10	104034	200	**16.85**	2.20
12	104035	200	**17.46**	2.64
16	122408	200	**21.96**	3.74
20	104038	200	**26.08**	4.62
25	120006	200	**36.89**	5.94
M6 (1) - Key Size 3mm				
M6 x 6	105476	200	**11.53**	1.54
8	108095	200	**9.96**	2.20
10	108111	200	**12.90**	2.86
12	122395	200	**21.11**	3.74

Pieces per Box Property Class: 45H

HIGH-GRADE ALLOY STEEL

Flat Point

Size	Part No.		$ Price /100	lbs /1000
M6 (1) - Key Size 3mm				
M6 x 15	401089	200	**21.85**	4.84
16	104041	200	**23.86**	5.28
20	108096	200	**30.79**	6.82
25	104042	200	**34.74**	8.80
30	104043	200	**41.70**	10.56
40	120009	200	**57.35**	14.52
M8 (1.25) - Key Size 4mm				
M8 x 8	120861	200	**31.64**	3.74
10	108227	200	**19.86**	4.40
12	104044	200	**15.63**	6.93
16	120012	200	**17.37**	8.43
20	120013	200	**23.09**	13.64
25	106340	200	**25.31**	14.96
30	120014	200	**40.95**	16.85
35	120016	200	**80.67**	28.60
40	120017	200	**93.08**	25.34
50	120020	200	**124.10**	29.72
M10 (1.5) - Key Size 5mm				
M10 X 10	107993	200	**23.09**	6.38
12	108257	200	**20.05**	7.92
16	110881	200	**24.21**	14.30
20	110897	200	**31.27**	17.14
25	120022	200	**40.23**	23.76
30	120023	200	**48.41**	28.60
40	120025	200	**67.38**	39.82
50	120027	100	**81.92**	48.40
M12 (1.75) - Key Size 6mm				
M12 X 12	120028	100	**50.70**	13.86
16	120029	100	**35.18**	19.80
20	107985	100	**38.72**	26.18
25	125795	100	**39.83**	35.20
40	120032	50	**66.11**	55.88
50	120033	50	**83.55**	70.62
60	120037	50	**296.69**	83.60

Dog Point

Size	Part No.		$ Price /100	lbs /1000
M3 (0.5) - Key Size 1.5mm				
M3 x 5*	120182	200	**31.03**	0.22
6	120185	200	**37.23**	0.44
8	108149	200	**40.95**	0.66
10	120188	200	**40.95**	0.66
M4 (0.7) - Key Size 2mm				
M4 x 5*	120194	200	**24.82**	0.55
6*	120195	200	**18.62**	0.66
8	120197	200	**24.82**	0.88
10	108226	200	**29.80**	1.32
12	120199	200	**34.77**	1.76
20	120204	200	**59.59**	2.64
M5 (0.8) - Key Size 2.5mm				
M5 x 6*	120209	200	**15.82**	1.10
8	120210	200	**13.04**	1.54
10	108151	200	**18.62**	2.20
12	120211	200	**37.23**	2.64
16	120212	200	**52.85**	3.74
M6 (1) - Key Size 3mm				
M6 x 8*	120216	200	**12.41**	2.20
10	122149	200	**16.17**	2.86
12	108112	200	**21.14**	3.74
16	108099	200	**29.80**	5.28
20	108034	200	**38.46**	6.82
25	108159	200	**49.64**	8.80
30	107988	200	**59.56**	10.56
M8 (1.25) - Key Size 4mm				
M8 x 8*	120222	200	**27.24**	3.74
10	107983	200	**24.82**	4.40
12	120226	200	**28.57**	5.06
16	120227	200	**30.55**	9.02
20	121121	200	**38.46**	13.64
25	120228	200	**42.21**	14.96
30	108188	200	**54.62**	24.20
40	108146	200	**74.46**	33.00

Size	Part No.		$ Price /100	lbs /1000
M10 (1.5) - Key Size 5mm				
M10 x 10*	108207	200	**28.57**	6.38
16	108191	200	**40.37**	14.30
20	108113	200	**41.70**	18.48
25	108085	200	**53.59**	23.76
30	108098	200	**59.18**	34.98
45	120238	100	**74.87**	44.22
50	120240	100	**82.27**	48.62
M12 (1.75) - Key Size 6mm				
M12 x 12*	120242	100	**67.23**	14.30
20	120243	100	**59.08**	26.18
25	120244	100	**75.96**	33.66
40	107982	50	**126.08**	55.88
50	120248	50	**139.44**	70.62
M16 (2) - Key Size 8mm				
M16 x 30	107984	50	**154.79**	65.78
40	108039	50	**158.60**	94.38
50	120259	50	**206.30**	122.76
60	120261	25	**208.00**	151.14
M20 (2.5) - Key Size 10mm				
M20 x 50	120270	25	**591.30**	210.10
60	120275	25	**756.85**	242.95

Cone Point

Size	Part No.		$ Price /100	lbs /1000
M3 (0.5) - Key Size 1.5mm				
M3 x 5	120071	200	**21.48**	0.31
6	108208	200	**30.68**	0.44
8	120072	200	**45.96**	0.66
M4 (0.7) - Key Size 2mm				
M4 x 5	120076	200	**9.14**	0.55
6	108143	200	**13.65**	0.66
8	108249	200	**18.24**	0.88
10	120077	200	**27.37**	1.32
12	120078	200	**36.48**	1.76

Pieces per Box Property Class: 45H * Half dog point as standard

HIGH-GRADE ALLOY STEEL

Cone Point

Size	Part No.		$ Price /100	lbs /1000
M5 (0.8) - Key Size 2.5mm				
M5 x 6	120085	200	**9.14**	1.10
8	120086	200	**13.59**	1.54
10	113532	200	**19.16**	2.20
12	108144	200	**22.88**	2.64
16	120088	200	**32.46**	3.74
M6 (1) - Key Size 3mm				
M6 x 6	108209	200	**27.31**	1.32
8	108041	200	**8.94**	1.87
10	108210	200	**13.17**	2.86
12	108081	200	**17.05**	3.74
16	108224	200	**24.00**	5.28
20	108020	200	**31.03**	6.82
25	108158	200	**40.03**	8.80
30	120093	200	**48.00**	10.56
M8 (1.25) - Key Size 4mm				
M8 x 8	108097	200	**12.60**	3.74
10	120102	200	**14.79**	4.40
12	120103	200	**17.06**	5.06
16	120104	200	**25.50**	9.02
20	120105	200	**30.82**	13.64
25	120106	200	**33.76**	14.96
M10 (1.5) - Key Size 5mm				
M10 x 12	120115	200	**22.36**	7.92
16	108211	200	**28.23**	13.64
20	120116	200	**29.12**	17.60
25	120916	200	**33.55**	23.76
40	403341	200	**53.55**	39.82
M12 (1.75) - Key Size 6mm				
M12 x 16	120129	100	**46.84**	19.80
20	120130	100	**54.20**	26.18

Plain Point

Size	Part No.		$ Price /100	lbs /1000
M2.5 (0.45) - Key Size 1.27mm				
M2.5 x 3	104173	200	**55.85**	0.13
6	104115	200	**130.31**	0.31
8	104116	200	**176.87**	0.42
10	104117	200	**223.37**	0.53
M3 (0.5) - Key Size 1.5mm				
M3 x 3	120917	200	**24.82**	0.18
4	104045	200	**15.68**	0.26
5	104048	200	**15.82**	0.31
6	104050	200	**16.77**	0.42
M4 (0.7) - Key Size 2mm				
M4 x 4	104051	200	**17.13**	0.44
5	104052	200	**17.46**	0.59
6	104053	200	**18.21**	0.75
8	104054	200	**22.98**	1.03
M5 (0.8) - Key Size 2.5mm				
M5 x 5	104057	200	**12.14**	0.86
6	104058	200	**12.41**	1.10
10	104060	200	**13.30**	2.05
12	107871	200	**14.32**	2.53
M6 (1) - Key Size 3mm				
M6 x 6	104061	200	**11.80**	1.67
8	114523	200	**12.04**	2.13
10	105882	200	**15.89**	2.82
12	104064	200	**16.77**	3.50
16	108121	200	**20.59**	4.86
25	108122	200	**33.69**	7.96
M8 (1.25) - Key Size 4mm				
M8 x 8	116965	200	**12.72**	3.76
10	119229	200	**14.12**	4.99
12	117455	200	**17.56**	6.23

Size	Part No.		$ Price /100	lbs /1000
M10 (1.5) - Key Size 5mm				
M10 x 16	104073	200	**26.18**	13.24
20	104074	200	**38.67**	17.14
25	122205	200	**49.71**	22.02
M12 (1.75) - Key Size 6mm				
M12 x 12	108056	100	**35.56**	12.61
20	108053	100	**53.94**	23.89

Pieces per Box Property Class: 45H

HIGH-GRADE ALLOY STEEL

Fasten collars, sheaves, gears, knobs on shafts. Locate machine parts. Self-locking knurled cup point is standard. Special Points like Flat, Dog, Cone & Plain Cup are also available.

Equivalent Standards

ASME B18.3, BS 2470

Mechanical Properties

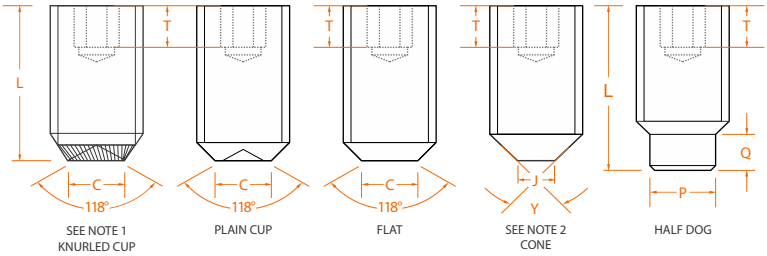
Material : ASTM F912
Dimensions : ASME/ANSI B18.3
Hardness : Rc 45-53
Thread : 3A

Length Tolerance

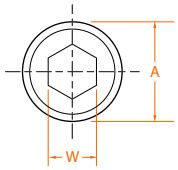
Diameter	.63 and under	over .63 to 2"	over 2" to 6"	over 6"
All	±.01	±.02	±.03	±.06

NOTE

1. Knurled Cup Point: When length equals nominal dia or less, included angle is 130°.
2. Cone Cup Point: When length equals nominal diameter or less, included angle is 118°. (#4 x 1/8 and #8 x 3/16 also have 118° angle)



SEE NOTE 1 KNURLED CUP | PLAIN CUP | FLAT | SEE NOTE 2 CONE | HALF DOG



Product Dimensions

nom. size	Threads per inch. UNRC	UNRF	Head Diameter A max	UNRC	UNRF	Hex Socket Size W nom	C max	min
#0	–	80	.0600	–	.0568	.028	.033	.027
#1	64	72	.0730	.0692	.0695	.035	.040	.033
#2	56	64	.0860	.0819	.0822	.035	.047	.039
#3	48	56	.0990	.0945	.0949	.050	.054	.045
#4	40	48	.1120	.1069	.1075	.050	.061	.051
#5	40	44	.1250	.1199	.1202	.0625	.067	.057
#6	32	40	.1380	.1320	.1329	.0625	.074	.064
#8	32	36	.1640	.1580	.1585	.0781	.087	.076
#10	24	32	.1900	.1825	.1840	.0937	.102	.088

nom. size	Q max	min	T* min	P max	min	Recommended ** seating torque In-lbs	screw length nom.
#0	.017	.013	.035	.040	.037	1.0	3/32
#1	.021	.017	.035	.049	.045	1.8	1/8
#2	.024	.020	.035	.057	.053	1.8	1/8
#3	.027	.023	.060	.066	.062	5	5/32
#4	.030	.026	.075	.075	.070	5	5/32
#5	.033	.027	.075	.083	.078	10	5/32
#6	.038	.032	.075	.092	.087	10	3/16
#8	.043	.037	.075	.109	.103	20	3/16
#10	.049	.041	.105	.127	.120	36	3/16

*CAUTION: Values shown in column T are for minimum stock length cup point screws. Screws shorter than nominal minimum length shown do not have sockets deep enough to utilize full key capability which can result in failure of socket, key or mating threads.

**Torque application only to minimum, nominal lengths shown or longer.

Fasten collars, sheaves, gears, knobs on shafts. Locate machine parts. Self-locking knurled cup point is standard. Special Points like Flat, Dog, Cone & Plain Cup are also available.

Equivalent Standards

ASME B18.3, BS 2470

Mechanical Properties

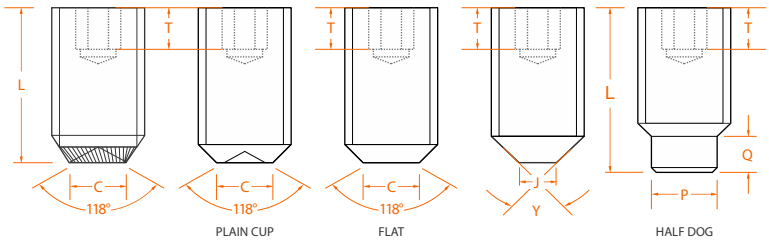
Material : ASTM F912 – alloy steel
Dimensions : ASME/ANSI B18.3
Hardness : Rc 45-53 (alloy steel only),
Thread : 3A

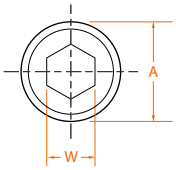
Length Tolerance

Diameter	.63 and under	over .63 to 2″	over 2″ to 6″	over 6″
All	±.01	±.02	±.03	±.06

NOTE

1. Cone Cup Point: When length equals nominal diameter or less, included angle is 118°. (#4 x 1/8 and #8 x 3/16 also have 118° angle)
2. Knurled Cup Point: When length equals nominal dia or less, included angle is 130°.





Product Dimensions

nom. size	Thread per inch. UNRC	UNRF	Head Diameter A max	UNRC	UNRF	Hex Socket Size W nom	C max	min
1/4	20	28	.2500	.2419	.2435	.125	.132	.118
5/16	18	24	.3125	.3038	.3053	.1562	.172	.156
3/8	16	24	.3750	.3656	.3678	.1875	.212	.194
7/16	14	20	.4375	.4272	.4294	.2187	.252	.232
1/2	13	20	.5000	.4891	.4919	.250	.291	.270
9/16	12	18	.5625	.5511	.5538	.250	.332	.309
5/8	11	18	.6250	.6129	.6163	.3125	.371	.347
3/4	10	16	.7500	.7371	.7406	.375	.450	.425
7/8	9	14	.8750	.8611	.8647	.500	.530	.502
1	8	12	1.0000	.9850	.9886	.5625	.609	.579
1 1/8	7	12	1.1250	1.1086	1.1136	.5625	.689	.655
1 1/4	7	12	1.2500	1.2336	1.2386	.625	.767	.733
1 3/8	6	12	1.3750	1.3568	1.3636	.625	.848	.808
1 1/2	6	12	1.5000	1.4818	1.4886	.750	.926	.886

nom. size	Q max	min	T* min	P max	min	Recommended ** seating torque In-lbs	screw length nom.
1/4	.067	.059	.105	.156	.149	87	5/16
5/16	.082	.074	.140	.203	.195	165	3/8
3/8	.099	.089	.140	.250	.241	290	7/16
7/16	.114	.104	.190	.297	.287	430	1/2
1/2	.130	.120	.210	.344	.334	620	9/16
9/16	.146	.136	.265	.390	.379	620	5/8
5/8	.164	.148	.265	.469	.456	1,325	11/16
3/4	.196	.180	.330	.562	.549	2,400	3/4
7/8	.227	.211	.450	.656	.642	3,600	3/4
1	.260	.240	.550	.750	.734	5,000	7/8
1 1/8	.291	.271	.650	.844	.826	7,200	1
1 1/4	.323	.303	.700	.938	.920	9,600	1 1/8
1 3/8	.354	.334	.700	1.031	1.011	9,600	1 1/4
1 1/2	.385	.365	.750	1.125	1.105	11,320	1 1/4

*CAUTION: Values shown in column T are for minimum stock length cup point screws. Screws shorter than nominal minimum length shown do not have sockets deep enough to utilize full key capability which can result in failure of socket, key or mating threads.

**Torque application only to minimum, nominal lengths shown or longer.

Torsional and axial holding power

(Based on Recommended Seating Torques – Inch-Lbs.)

Tabulated axial and torsional holding powers are typical strengths and should be used accordingly, with specific safety factors appropriate to the given application and load conditions.

Thread Size	Seating Torque lbf.in.	Axial Holding Power (lbf.)	Shaft diameter (shaft hardness Rc 15 to Rc 35) Torsional Holding Power lbf.in. 1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16	3/8	7/16	1/2	9/16
#0	1.0	50	1.5	2.3	3.1	3.9	4.7	5.4	6.2					
#1	1.8	65	2.0	3.0	4.0	5.0	6.1	7.1	8.1	10.0				
#2	1.8	85	2.6	4.0	5.3	6.6	8.0	9.3	10.6	13.2	16.0			
#3	5.0	120	3.2	5.6	7.5	9.3	11.3	13.0	15.0	18.7	22.5	26.3		
#4	5.0	160		7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	35.0	40.0	
#5	10.0	200			12.5	15.6	18.7	21.8	25.0	31.2	37.5	43.7	50.0	56.2
#6	10.0	250				19.0	23.0	27.0	31.0	39.0	47.0	55.0	62.0	70.0
#8	20.0	385				30.0	36.0	42.0	48.0	60.0	72.0	84.0	96.0	108.0
#10	36.0	540					51.0	59.0	68.0	84.0	101.0	118.0	135.0	152.0
1/4	87.0	1,000							125.0	156.0	187.0	218.0	250.0	281.0
5/16	165.0	1,500								234.0	280.0	327.0	375.0	421.0
3/8	290.0	2,000									375.0	437.0	500.0	562.0
7/16	430.0	2,500										545.0	625.0	702.0
1/2	620.0	3,000											750.0	843.0
9/16	620.0	3,500												985.0

Thread Size	Seating Torque lbf.in.	Axial Holding Power (lbf)	Shaft diameter (shaft hardness Rc 15 to Rc 35) Torsional Holding Power lbf.in. 5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	2 1/2	3	3 1/2	4
#5	10.0	200	62											
#6	10.0	250	78	94	109									
#8	20.0	385	120	144	168	192								
#10	36.0	540	169	202	236	270	338							
1/4	87.0	1,000	312	375	437	500	625	750						
5/16	165.0	1,500	468	562	656	750	937	1125	1310	1500				
3/8	290.0	2,000	625	750	875	1000	1250	1500	1750	2000				
7/16	430.0	2,500	780	937	1095	1250	1560	1875	2210	2500	3125			
1/2	620.0	3,000	937	1125	1310	1500	1875	2250	2620	3000	3750	4500		
9/16	620.0	3,500	1090	1310	1530	1750	2190	2620	3030	3500	4370	5250	6120	
5/8	1,325.0	4,000	1250	1500	1750	2000	2500	3000	3750	4000	5000	6000	7000	8000
3/4	2,400.0	5,000		1875	2190	2500	3125	3750	4500	5000	6250	7500	8750	10000
7/8	5,200.0	6,000			2620	3000	3750	4500	5250	6000	7500	9000	10500	12000
1	7,200.0	7,000				3500	4375	5250	6120	7000	8750	10500	12250	14000

Unbrako

HIGH-GRADE ALLOY STEEL

Knurled Point

Size	Part No.		$ Price /100	lbs /1000
#4-40 UNC - Key Size 0.05"				
#4 x 1/8	107218	100	**14.60**	0.18
3/16	107235	100	**14.83**	0.29
1/4	117866	100	**22.83**	0.40
1/2	117933	100	**29.58**	0.81
#4-48 UNF - Key Size 0.05"				
#4 x 1/8	107829	100	**17.04**	0.18
3/16	107846	100	**15.99**	0.31
3/8	107894	100	**23.18**	0.64
#5-40 UNC - Key Size 1/16"				
#5 x 1/8	117965	100	**17.88**	0.22
3/16	117981	100	**13.19**	0.33
1/4	117997	100	**19.92**	0.48
1/2	118063	100	**39.40**	1.03
5/8	114014	100	**50.30**	1.32
#5-44 UNF - Key Size 1/16"				
#5 x 1/8	107912	100	**17.88**	0.20
#6-32 UNC - Key Size 1/16"				
#6 x 1/8	102949	100	**15.74**	0.24
3/16	102967	100	**15.77**	0.42
1/4	102983	100	**18.42**	0.57
5/16	108396	100	**21.76**	0.75
3/8	121651	100	**26.23**	0.90
7/16	102767	100	**31.33**	1.17
1/2	121751	100	**35.81**	1.23
3/4	102866	100	**55.00**	1.89
7/8	115033	100	**64.60**	2.22
#8-32 UNC - Key Size 5/64"				
#8 x 1/8	113100	100	**15.01**	0.33
3/16	105233	100	**15.77**	0.57
1/4	114173	100	**16.35**	0.81
5/16	102972	100	**15.36**	1.06
3/8	103005	100	**18.02**	1.32
1/2	103071	100	**23.60**	1.80
5/8	108566	100	**29.94**	2.29
3/4	113228	100	**36.55**	2.79
1	111282	100	**49.22**	3.76
#8-36 UNF - Key Size 5/64"				
#8 x 1/8	119355	100	**16.01**	0.35

Size	Part No.		$ Price /100	lbs /1000
#10-24 UNC - Key Size 3/32"				
#10 x 3/16	105845	100	**15.36**	0.70
1/4	105877	100	**15.51**	1.01
5/16	105909	100	**17.55**	1.34
3/8	116953	100	**17.01**	1.67
7/16	116987	100	**19.92**	2.16
1/2	117019	100	**16.47**	2.27
5/8	117053	100	**21.26**	2.93
3/4	117085	100	**25.74**	3.54
7/8	119137	100	**30.38**	4.18
1	119170	100	**34.86**	4.80
#10-32 UNF - Key Size 3/32"				
#10 x 3/16	119453	100	**15.51**	0.84
1/4	119470	100	**15.51**	1.19
5/16	119486	100	**19.28**	1.47
3/8	119502	100	**17.35**	1.80
1/2	119535	100	**18.44**	2.51
5/8	105919	100	**23.18**	3.19
3/4	109095	100	**28.14**	3.87
1	109112	100	**38.22**	5.26
1-1/4	109129	100	**51.17**	7.04
1/4-20 UNC - Key Size 1/8"				
1/4 x 3/16	114668	100	**25.84**	1.17
1/4	114700	100	**15.92**	1.52
5/16	114733	100	**16.77**	2.68
3/8	114766	100	**17.44**	3.39
7/16	119197	100	**17.46**	3.43
1/2	120250	100	**18.27**	3.98
5/8	119902	100	**20.12**	5.13
3/4	119934	100	**25.86**	6.25
7/8	113809	100	**31.17**	7.39
1	113841	100	**32.18**	8.51
1-1/4	113874	100	**40.74**	10.78
1-1/2	103000	100	**54.63**	14.45
2	103032	100	**72.17**	19.10
1/4-28 UNF - Key Size 1/8"				
1/4 x 3/16	120550	100	**15.36**	1.32
1/4	120568	100	**15.92**	1.61
5/16	120584	100	**16.77**	2.35
3/8	120600	100	**17.44**	3.17
7/16	120616	100	**18.85**	3.43
1/2	120632	100	**20.47**	4.40
5/8	120648	100	**22.10**	5.63
3/4	120665	100	**28.94**	6.86
1	120681	100	**47.15**	9.35

Size	Part No.		$ Price /100	lbs /1000
5/16-18 UNC - Key Size 5/32"				
5/16" x 1/4	104901	100	**37.20**	2.68
5/16	104917	100	**16.86**	3.59
3/8	104934	100	**17.44**	4.51
7/16	104950	100	**17.37**	5.43
1/2	104966	100	**19.03**	7.28
5/8	104982	100	**24.62**	8.18
3/4	104998	100	**27.45**	10.01
1	105030	100	**37.20**	13.68
1 1/4	118995	100	**47.94**	17.36
1 1/2	119011	100	**58.03**	21.01
2	119043	100	**78.32**	28.36
5/16 -24 UNF - Key Size 5/32"				
5/16"x1/4	118675	100	**19.51**	2.93
5/16	118691	100	**18.22**	3.92
3/8	118707	100	**17.44**	4.91
7/16	118723	100	**18.78**	5.87
1/2	118739	100	**19.03**	6.49
5/8	118755	100	**26.94**	8.82
3/4	118773	100	**31.33**	10.78
1	120327	100	**40.59**	13.64
3/8-16 UNC - Key Size 3/16"				
3/8" x 1/4	112027	100	**33.42**	3.65
5/16	112043	100	**34.60**	4.99
3/8	112059	100	**21.44**	6.36
1/2	112092	100	**22.10**	10.58
5/8	112108	100	**34.22**	11.77
3/4	112124	100	**26.95**	14.48
1	112157	100	**38.88**	19.87
1-1/4	112173	100	**47.77**	25.28
1-1/2	112189	100	**58.00**	30.69
1-3/4	112206	100	**68.23**	36.10
2	112221	100	**78.45**	41.51
2-1/2	112237	100	**98.86**	52.32
3/8-24 UNF - Key Size 3/16"				
3/8" x 5/16	120377	100	**20.06**	5.52
3/8	120393	100	**21.44**	7.00
1/2	120412	100	**26.34**	9.92
5/8	120420	100	**37.35**	12.85
3/4	120428	100	**29.77**	15.75
1	120436	100	**48.65**	21.60
1-1/4	120444	100	**61.76**	27.43
1-1/2	120452	100	**74.95**	33.29

Pieces per Box

Knurled Point

Size	Part No.		$ Price /100	lbs /1000
7/16-14 UNC - Key Size 7/32″				
7/16″ x 1/2	112285	100	**52.58**	12.06
3/4	112319	100	**84.72**	19.43
1	108800	100	**116.95**	26.82
7/16-20 UNF - Key Size 7/32″				
7/16″ x 3/8	120460	100	**40.01**	9.17
7/16	117092	100	**48.55**	11.13
1/2-13 UNC - Key Size 1/4″				
1/2″ x 3/8	108901	100	**39.91**	10.56
1/2	119072	100	**56.97**	15.47
5/8	119088	100	**62.06**	20.35
3/4	119104	100	**66.58**	25.23
1	108300	100	**84.27**	35.00
1-1/4	108316	100	**97.61**	44.77
1-1/2	116557	100	**118.91**	54.54
2	102333	100	**161.56**	74.10
1/2-20 UNF - Key Size 1/4″				
1/2″ x 1/2	119207	100	**64.51**	17.07
3/4	119239	100	**97.50**	27.63
1	119256	100	**99.99**	38.21
5/8-11 UNC - Key Size 5/16″				
5/8″ x 1/2	111417	100	**93.84**	22.57
5/8	111449	50	**105.10**	30.34
7/8	117842	50	**133.41**	45.89
1	117875	50	**132.65**	53.68
1-1/4	117909	25	**171.09**	69.23
1-1/2	111467	25	**209.52**	84.79
1-3/4	111499	25	**247.89**	100.32
5/8-18 UNF - Key Size 5/16″				
5/8″ x 5/8	119273	50	**97.41**	33.51
1	119289	50	**145.10**	58.72

Plain Point

Size	Part No.		$ Price /100	lbs /1000
#0-80 UNF - Key Size 0.028″				
#0 x 1/16	114082	100	**159.90**	0.02
3/32	114099	100	**95.94**	0.04
1/8	114116	100	**143.91**	0.07
3/16	114148	100	**191.87**	0.09
1/4	107259	100	**239.84**	0.11
#1-64 UNF - Key Size 0.035″				
#1 x 1/16	107275	100	**159.90**	0.04
3/32	119983	100	**159.90**	0.06
1/8	118176	100	**159.90**	0.08
#2-56 UNC - Key Size 0.035″				
#2 x 1/16	106816	100	**43.81**	0.06
3/32	113649	100	**48.46**	0.09
1/8	113665	100	**48.46**	0.11
3/16	113698	100	**61.58**	0.18
1/4	113714	100	**66.15**	0.24
#3-48 UNC - Key Size 0.050″				
#3 x 3/32	113730	100	**30.03**	0.09
1/8	113747	100	**30.28**	0.11
3/16	102978	100	**38.37**	0.26
1/4	102995	100	**31.87**	0.37
#4-40 UNC - Key Size 0.050″				
#4 x 1/8	103011	100	**13.27**	0.18
3/16	103027	100	**13.27**	0.29
1/4	103043	100	**13.68**	0.40
5/16	103061	100	**14.94**	0.51
3/8	103078	100	**15.26**	0.62
1/2	108572	100	**17.18**	0.84
5/8	108589	100	**21.36**	1.08
#4-48 UNF - Key Size 0.050″				
#4 x 1/8	118241	100	**15.81**	0.20
#5-40 UNC - Key Size 1/16″				
#5 x 1/8	108607	100	**14.87**	0.24
3/16	108623	100	**14.26**	0.37
1/4	108640	100	**15.58**	0.53
5/16	108658	100	**16.19**	0.70
3/8	108674	100	**16.70**	0.81
1/2	108707	100	**18.46**	1.03

Size	Part No.		$ Price /100	lbs /1000
#6-32 UNC - Key Size 1/16″				
#6 x 1/8	113057	100	**13.82**	0.24
3/16	113073	100	**14.50**	0.42
1/4	109399	100	**14.76**	0.59
5/16	109417	100	**15.60**	0.75
3/8	109433	100	**16.36**	0.92
1/2	109465	100	**17.71**	1.25
5/8	109481	100	**21.74**	1.58
3/4	109498	100	**23.18**	1.94
1	109531	100	**35.15**	2.60
#6-40 UNF - Key Size 1/16″				
#6 x 1/8	119216	100	**16.30**	0.26
3/16	119232	100	**17.10**	0.46
1/4	119249	100	**17.40**	0.64
3/8	119282	100	**19.29**	0.99
#8-32 UNC - Key Size 5/64″				
#8 x 1/8	114993	100	**19.56**	0.33
3/16	115009	100	**14.35**	0.59
1/4	108241	100	**14.85**	0.84
5/16	108256	100	**15.44**	1.10
3/8	108273	100	**15.60**	1.34
1/2	118841	100	**17.77**	1.85
5/8	118857	100	**21.95**	2.33
3/4	118873	100	**24.27**	2.84
1	118905	100	**34.12**	3.85
#10-24 UNC - Key Size 3/32″				
#10 x 3/16	118921	100	**14.10**	0.73
1/4	118937	100	**14.10**	1.03
5/16	118953	100	**14.51**	1.36
3/8	118970	100	**15.77**	1.67
1/2	111770	100	**16.77**	2.33
#10-32 UNF - Key Size 3/32″				
#10 x 3/16	119397	100	**16.67**	0.84
1/4	119413	100	**14.10**	1.19
5/16	119429	100	**15.90**	1.50
3/8	120397	100	**15.77**	1.85
1/2	107300	100	**16.77**	2.55
5/8	107316	100	**21.51**	3.26
3/4	107332	100	**23.28**	3.94
1	117212	100	**33.79**	5.35
1 1/4	117228	100	**41.80**	6.73
1/4-20 UNC - Key Size 1/8″				
1/4″ x 1/4	106510	100	**14.51**	1.78
5/16	113489	100	**15.18**	2.38

Pieces per Box

Socket Set Screws - Inch
Plain Point

Unbrako

HIGH-GRADE ALLOY STEEL

Size	Part No.		$ Price /100	lbs /1000
1/4-20 UNC - Key Size 1/8"				
1/4" x 3/8	113554	100	**15.85**	3.39
1/2	106569	100	**16.60**	4.11
5/8	119558	100	**20.85**	5.28
3/4	117296	100	**23.53**	6.42
1	117427	100	**32.95**	8.76
1 1/4	117492	100	**40.38**	11.07
1 1/2	112469	100	**53.23**	13.40
1 3/4	103102	100	**62.73**	15.71
2	103135	100	**71.74**	18.04
#1/4-28 UNF - Key Size 1/8"				
1/4" x 1/4	117260	100	**14.51**	1.94
5/16	117277	100	**15.18**	2.66
3/8	117293	100	**15.85**	3.26
1/2	107183	100	**17.40**	4.51
5/8	107199	100	**21.87**	5.79
3/4	116503	100	**24.67**	7.04
1	104560	100	**34.55**	9.57
1 1/4	104592	100	**42.34**	12.08
#5/16-18 UNC - Key Size 5/32"				
5/16" x 1/4	103169	100	**17.77**	2.77
5/16	103201	100	**15.36**	3.70
3/8	112503	100	**15.36**	4.64
1/2	112568	100	**17.35**	6.51
5/8	103243	100	**22.35**	8.38
3/4	105227	100	**28.54**	10.25
1	113079	100	**33.79**	14.01
1 1/4	109423	100	**44.18**	17.75
1 1/2	109455	100	**56.47**	21.49
1 3/4	109487	100	**64.65**	25.26
2	109521	100	**71.67**	30.98
#5/16-24 UNF - Key Size 5/32"				
5/16" x 1/4	104624	100	**17.77**	3.01
5/16	104657	100	**15.36**	4.00
3/8	104689	100	**16.84**	5.02
1/2	104753	100	**17.35**	7.02
5/8	104785	100	**22.35**	8.25
3/4	110243	100	**24.95**	11.00
1	115929	100	**33.79**	15.00
#3/8-16 UNC - Key Size 3/16"				
3/8" x 1/4	114999	100	**22.31**	4.38
5/16	108247	100	**18.63**	4.99
3/8	118815	100	**19.34**	6.40
1/2	118879	100	**20.56**	9.13
5/8	118911	100	**22.27**	11.86

Size	Part No.		$ Price /100	lbs /1000
#3/8-16 UNC - Key Size 3/16"				
3/8" x 3/4	118943	100	**24.54**	14.56
7/8	117817	100	**28.28**	17.29
1	112019	100	**35.37**	20.02
1 1/4	113565	100	**45.04**	26.84
1 1/2	113597	100	**59.40**	33.88
1 3/4	113630	100	**72.92**	36.34
2	106548	100	**81.00**	41.80
3/8-24 UNF - Key Size 3/16"				
3/8" x 1/4	115994	100	**21.27**	4.66
5/16	116026	100	**19.94**	5.65
3/8	115083	100	**18.44**	7.15
1/2	115149	100	**19.61**	10.60
5/8	115181	100	**22.50**	13.09
3/4	114813	100	**24.54**	16.06
1	114845	100	**37.09**	22.00
1 1/4	114880	100	**47.23**	27.94
1 1/2	114912	100	**62.29**	33.88
7/16-14 UNC - Key Size 7/32"				
7/16" x 3/8	114169	100	**46.05**	8.80
1/2	103001	100	**49.38**	12.28
3/4	103067	100	**58.82**	19.80
1	108595	100	**74.91**	27.30
7/16-20 UNF - Key Size 7/32"				
7/16" x 3/8	103568	100	**46.05**	9.35
1/2	103602	100	**49.38**	13.38
1/2-13 UNC - Key Size 1/4"				
1/2" x 3/8	114340	100	**51.22**	10.82
1/2	108519	100	**51.81**	15.77
5/8	108535	100	**56.47**	20.75
3/4	102895	100	**61.15**	25.72
7/8	102911	100	**69.23**	30.69
1	104078	100	**76.59**	35.66
1 1/4	104095	100	**93.60**	45.58
1 1/2	104112	100	**107.28**	55.53
1 3/4	104128	50	**122.22**	65.45
2	104144	50	**136.15**	75.39
2 1/2	104160	50	**180.37**	95.26
1/2-20 UNF - Key Size 1/4"				
1/2" x 1/2	103619	100	**59.27**	17.36
5/8	103635	100	**70.78**	22.73
3/4	115447	100	**69.95**	28.07
1	115463	100	**87.61**	38.81

Size	Part No.		$ Price /100	lbs /1000
5/8-11 UNC - Key Size 5/16"				
5/8" x 1/2	109923	100	**99.01**	22.57
5/8	109939	50	**90.69**	30.34
3/4	109957	50	**96.60**	38.13
1	109990	50	**118.72**	53.68
1 1/4	110006	25	**135.56**	69.23
1 1/2	110022	25	**150.08**	84.79
1 3/4	110038	25	**182.61**	100.32
2	110055	25	**196.29**	115.87
5/8-18 UNF - Key Size 5/16"				
5/8" x 5/8	115480	50	**90.69**	33.59
1	115497	50	**118.72**	58.85

Pieces per Box

TAPER PRESSURE PLUGS

Dryseal Type With 3/4-inch Taper per Foot

- Dryseal-thread form achieves a seal without need for compound
- Heat treated alloy steel for strength
- Roundness-closely controlled for better sealing
- Uniform taper of 3/4 inch per foot

Precision hex socket with maximum depth for positive wrenching at higher seating torques

Controlled chamfer for faster starting

LEVL SEAL® TYPE Dryseal Thread Form with 7/8-inch per foot

Precision hex socket with maximum depth for positive wrenching at higher seating torques

Heat treated alloy steel for strength Rounded closely controlled for better sealing

High pressure is developed through a deliberate difference of taper between the plug and the tapped hole having standard 3/4" taper

Flush seating is achieved through closer control of thread forms, sizes and taper-improves safety and appearance Fully formed PTF dryseal threads for better sealing without the use of a compound

Controlled chamfer for faster starting

Pressure plugs are not pipe plugs. Pipe plugs (plumber's fittings) are limited to pressures of 600 psi, are sealed with a compound, and are made of cast iron with cut threads and protruding square drive.

Pressure plugs are made to closer tolerances, are generally of higher quality, and almost all have taper threads. Properly made and used, they will seal at pressures to 5000 psi and without a sealing compound (pressure tests are usually at 20,000 psi.) they are often used in hydraulic and pneumatic designs.

Performance Requirements
Pressure plugs used in industrial applications should:
- not leak at pressures to 5000 psi
- need no sealing compounds
- be reusable without seizure
- give a good seal when reused
- seal low viscosity fluids
- require minimum seating torque
- require minimum re-tooling or special tools.

For a satisfactory seal, the threads of the plug and those in the mating hole must not gall or seize up to maximum possible tightening torque. Galling and seizure are caused by metal pickup on the mating surfaces and are directly related to force on the surface, material hardness, lubrication used, and thread finish.

How Pressure Plugs Seal
Sealing is achieved by crushing the crest of one thread against the root of the mating thread. If too much of compressive force is required to torque the plug, it will tend to gall in the hole. Too little force will not deform the crest of threads enough to produce a seal. Increasing the hardness of the material will reduce galling but will also increase the required sealing force. Generally a hardness range of Rc 30 to 40 will meet most requirements. The tightening force must be low enough to cause no galling in this range.

Cost Considerations
Dryseal plugs are more frequently used, especially where reuse is frequent. Reason: more threads are engaged and they therefore resist leakage better. They are also preferred in soft metals to reduce of over-torquing.

TYPES OF PRESSURE PLUG THREADS
Three thread forms are commonly used for pipe plugs and pressure plugs:

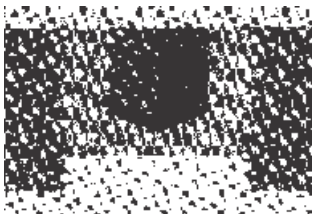
NPT: National Pipe thread, Tapered. This is the thread form commonly used for commercial pipe and fittings for low pressure applications. A lubricant and sealer are generally used.

ANPT: Aeronautical National Pipe thread, Tapered. Covered by MIL-S-7105, this thread form was developed for aircraft use. It is basically the same as the NPT thread except that tolerances have been reduced about 50 percent. Plugs made with this thread should be used with lubricants and sealers. They are not to be used for hydraulic applications.

NPTF: National Pipe thread, Tapered, Fuel. This is the standard thread for pressure plugs. They make pressure-tight joints without a sealant. Tolerances are about 1/4 those for NPT threads. The standard which applies is ANSI B1.20.3. Applicable for fluid power applications.

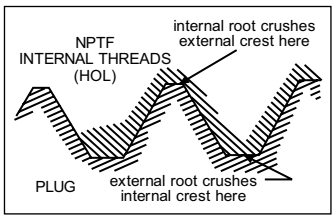
TAPER PRESSURE PLUGS

Deliberate difference in taper between the plug and the tapped hole. Ideal for use in assemblies where clearance is limited and in hydraulic lines near moving parts. Designed for use in hard materials and in thick-walled sections as well as for normal plug applications.



High pressure seal— Achieved through metal-to-metal contact at the large end of the plug. High load placed on the few mating threads near the top of the hole.

Flush seating—Design of LEVL-SEAL plug permits seating within half a pitch in a normally tapped hole. Conventional plugs have the greater tolerance of a full pitch and usually protrude above the surface.



PTF fully formed Dryseal threads designed to achieve seal in tapped holes without need for sealing compounds.

PTFE/TEFLON Coated LEVL-SEAL Type

Typical thickness is 0.0005-inch LEVL-SEAL precision coated with tough, corrosion-resistant PTFE/TEFLON.

Installation of the new plugs is faster with the coating of PTFE/TEFLON which acts as a lubricant as well as seal. Power equipment can be used to install the smaller sizes instead of the manual wrenching required by higher torques of un-coated plugs. Suited for in assembly line production.

Higher hydraulic and pneumatic working pressures can be effectively sealed. Seal is effective without use of tapes or sealing compounds, even with liquids of very low viscosity. Unbrako Laboratories have tested these plugs with surges up to 13,500 psi 8 times in 5 minutes, then held peak pressure for 6 full hours without traceof leakage.

Flush seating improves appearance and adds safety. LEVL-SEAL plugs seat flush because of a combination of (1) gaging procedures, and (2) a deliberate difference in taper between the plug and a normally tapped NPTF hole. (The taper of the plug is 7/8" per foot , while that of the hole is 3/4" per foot.)

PTFE/TEFLON was selected for the coating material because of its combination of extra hardness and abrasion resistance which permit reuse up to 5 times without appre ciable loss of seal.

The coating is serviceable to +450°F without deterioration.

Temperatures lower than –100°F require the use of stainless steel plugs. These are available in the same range of sizes as the alloy steel plugs.

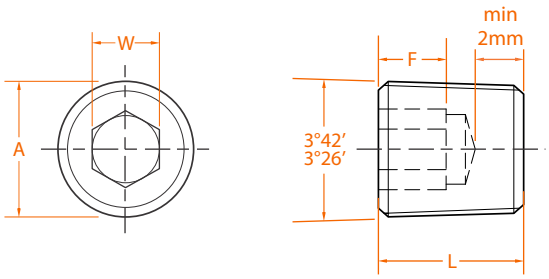
With no tape or sealing compound involved, there is no danger of foreign matter entering and contaminating the system or equipment. The coating reduces any tendency of the plug to "freeze" in the hole because of rust or corrosion.

Taper Pressure Plugs
DIN 906

Precision thread for positive seal without sealing compound; controlled chamfer for faster starting.

Mechanical Properties

Thread shall conform to DIN 158
Heat Treatment: 35-40 HRC



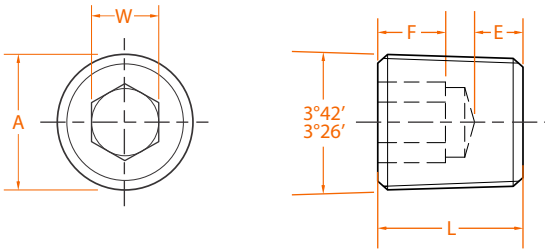
Product Dimensions

Nom Dia	Pitch	Head Diameter A max	Head Diameter A min	Hex Socket Size W max	Hex Socket Size W min	Length L max	Length L min	Socket Depth F min	Socket Drill Size
M8	1	6.66	6.41	4.07	4.02	8.25	7.75	4.00	4.14
M10	1	8.66	8.41	5.08	5.02	8.25	7.75	4.00	5.15
M12	1.5	10.09	9.84	6.09	6.02	10.25	9.75	5.00	6.17
M14	1.5	12.09	11.84	7.11	7.03	10.25	9.75	5.00	7.20
M16	1.5	14.09	13.84	8.11	8.03	10.25	9.75	5.00	8.20
M18	1.5	16.09	15.84	8.11	8.03	10.25	9.75	5.00	8.20
M20	1.5	18.09	17.84	10.12	10.03	10.25	9.75	5.00	10.23
M22	1.5	20.09	19.84	10.12	10.03	10.25	9.75	5.00	10.23
M24	1.5	22.22	21.97	12.13	12.04	12.25	11.75	6.00	12.28
M26	1.5	24.22	23.97	12.13	12.04	12.25	11.75	6.00	12.28
M30	1.5	28.22	27.97	17.15	17.05	12.25	11.75	6.00	17.30

Features 3/4" taper. Precision thread for positive seal without sealing compound; controlled chamfer for faster starting.

Mechanical Properties

Heat Treatment: 35-40 HRC



Product Dimensions

Plug Size	Threads per Inch	Head Diameter A max	Head Diameter A min	Hex Socket Size W nom	Socket Depth F min	Length L max	Length L min
1/8	28	0.329	0.319	0.1875	0.183	0.385	0.365
1/4	19	0.438	0.428	0.2500	0.245	0.510	0.490
3/8	19	0.578	0.568	0.3125	0.276	0.573	0.553
1/2	14	0.731	0.721	0.3750	0.339	0.698	0.678
5/8	14	0.808	0.798	0.5000	0.370	0.760	0.740
3/4	14	0.946	0.936	0.5625	0.370	0.823	0.803
7/8	14	1.098	1.088	0.5625	0.442	0.885	0.865
1	11	1.181	1.171	0.6250	0.558	1.010	0.990
1 1/4	11	1.530	1.520	0.7500	0.677	1.260	1.240
1 1/2	11	1.754	1.744	0.7500	0.677	1.260	1.240

Plug Size	E min	Socket Drill Size
1/8	0.076	0.1923
1/4	0.107	0.2564
3/8	0.139	0.3205
1/2	0.170	0.3847
5/8	0.170	0.5129
3/4	0.232	0.5770
7/8	0.232	0.5770
1	0.232	0.6400
1 1/4	0.300	0.7680
1 1/2	0.300	0.7680

Taper Pressure Plugs - Inch

NPTF Threads
Dry Seal (3/4 Taper)

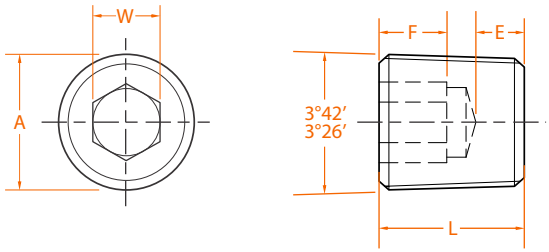
Features 3/4" and 7/8" tapers. Dryseal thread for positive seal without sealing compound; controlled chamfer for faster starting

Application Data

Unbrako recommends using a tapered reamer with corresponding size tap drill

Notes

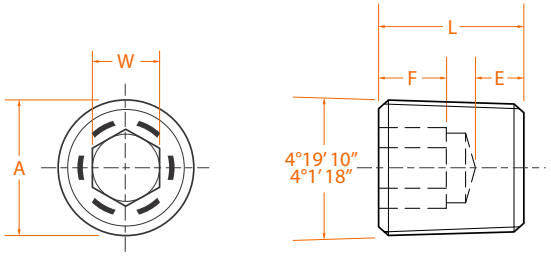
+With use of reamer (taper thread).
++Without use of tapered reamer.
*Recommended torques for alloy steel only. Multiply by .65 for stainless steel and .50 for brass.
NPTF fully formed Dryseal threads achieve seal in tapped holes without need for sealing compounds.



Product Dimensions

Thread size nom	Thread per Inch	Head Diameter A ref	Hex Socket Size W nom	E min	Length (±.010) L max	Socket Depth F min
1/16	27	.318	.156	.062	.312	.140
1/8	27	.411	.188	.062	.312	.140
1/4	18	.545	.250	.073	.437	.218
3/8	18	.684	.312	.084	.500	.250
1/2	14	.847	.375	.095	.562	.312
3/4	14	1.061	.562	.125	.625	.312
1	11 1/2	1.333	.625	.125	.750	.375
1 1/4	11 1/2	1.679	.750	.126	.812	.437
1 1/2	11 1/2	1.918	1.000	.156	.812	.437
2	11 1/2	2.395	1.000	.156	.875	.437

Thread size nom	Tap Drill Size+	Tap Drill Size++	recommended torque in.-lbs*
1/16	15/64	1/4	150
1/8	21/64	11/32	250
1/4	27/64	7/16	600
3/8	9/16	37/64	1200
1/2	11/16	23/32	1800
3/4	57/64	59/64	3000
1	1 1/8	1 5/32	4200
1 1/4	37.5mm	–	5400
1 1/2	43.5mm	–	6900
2	2 3/16	–	8500



Levl-seal features: controlled 7/8" taper in 3/4" taper hole seats plug level, flush with surface within 1/2 pitch.

Mechanical Properties

1. Material: ASTM A574 alloy steel, austenitic stainless steel or brass.
2. Hardness: Rc 35-40 for steel.
3. DRY-SEAL and LEVL-SEAL: Small end of plug to be flush with face of standard NPTF ring gages within one thread (L1, L2 and tapered ring). Large end of plug to be flush with face of special 7/8 taper ring gages within one-half thread.
4. Undercut in socket at mfrs. option
5. Six equally spaced identification grooves (1/16-27 plug to have 3 identification grooves) on alloy steel plugs. (LEVL-SEAL)
6. Dimensions apply before plating and/or coating.

Notes

* for taper thread (using tapered reamer)
** Maximum for PTFE / Teflon-coated but can be reduced as much as 60% in most applications.

Product Dimensions

Thread size nom	Thread per Inch min	Head Diameter A ref	Hex Socket Size W nom	E min	Length (+0, -.015) L max	Socket Depth F min
1/16	27	.307	.156	.052	.250	.141
1/8	27	.401	.188	.049	.250	.141
1/4	18	.529	.250	.045	.406	.266
3/8	18	.667	.312	.040	.406	.266
1/2	14	.830	.375	.067	.531	.329
3/4	14	1.041	.562	.054	.531	.329
1	11 1/2	1.302	.625	.112	.656	.360
1 1/4	11 1/2	1.647	.750	.102	.656	.360
1 1/2	11 1/2	1.885	.750	.102	.656	.360
2	11 1/2	2.360	1.000	.084	.656	.360

Thread size nom	tap drill size*	Recommended torque (inch-lbs.) alloy steel**
1/16	15/64	150
1/8	21/64	250
1/4	27/64	600
3/8	9/16	1,200
1/2	11/16	1,800
3/4	57/64	3,000
1	1 1/8	4,200
1 1/4	37.5mm	5,400
1 1/2	43.5mm	6,900
2	2 3/16	8,500

Head Marking

Unbrako

Taper Pressure Plugs - Metric

Size	Part No.	Pieces per Box	$ Price /100	lbs /1000
DIN906.22 - Grade 5.8				
M8 (1.0)	402218	100	**156.91**	4.40
M10 (1.0)	402219	100	**166.85**	7.48
M12 (1.5)	402220	100	**210.68**	14.08
M16 (1.5)	402221	100	**299.19**	24.20
M18 (1.5)	402222	100	**318.65**	35.20
M20 (1.5)	402223	100	**389.35**	38.72
M22 (1.5)	402224	100	**488.99**	46.20

Taper Pressure Plugs - Inch

Size	Part No.	Pieces per Box	$ Price /100	lbs /1000
BSPT 3/4" Taper **Alloy Steel**				
1/8-28	402208	200	**55.49**	9.31
1/4-19	402209	200	**59.22**	22.33
3/8-19	402210	100	**74.72**	41.51
1/2-14	402211	100	**150.09**	75.90
5/8-14	402212	50	**229.21**	99.51
3/4-14	402213	50	**261.29**	150.15
1-11	402214	25	**1953.29**	294.47
1 1/4-11	402215	25	**3825.08**	598.40
1 1/2-11	402216	25	**7393.62**	756.80
NPTF 3/4" Taper / Dryseal **Alloy Steel**				
1/16-27	117052	100	**31.44**	4.40
1/8-27	117068	100	**37.09**	11.00
1/4-18	117084	100	**55.57**	19.18
3/8-18	118963	100	**89.67**	37.40
1/2-14	103846	50	**120.75**	61.60
3/4-14	103747	50	**204.68**	101.64
1-11.5	103644	25	**1566.78**	202.40
1 1/4-11.5	103588	25	**4105.36**	360.80

Size	Part No.	Pieces per Box	$ Price /100	lbs /1000
NPTF 3/4" Taper / **Dryseal Brass**				
1/16-27	102940	100	**55.33**	3.96
1/8-27	103266	100	**73.99**	9.90
1/4-18	103164	100	**166.16**	18.92
3/8-18	103072	100	**162.24**	37.84
NPTF 3/4" Taper / Dryseal **Stainless 304**				
1/16-27	102262	100	**165.90**	3.96
1/8-27	102182	100	**119.69**	10.12
1/4-18	102076	100	**368.64**	18.92
3/8-18	110890	100	**414.35**	59.84
1/2-14	110779	50	**727.22**	84.04
NPTF 7/8" Taper / LEVL - SEAL **Alloy Steel**				
1/16-27	107577	100	**32.32**	3.08
1/8-27	107593	100	**37.02**	5.94
1/4-18	105766	100	**55.57**	16.28
3/8-18	105782	100	**64.88**	29.04
1/2-14	112286	50	**120.47**	53.68
3/4-14	109168	50	**148.06**	85.80
1-11.5	109184	50	**1797.33**	167.20
1 1/4-11.5	109201	50	**3000.71**	286.00

Size	Part No.	Pieces per Box	$ Price /100	lbs /1000
NPTF 7/8" Taper / LEVL - SEAL **Teflon Coated**				
1/16-27	796087	100	**81.18**	3.08
1/8-27	138240	100	**99.49**	5.94
1/4-18	138241	100	**160.20**	18.33
3/8-18	796086	100	**342.66**	29.04
1/2-14	138243	50	**470.82**	53.68
3/4-14	796088	50	**673.75**	72.60
1-11.5	796089	25	**5693.80**	88.00
1 1/4-11.5	796090	25	**8477.00**	110.00
NPTF 7/8" Taper / LEVL - SEAL **Brass**				
1/16-27	134502	100	**68.14**	3.08
1/8-27	134503	100	**66.28**	5.94
1/4-18	134504	100	**132.01**	15.84
3/8-18	134505	100	**185.22**	28.82
1/2-14	134506	50	**360.14**	57.64
NPTF 7/8" Taper / LEVL- SEAL **Stainless 304**				
1/8-27	183840	100	**POA**	5.94
1/4-18	183538	100	**POA**	15.84

Pieces per Box

Unbrako
THE WORLD LEADER

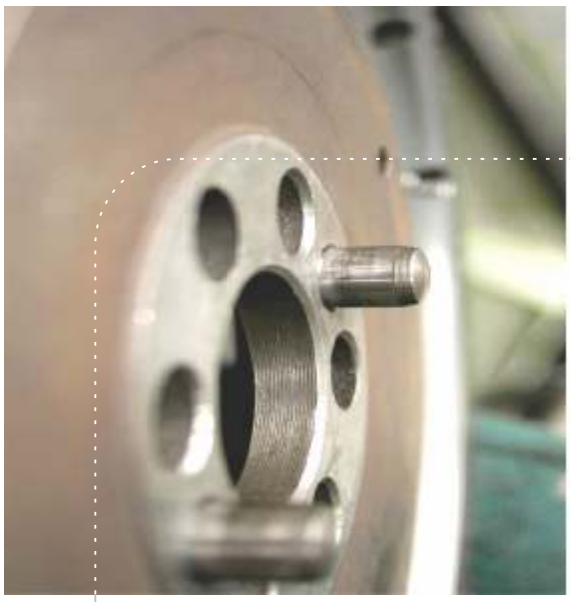
Pins

Page Contents


Its about
Time
& Money...
whether you're an engineer
or purchase manager,
Unbrako has fastening solutions to save
you time & help increase revenue.
Unbrako

DOWEL PINS

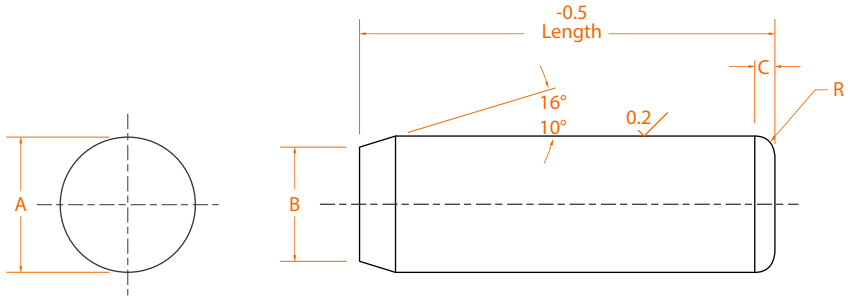
Surface hardness: Rockwell "C" 60 minimum
Surface finish: 8 micro inch maximum
Core hardness: Rockwell "C" 50–58
Case depth: .020-inch minimum
Shear strength: 150,000 psi (calculated based on conversion from hardness)
Heat treated alloy steel for strength and toughness
Held to precise tolerance by automatic gaging and electronic feed-back equipment
Material, Heat Treatment, Dimensions: ASME B18.8.2
.0002 – inch oversize typically used for first installation.
.0010 – inch oversize typically used after hole enlarges.



APPLICATIONS
Widely used as plug gages in various production operations, and as guide pins, stops, wrist pins, hinges and shafts. Also used as position locators on indexing machines, for aligning parts, as feeler gages in assembly work, as valves and valve plungers on hydraulic equipment, as fasteners for laminated sections and machine parts, and as roller bearings in casters and truck wheels.

Installation Warning –
Do not strike. Use safety shield or glasses when pressing chamfered end in first.

Continuous grain flow resists chipping of ends. Precision heat treated for greater strength and surface hardness.
Chamfered end provides easier insertion in hole. Surface finish to 8 microinch maximum.



Formed ends, controlled heat treat; close tolerances; standard for die work; also used as bearings, gages, precision parts, etc.

Mechanical Properties

Specifications: ANSI B18.8.5M, ISO 8734 or DIN 6325.
Material: ANSI B18.85-alloy steel
Hardness: Rockwell C60 minimum (surface)
Rockwell C 50-58 (core)
Shear Stress: Calculated values based on 1050 MPa.
Surface Finish: 0.2 micrometer maximum

Application Data

Nominal Size	calculated single shear strength kN	lbs	Recommended hole size max	min
3	7.4	1,670	3.000	2.987
4	13.2	2,965	4.000	3.987
5	20.6	4,635	5.000	4.987
6	29.7	6,650	6.000	5.987
8	52.5	11,850	8.000	7.987
10	82.5	18,550	10.000	9.987
12	119.0	26,700	12.000	11.985
16	211.0	47,450	16.000	15.985
20	330.0	74,000	20.000	19.983
25	515.0	116,000	25.000	24.983

Warning

Installation warning: Dowel pins should not be installed by striking or hammering. Wear safety glasses or shield when pressing chamfered point end first.

Product Dimensions

Size nom	Pin diameter A max	min	Point diameter B max	min	Crown height C max	Crown radius R min
3	3.008	3.003	2.9	2.6	0.8	0.3
4	4.009	4.004	3.9	3.6	0.9	0.4
5	5.009	5.004	4.9	4.6	1.0	0.4
6	6.010	6.004	5.8	5.4	1.1	0.4
8	8.012	8.006	7.8	7.4	1.3	0.5
10	10.012	10.006	9.8	9.4	1.4	0.6
12	12.013	12.007	11.8	11.4	1.6	0.6
16	16.013	16.007	15.8	15.3	1.8	0.8
20	20.014	20.008	19.8	19.3	2.0	0.8
25	25.014	25.008	24.8	24.3	2.3	1.0

Dowel Pins - Metric

Size	Part No.		$ Price /100	lbs /1000
		2mm		
2 x 8	407831	40	**52.86**	0.43
10	407832	40	**52.86**	0.54
12	407833	40	**52.86**	0.65
16	407835	40	**58.06**	0.87
18	407836	40	**61.23**	0.98
20	407837	40	**61.23**	1.08
		3mm		
3 x 10	115001	40	**47.48**	1.22
12	115002	40	**52.81**	1.47
16	115003	40	**58.06**	1.95
18	402118	40	**61.23**	2.20
20	115004	40	**61.23**	2.44
28	402120	40	**61.23**	3.42
30	115007	40	**67.02**	3.66
32	402121	40	**67.02**	3.91
36	406345	40	**72.09**	4.40
40	402124	40	**77.16**	4.89
		4mm		
4 x 10	115010	40	**54.08**	2.17
12	115011	40	**60.68**	2.60
16	115012	40	**72.76**	3.47
20	115015	40	**84.93**	4.34
24	407127	40	**100.13**	5.21
25	115016	40	**100.13**	5.43
28	402128	40	**100.13**	6.05
30	115017	40	**115.26**	6.51
50	402132	40	**115.26**	10.85
		5mm		
5 x 10	402133	40	**55.64**	3.39
12	115021	40	**60.68**	4.07
14	402134	40	**75.79**	4.75
16	115022	40	**75.79**	5.43
20	115024	40	**87.96**	6.78
24	407128	40	**103.14**	8.14
25	115025	40	**103.14**	8.48
28	402137	40	**118.26**	9.50
30	115026	40	**118.26**	10.17
32	402138	40	**118.26**	10.85
36	406347	40	**129.09**	12.21
40	115028	40	**151.66**	13.56
45	115029	40	**166.84**	15.26
50	115031	40	**166.84**	16.96
		6mm		
6 x 12	402141	40	**75.79**	5.86
16	115032	40	**75.79**	7.81

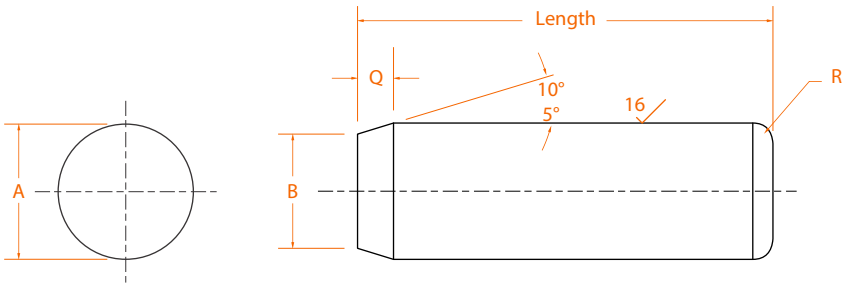
Size	Part No.		$ Price /100	lbs /1000
		6mm		
6 x 18	402143	40	**90.97**	8.79
20	115034	40	**90.97**	9.77
24	115037	40	**106.17**	11.72
28	402145	40	**124.38**	13.67
30	115038	40	**124.38**	14.65
32	402146	40	**124.38**	15.63
36	406348	40	**124.38**	17.58
40	115043	40	**157.70**	19.53
45	115044	40	**172.89**	21.97
50	115046	40	**191.10**	24.42
60	115047	40	**224.42**	29.30
		8mm		
8 x 20	115049	40	**106.17**	17.36
24	406349	40	**117.65**	20.83
28	402150	40	**142.51**	24.31
30	115053	40	**142.51**	26.04
32	402151	40	**142.51**	27.78
36	406350	40	**181.96**	31.25
40	115055	40	**181.96**	34.72
45	115056	40	**200.16**	39.06
50	115057	40	**218.37**	43.40
55	402153	40	**235.69**	47.74
60	115058	40	**254.72**	52.09
		10mm		
10 x 20	115063	40	**125.33**	27.13
24	406351	40	**132.73**	32.55
30	115066	40	**242.63**	40.69
36	406352	40	**312.38**	48.83
40	115070	40	**312.38**	54.26
45	115071	40	**345.77**	61.04
50	402161	40	**379.11**	67.82
60	402163	40	**421.20**	81.38
70	402164	40	**463.32**	94.60
90	402167	40	**555.88**	122.07
100	402169	40	**591.76**	135.64
		12mm		
12 x 24	406353	40	**214.89**	46.88
30	402174	40	**266.89**	58.59
36	406354	40	**312.52**	70.31
40	402178	40	**345.77**	78.13
50	402180	40	**421.56**	97.66
60	402182	40	**595.40**	117.19
70	402183	40	**595.40**	136.72
80	402184	40	**659.10**	156.26
90	402185	40	**724.88**	175.79
100	402186	40	**817.70**	195.32

Size	Part No.		$ Price /100	lbs /1000
		16mm		
16 x 32	406218	20	**595.40**	110.00
40	406220	20	**595.40**	138.89
70	406225	20	**877.50**	243.06
80	406226	20	**1001.00**	277.79
90	406227	20	**1036.10**	312.51

Note:

- Unbrako Dowel Pins are through hardened and precision ground from nominal to 0.0002" over size on Inch sizes and a surface finish of 0.15 micrometers max, on both Metric and Inch products.
- CAUTION: Unbrako advises that correct tools should be used for the application.
- Safety goggles should be worn for your security and protection.

Pieces per Box



Formed ends, controlled heat treat; close tolerances; standard for die work; also used as bearings, gages, precision parts, etc.

Mechanical Properties

Material: ASME B18.8.2
Shear Hardness: 150,000 psi
Surface Hardness: 60 HRC
Core Hardness: 50 - 58 HRC

Shear Strength and Recommended hole Size

Nominal Size	calculated single shear strength (pounds)	Recommended hole size (.0002 over nom.) max	min
1/16	465	.0625	.0620
3/32	1,035	.0937	.0932
1/8	1,845	.1250	.1245
5/32	2,880	.1562	.1557
3/16	4,140	.1875	.1870
1/4	7,370	.2500	.2495
5/16	11,500	.3125	.3120
3/8	16,580	.3750	.3745
7/16	22,540	.4375	.4370
1/2	29,460	.5000	.4995
9/16	37,270	.5625	.5620
5/8	46,020	.6250	.6245
3/4	66,270	.7500	.7495
7/8	90,190	.8750	.8745
1	117,810	1.0000	.9995

Warning

Installation warning: Do not strike.
Use safety shield or glasses when pressing chamfered end in first.

Product Dimensions

Size nom	Pin diameter A .0002 over nom. max	min	Point diameter B max	Q max	min	Crown radius R min
1/16	.0628	.0626	0.056	0.056	0.019	0.010
3/32	.0941	.0939	0.084	0.074	0.028	0.026
1/8	.1253	.1251	0.116	0.070	0.026	0.043
5/32	.1565	.1563	0.147	0.071	0.026	0.043
3/16	.1878	.1876	0.178	0.073	0.027	0.043
1/4	.2503	.2501	0.237	0.093	0.037	0.058
5/16	.3128	.3126	0.298	0.102	0.041	0.058
3/8	.3753	.3751	0.359	0.110	0.046	0.073
7/16	.4378	.4376	0.417	0.136	0.058	0.089
1/2	.5003	.5001	0.480	0.133	0.057	0.104
9/16	.5628	.5626	0.542	0.136	0.058	0.120
5/8	.6253	.6251	0.605	0.133	0.057	0.120
3/4	.7503	.7501	0.725	0.161	0.071	0.120
7/8	.8753	.8751	0.850	0.161	0.071	0.120
1	1.0003	1.0001	0.975	0.161	0.071	0.120

Dowel Pins - Inch

Unbrako

Size	Part No.		$ Price /100	lbs /1000
		1/8"		
1/8" x 3/8	116081	40	**15.18**	1.67
1/2	116097	40	**16.78**	1.74
5/8	116113	40	**19.11**	2.17
3/4	116129	40	**21.30**	2.60
7/8	116146	40	**25.38**	4.95
1	116162	40	**25.02**	3.47
1 1/4	116179	40	**29.84**	4.34
1 1/2	116195	40	**33.71**	4.95
1 3/4	110261	40	**42.60**	10.45
2	110277	40	**43.18**	12.65
		3/16"		
3/16" x 1/2	110293	40	**21.16**	3.91
5/8	110310	40	**23.49**	4.88
3/4	110327	40	**25.39**	5.86
7/8	110344	40	**29.77**	7.70
1	110360	40	**31.23**	7.81
1 1/4	110376	40	**37.36**	9.90
1 1/2	110393	40	**42.82**	12.65
1 3/4	110410	40	**53.11**	14.85
2	110426	40	**55.74**	17.60
		1/4"		
1/4" x 1/2	104185	40	**24.23**	10.42
5/8	115069	40	**27.86**	9.90
3/4	113104	40	**30.79**	10.42
7/8	105237	40	**36.11**	13.75
1	108942	40	**37.50**	13.89
1 1/4	108974	40	**44.80**	17.36
1 ½	105277	40	**51.35**	20.84
1 3/4	105309	40	**59.53**	23.96
2	105341	40	**66.46**	24.31
2 1/4	118645	40	**83.02**	33.00
2 1/2	120490	40	**83.16**	37.40
		5/16"		
5/16" x 1/2	120557	40	**31.74**	12.65
5/8	120621	40	**34.29**	14.85
3/4	117265	40	**38.66**	16.28
7/8	117298	40	**47.94**	18.99
1	117331	40	**46.47**	21.71
1 1/4	117363	40	**54.28**	29.70
1 1/2	117397	40	**62.53**	35.20
1 3/4	117429	40	**72.81**	42.35
2	117462	40	**83.24**	43.41
2 1/4	117494	40	**98.13**	48.84
2 1/2	117527	40	**101.92**	59.95
3	117561	40	**123.95**	69.85

Size	Part No.		$ Price /100	lbs /1000
		3/8"		
3/8" x 1/2	117593	40	**42.24**	19.80
5/8	109422	40	**48.66**	22.55
3/4	109454	40	**50.27**	31.26
7/8	109486	40	**58.29**	32.45
1	109520	40	**61.42**	35.20
1 1/4	114998	40	**69.60**	39.07
1 1/2	115030	40	**83.89**	46.89
1 3/4	115062	40	**100.97**	54.70
2	113097	40	**109.14**	62.51
2 1/4	109028	40	**129.64**	75.90
2 1/2	111888	40	**143.14**	84.70
3	107654	40	**172.54**	93.77
		7/16"		
7/16" x 1	107686	20	**138.62**	49.50
1 1/4	107718	20	**166.62**	59.40
1 1/2	113240	20	**180.86**	70.40
1 3/4	107457	20	**204.93**	84.70
2	107489	20	**199.90**	94.60
2 1/2	107521	20	**241.19**	114.40
3	107553	20	**274.67**	134.20
		1/2"		
1/2" x 3/4	117073	20	**110.75**	41.68
1	119158	20	**122.05**	55.57
1 1/4	114656	20	**133.51**	80.30
1 1/2	114721	20	**148.03**	90.20
1 3/4	117103	20	**173.41**	104.50
2	106609	20	**194.57**	111.14
2 1/4	119565	20	**217.11**	134.20
2 1/2	119597	20	**254.24**	138.92
3	119631	20	**286.85**	174.90
3 1/2	109023	20	**350.91**	194.49
4	111884	20	**393.15**	222.27
		5/8"		
5/8" x 1	107650	10	**245.20**	86.83
1 1/4	107682	10	**277.15**	110.00
11/2	107714	10	**310.56**	173.65
1 3/4	121862	10	**348.29**	160.70
2	107453	10	**380.97**	189.20
2 1/4	107485	10	**445.76**	209.00
2 1/2	107517	10	**437.58**	217.06
3	107549	10	**564.16**	268.40
3 1/2	107582	10	**640.99**	310.20
4	107614	10	**702.85**	358.60
4 1/2	113268	10	**866.85**	409.20
5	113300	10	**1005.31**	440.00

Size	Part No.		$ Price /100	lbs /1000
		3/4"		
3/4" x 2	106412	10	**575.68**	250.05
2 1/2	106444	10	**624.78**	334.40
3	106477	10	**743.20**	375.08
3 1/2	106509	10	**867.00**	462.00
4	113456	10	**956.51**	500.11
5	113521	10	**1423.34**	625.14
6	111925	10	**1941.17**	770.00
		7/8"		
7/8" x 2	111958	10	**1230.24**	374.00
3	108424	10	**1878.66**	539.00
4	108490	10	**2156.83**	704.00
5	102900	10	**2750.79**	858.00
		1"		
1" x 2	102968	10	**1253.14**	444.54
2 1/2	107094	10	**1584.79**	552.00
3	107126	10	**1743.40**	710.60
3 1/2	104251	10	**2210.16**	777.95
4	104317	10	**2325.79**	924.00
5	108138	10	**3432.66**	1067.00

Note:

- Unbrako Dowel Pins are through hardened and precision ground from nominal to 0.0002" over size on Inch sizes and a surface finish of 0.15 micrometers max, on both Metric and Inch products.
- CAUTION: Unbrako advises that correct tools should be used for the application.
- Safety goggles should be worn for your security and protection.

Pieces per Box

PULL-OUT DOWEL PINS

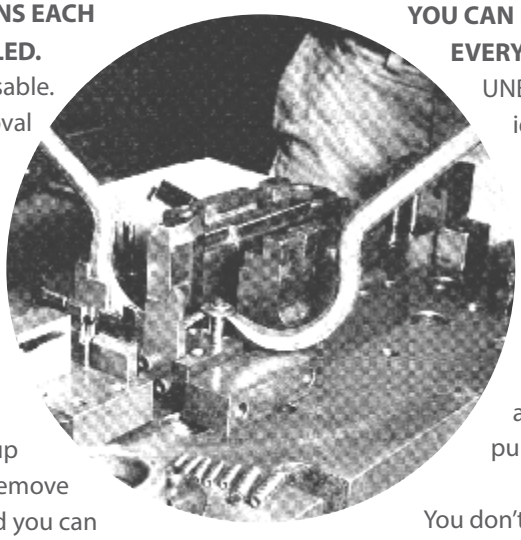
5 WAYS TO SAVE

UNBRAKO Pull-Out Dowel Pins are easier, more accurate and more economical than "do-it-your-self" modifications of standard dowels. They save you money FIVE ways:

1. YOU SAVE COST OF SEPARATE KNOCK-OUT HOLES IN BLIND HOLES WHERE PINS MUST BE REMOVED.
UNBRAKO pull-out pins are easy to install in blind holes, easy to remove. Exclusive spiral grooves release trapped air for insertion or removal without danger of hole-scoring.

2. YOU MUST SAVE COST OF NEW PINS EACH TIME DIE IS SERVICED OR DISMANTLED.
UNBRAKO pull-out dowel pins are reusable. The hole tapped in one end for a removal screw or threaded "puller" makes it easy and fast to remove the pin without damage to pin or hole, permits repeated re-use.

3. YOU SAVE MONEY IN REDUCED DOWNTIME AND LOSS OF PRODUCTION
UNBRAKO pull-out dowel pins speed up die servicing and reworking. You can remove them without turning the die over, and you can take out individual sections of the die for rework or service without removing entire die assembly from the press.



4. YOU SAVE MODIFICATIONS COSTS, YOU AVOID HEADACHES AND YOU SAVE YOUR SKILLED PEOPLE FOR PROFITABLE WORK.
UNBRAKO pull-out dowel pins have tapped holes and relief grooves built in. Time-consuming "do-it-yourself" modification of standard pin eliminated. No need for annealing (to make pins soft enough to drill and tap) and re-hardening, which can result in damage to finish, and in inaccuracies and distortion.

5. YOU SAVE TIME AND MONEY BECAUSE OF THIS QUALITY "REPEATABILITY". NO SPECIAL PREPARATION OF INDIVIDUAL HOLES NEEDED- YOU CAN BE SURE OF ACCURATE FIT EVERY TIME.
UNBRAKO pull-out dowel pins are identical and interchangeable with standard UNBRAKO dowels. They have the same physical, finish, accuracy and tolerances. And they are consistently uniform. Their exclusive spiral relief grooves provide more uniform relief than other types of removable pins, assuring more uniform pull-out values.

You don't need any special tools to remove UNBRAKO pull-out dowels-just an ordinary die hook and a socket head cap or button head socket screw.

FEATURES

Formed ends resist chipping

Exclusive spiral grooves afford uniform relief for insertion and removal, reduce chances of hole-scoring

Tapped hole for easy pull-out (ANSI B1.1)

Surface hardness-Rockwell C60 minimum
Surface finish-8 micro inch maximum
Core hardness-Rockwell C 50–58

Shear strength: 150,000 psi (calculated based on conversion from hardness)

Heat treated alloy steel for strength and toughness

Held to precise tolerance

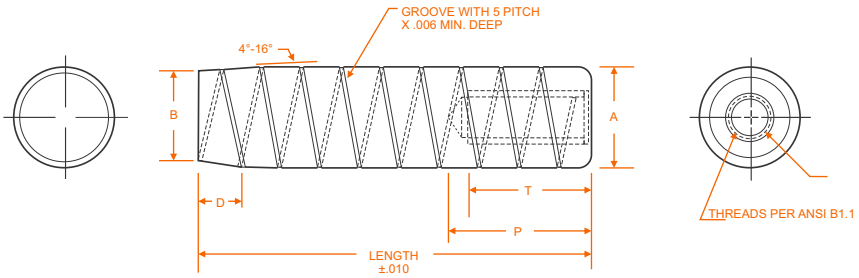
For use in blind holes. Easily removed without special tools. Reusable, Saves money. No need for knock-out holes. Same physicals & finish as standard Unbrako dowel pins.

Mechanical Properties

Material and Heat Treatment: ASME B18.8.2
Length equal to shorter than 'p' max values may be drilled through

Shear Strength and Recommended hole Size

Nominal Size	Single Shear Strength (lbs) ref.	Recommended hole diameter max	min
1/4	7,370	.2500	.2495
5/16	11,500	.3125	.3120
3/8	16,580	.3750	.3745
7/16	22,540	.4370	.4315
1/2	29,460	.5000	.4995
5/8	46,020	.6250	.6245
3/4	66,270	.7500	.7495
7/8	90,190	.8750	.8745
1	117,810	1.0000	.9995



Product Dimensions

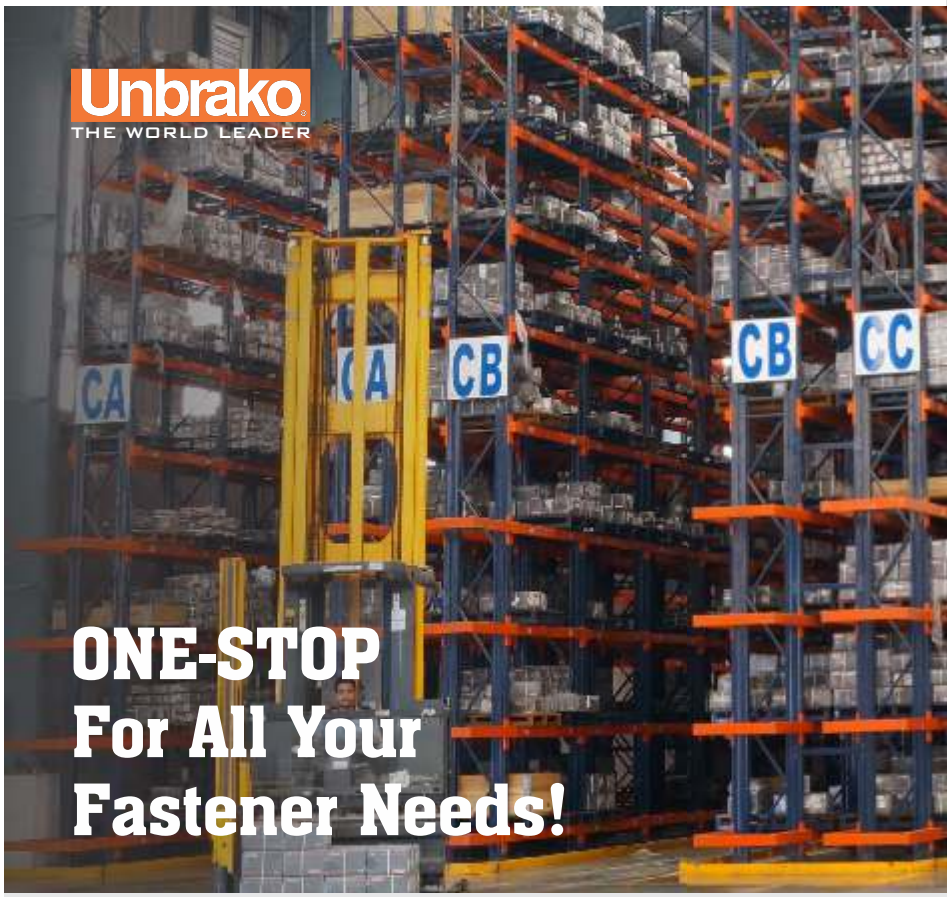
Nominal Size	Thread size	B max	A max	A min	D min	P max	T min
1/4	#8-32 UNC-2B	.237	.2503	.2501	.031	.500	.212
5/16	#10-32 UNF-2B	.302	.3128	.3126	.034	.625	.243
3/8	#10-32 UNF-2B	.365	.3753	.3751	.038	.625	.243
7/16	#10-32 UNF-2B	.424	.4378	.4376	.047	.625	.243
1/2	1/4-20 UNC-2B	.486	.5003	.5001	.047	.750	.315
5/8	1/4-20 UNC-2B	.611	.6253	.6251	.047	.750	.315
3/4	5/16-18 UNC-2B	.735	.7503	.7501	.059	.875	.390
7/8	3/8-16 UNC-2B	.860	.8753	.8751	.059	.875	.390
1	3/8-16 UNC-2B	.980	1.0003	1.0001	.059	.875	.390

Pull-Out Dowel Pins - Inch

Size	Part No.	Pieces per Box	$ Price /100	lbs /1000
1/4" (#8-32 UNC)				
1/4" x 3/4	138431	40	POA	12.65
1	138433	40	POA	14.85
1 1/4	138434	40	POA	17.60
1 1/2	138436	40	POA	22.55
1 3/4	138437	40	POA	24.75
2	138438	40	POA	29.70
2 1/2	138440	40	POA	37.40
5/16" (#10-32 UNF)				
5/16" x 3/4	138441	40	POA	17.60
1	138443	40	POA	24.75
1 1/4	138444	40	POA	29.70
1 1/2	138445	40	POA	35.20
2	138447	40	POA	47.30
2 1/4	138448	40	POA	51.15
2 1/2	138449	40	POA	59.95
3/8" (#10-32 UNF)				
3/8" x 1	138451	40	POA	35.20
1 1/4	138452	40	POA	39.67
1 1/2	138453	40	POA	46.89
1 3/4	138454	40	POA	54.70
2	138455	40	POA	62.51
2 1/4	138456	40	POA	75.90
2 1/2	138457	40	POA	84.70
3	138458	40	POA	93.77
1/2" (1/4-20 UNC)				
1/2" x 1	135459	40	POA	61.60
1 1/4	135460	40	POA	75.90
1 1/2	138461	20	POA	90.20
1 3/4	138462	20	POA	104.50
2	138463	20	POA	119.90
2 1/4	138464	20	POA	134.20
2 1/2	138465	20	POA	149.60
3	138466	20	POA	174.90
3 1/2	138467	20	POA	204.60
4	138468	20	POA	234.30

Size	Part No.	Pieces per Box	$ Price /100	lbs /1000
5/8" (1/4-20 UNC)				
5/8" x 1 1/2	138469	20	POA	70.40
2	138471	20	POA	94.60
2 1/4	138472	10	POA	209.00
2 1/2	138473	10	POA	228.80
3	138474	10	POA	268.40
4	138476	10	POA	358.60
3/4" (5/16-18 UNC)				
3/4"x 2	138477	10	POA	268.4
2 1/2	138478	10	POA	334.4
3	138479	10	POA	398.2
4	138480	10	POA	528.0
1" (3/8-16 UNC)				
1"x 2	138481	10	POA	479.6
2 1/2	138482	10	POA	589.6
3	138483	10	POA	710.6
4	138485	10	POA	850.7

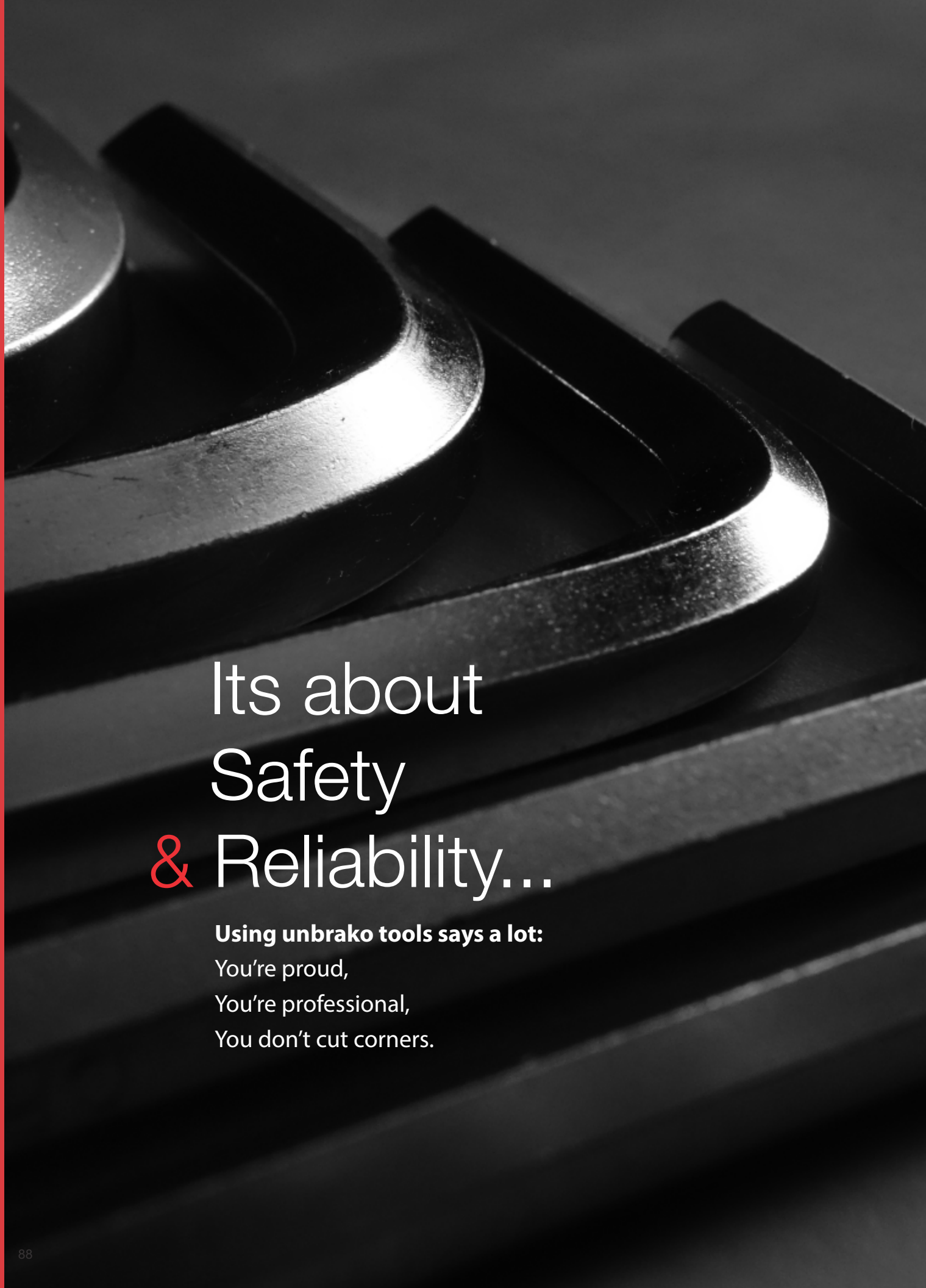
Pieces per Box



With up to 9 months inventory cover for standard products
More than 3,000 categories of High Tensile Alloy and Stainless Steel Industrial Fasteners are just a call away!

Unbrako
THE WORLD LEADER

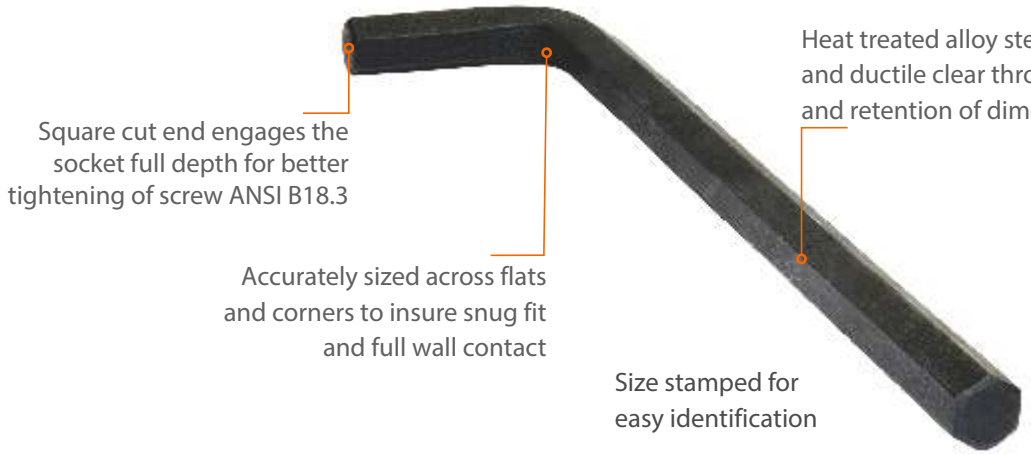
Wrenches & Tools



Its about Safety & Reliability...

Using unbrako tools says a lot:
You're proud,
You're professional,
You don't cut corners.

HEXAGON WRENCHES



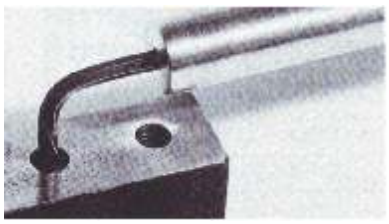
Why Unbrako wrenches are Safer ?

An UNBRAKO key is not an ordinary hexagon key – it is a precision internal wrenching tool of great strength and ductility. With an UNBRAKO key, far more tightening torque than is needed can be applied without damaging the screw or the key, and it can be done safely. This is an important feature, especially true of the smaller sizes (5/32" and under) which are normally held in the hand.

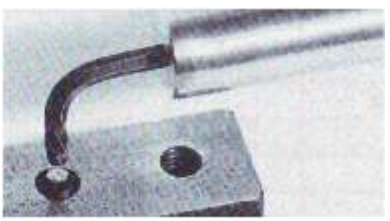
Photographs of a destruction test show what we mean. Under excessive torque a 5/64" UNBRAKO key twists but does not shear until a torque has been reached that is approximately 20% greater than can be applied with an ordinary key. At his point it shears off clean, flush with the top of the socket, leaving no jagged edge to gash a hand.

Still the UNBRAKO screw has not been harmed. The broken piece of the key is not wedged into the socket. It can be lifted out with a small magnet, convincing proof that the socket has not been reamed or otherwise damaged.

NOTE: The use of an extension in these illustrations is for demonstration purposes only. The manufacturer does not recommend the use of extensions with any hex key product under normal conditions.



A 5/64" UNBRAKO key will twist up to 180° without weakening.



Twisted to about 270°, the key shears off clean. Note the extension bar illustrated for test purposes only.

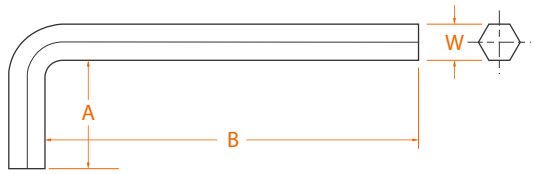
The socket hasn't been reamed or damaged. Broken section can be lifted out with a magnet.

HIGH-GRADE ALLOY STEEL

Tough, ductile, for high torqueing; accurate fit in all types of socket screws; size marked for quick identity

Mechanical Properties

1. Material: ASME B18.3.2.M Alloy Steel
2. Dimensions: B18.3.2M
3. Similar Standards: ISO 2936 AND BS4168
4. Unbrako Long arm similar to ISO extra long
5. Please specify standard required at time of purchase.



Product Dimensions

Size nom.	Width Across Flats W max.	W min.	A max.	A min.	Unbrako / ASME Short B max.	Short B min.	Unbrako Long B max.	Long B min.
0.71	0.711	0.698	5.5		31			
0.89	0.889	0.876	9		31			
1.27	1.270	1.244	13.5		42			
1.5	1.500	1.470	14	13	45	43	90	88
2.0	2.000	1.970	16	15	50	48	100	98
2.5	2.500	2.470	18	17	56	53	112	109
3.0	3.000	2.955	20	19	63	60	126	123
4.0	4.000	3.955	25	24	70	66	142	138
5.0	5.000	4.955	28	27	80	76	160	156
6.0	6.000	5.955	32	30	90	86	180	176
8.0	8.000	7.955	36	34	100	95	200	195
10.0	10.000	9.955	40	38	112	106	224	218
12.0	12.000	11.955	45	43	125	119	250	244
14.0	14.000	13.930	55	53	140	133	280	273
17.0	17.000	16.930	63	60	160	152	320	312
19.0	19.000	18.930	70	67	180	171	360	351
22.0	22.000	21.930	80	76	200	190	400	390
24.0	24.000	23.930	90	86	224	213	448	437
27.0	27.000	26.820	100	96	250	238	500	488
32.0	32.000	31.820	125	121	315	300	630	615
36.0	36.000	35.820	140	135	355	338	710	693

Size nom.	ASME Long B max.	ASME Long B min.	Torsional Shear Strength Minimum N-m	Torsional Shear Strength Minimum In-lbs.	Torsional Yield Strength Minimum N-m	Torsional Yield Strength Minimum In-lbs.
0.71	69		0.12	1.1	0.1	0.9
0.89	71		0.26	2.3	0.23	2.
1.27	75		0.73	6.5	.63	5.6
1.5	78	76	1.19	10.5	1.02	9.0
2.0	83	81	2.90	26	2.4	21
2.5	90	87	5.40	48	4.4	39
3.0	100	97	9.30	82	8.0	71
4.0	106	102	22.2	196	18.8	166
5.0	118	114	42.7	378	36.8	326
6.0	140	136	74.0	655	64	566
8.0	160	155	183.0	1,620	158	1,400
10.0	170	164	345.0	3,050	296	2,620
12.0	212	206	634.0	5,610	546	4,830
14.0	236	229	945.0	8,360	813	7,200
17.0	250	242	1,690	15,000	1,450	12,800
19.0	280	271	2,360	20,900	2,030	18,000
22.0	335	325	3,670	32,500	3,160	28,000
24.0	375	364	4,140	36,600	3,560	31,500
27.0			5,870	51,900	5,050	44,700
32.0			8,320	73,600	7,150	63,300
36.0			11,800	104,000	10,200	90,300

Marking

UNBRAKO & Size

Sizes 2 or Larger

Hexagon Wrenches- Metric

Size	Part No.		$ Price /100	lbs /1000
Short Series				
0.71	110230	100	**51.90**	0.26
0.89	115932	100	**47.35**	1.36
1.27	115965	100	**27.32**	2.27
1.5	125648	100	**20.04**	2.84
2.0	122263	100	**23.08**	4.99
2.5	122270	100	**25.50**	8.73
3.0	121093	100	**30.36**	13.18
4.0	119953	100	**42.49**	26.60
5.0	122245	100	**68.59**	44.24
6.0	121066	50	**94.10**	71.87
8.0	115557	50	**179.09**	133.36
10.0	120859	25	**282.29**	225.54
12.0	120860	25	**671.88**	354.71
14.0	111100	25	**956.00**	545.56
17.0	138487	10	**1736.10**	941.60
19.0	111133	10	**2414.34**	1349.77
22.0	402603	1	**3470.79**	2026.20
24.0	402604	1	**5556.34**	2706.00
27.0	402605	1	**7587.31**	3843.40
32.0	402606	1	**14545.19**	6813.40

Size	Part No.		$ Price /100	lbs /1000
Long Series (ASME B18.3.2m)				
0.89	C14663	100	**57.23**	0.95
1.5	C04118	100	**47.96**	3.12
2.0	C04119	100	**52.82**	5.94
2.5	C04120	100	**55.85**	10.08
3.0	C04122	100	**74.67**	16.04
4.0	C04123	100	**102.59**	31.46
5.0	C04127	100	**137.80**	54.52
6.0	C04129	50	**163.31**	92.14
8.0	C04130	50	**257.74**	255.64
10.0	C04131	10	**558.49**	314.91
12.0	C04132	10	**1062.35**	556.23
14.0	C04133	10	**1450.87**	861.78
17.0	C04134	1	**2507.13**	1366.07
19.0	C04135	1	**3466.29**	1911.58

Note:
- The following Imperial are identical to Metric Sizes : 0.028 ins = 0.71mm, 0.035 ins = 0.89mm, 0.050 ins = 1.27mm. Please order by across flats dimensions and description.
- CAUTION: Unbrako advise that correct tools should be used for the application.
- Safety goggles should be worn for your security and protection.

Metric Wrenches Application Chart

Size nom.	Socket Head Cap screws	Low Head Cap Screws	Flat Head Socket screws	Button Head screws	Socket Set screws
0.71	-	-	-	-	M1.6
0.89	-	-	-	-	M2
1.27	-	-	-	-	M2.5
1.50	M1.6/M2	-	-	-	M3
2.00	M2.5	-	M3	-	M4
2.50	M3	-	M4	-	M5
3.00	M4	M4	M5	M6	M6
4.00	M5	M5	M6	M8	M8
5.00	M6	M6	M8	M10	M10
6.00	M8	M8	M10	M12	M12
8.00	M10	M10	M12	M16	M16
10.00	M12	M12	M16	M20	M20
12.00	M14	M16	-	M24	M24
14.00	M16	M20	-	-	-
17.00	M20	M24	-	-	-
19.00	M24	-	-	-	-
22.00	M30	-	-	-	-
27.00	M36	-	-	-	-
32.00	M42	-	-	-	-
36.00	M48	-	-	-	-

Pieces per Box

HIGH-GRADE ALLOY STEEL

Tough, ductile, for high torqueing; accurate fit in all types of socket screws; size marked for quick identity

Mechanical Properties

Material: ANSI B18.3, alloy steel
Heat treat: Rc 47-57

Torsional Shear and Yield Strength

size nom.	Torsional shear strength inch-lbs. min	Torsional yield inch-lbs. min
.028	1.1	0.9
.035	2.3	2.0
.050	6.5	5.6
1/16	12.2	10.5
5/64	25.0	21.0
3/32	43.0	35.0
7/64	68.0	60.0
1/8	98.0	85.0
9/64	146.0	125.0
5/32	195.0	165.0
3/16	342.0	295.0
7/32	535.0	460.0
1/4	780.0	670.0
5/16	1,600.0	1,370.0
3/8	2,630.0	2,260.0
7/16	4,500.0	3,870.0
1/2	6,300.0	5,420.0
9/16	8,900.0	7,650.0
5/8	12,200.0	10,500.0
3/4	19,500.0	16,800.0
7/8	29,000.0	24,900.0
1	43,500.0	37,400.0
1 1/4	71,900.0	62,500.0
1 1/2	124,000.0	108,000.0
1 3/4	198,000.0	172,000.0
2	276,000.0	240,000.0

Marking

UNBRAKO & Size

Sizes 5/64 or Larger

Product Dimensions

size	Width Across Flats W		Length of Short Arm B		C - Length of Long Arm				
					short series		long series		6" long
nom.	max	min	max	min	max	min	max	min	arm
.028	.0280	.0275	.312	.125	1.312	1.125	2.688	2.500	–
.035	.0350	.0345	.438	.250	1.312	1.125	2.766	2.578	–
.050	.0500	.0490	.625	.438	1.750	1.562	2.938	2.750	–
1/16	.0625	.0615	.656	.469	1.844	1.656	3.094	2.906	–
5/64	.0781	.0771	.703	.516	1.969	1.781	3.281	3.094	6.000
3/32	.0937	.0927	.750	.562	2.094	1.906	3.469	3.281	6.000
7/64	.1094	.1079	.797	.609	2.219	2.031	3.656	3.469	6.000
1/8	.1250	.1235	.844	.656	2.344	2.156	3.844	3.656	6.000
9/64	.1406	.1391	.891	.703	2.469	2.281	4.031	3.844	6.000
5/32	.1562	.1547	.938	.750	2.594	2.406	4.219	4.031	6.000
3/16	.1875	.1860	1.031	.844	2.844	2.656	4.594	4.406	6.000
7/32	.2187	.2172	1.125	.938	3.094	2.906	4.969	4.781	6.000
1/4	.2500	.2485	1.219	1.031	3.344	3.156	5.344	5.156	6.000
5/16	.3125	.3110	1.344	1.156	3.844	3.656	6.094	5.906	6.000
3/8	.3750	.3735	1.469	1.281	4.344	4.156	6.844	6.656	6.000
7/16	.4375	.4355	1.594	1.406	4.844	4.656	7.594	7.406	–
1/2	.5000	.4975	1.719	1.531	5.344	5.156	8.344	8.156	–
9/16	.5625	.5600	1.844	1.656	5.844	5.656	9.094	8.906	–
5/8	.6250	.6225	1.969	1.781	6.344	6.156	9.844	9.656	–
3/4	.7500	.7470	2.219	2.031	7.344	7.156	11.344	11.156	–
7/8	.8750	.8720	2.469	2.281	8.344	8.156	12.844	12.656	–
1	1.0000	.9970	2.719	2.531	9.344	9.156	14.344	14.156	–
1 1/4	1.2500	1.2430	3.250	2.750	11.500	11.000			–
1 1/2	1.5000	1.4930	3.750	3.250	13.500	13.000			–
1 3/4	1.7500	1.7430	4.250	3.750	15.500	15.000			–
2	2.0000	1.9930	4.750	4.250	17.500	17.000			–

Hexagon Wrenches - Inch

Unbrako

HIGH-GRADE ALLOY STEEL

Size	Part No.		$ Price /100	lbs /1000
Short Series				
1/16	108468	100	**20.04**	3.32
5/64	110164	100	**23.08**	5.04
3/32	110180	100	**25.50**	7.77
7/64	110197	100	**27.92**	10.58
1/8	110213	100	**30.36**	13.99
9/64	115080	100	**36.42**	19.36
5/32	110246	100	**42.49**	24.22
3/16	115915	100	**45.35**	36.26
7/32	115948	50	**81.35**	53.46
1/4	115981	50	**94.10**	73.13
5/16	115997	50	**179.09**	126.21
3/8	116013	25	**282.29**	198.97
7/16	116029	25	**376.38**	294.25
1/2	116046	25	**469.87**	414.90
9/16	116063	25	**751.15**	563.86
5/8	116080	10	**1736.10**	743.89
3/4	116096	10	**2586.80**	1331.84
7/8	116112	5	**3401.13**	2050.40
1	116128	5	**5796.70**	2983.20

Size	Part No.		$ Price /100	lbs /1000
Long Series				
1/16	108485	100	**31.03**	4.51
5/64	117441	100	**31.03**	7.00
3/32	117457	100	**36.27**	10.71
7/64	117473	100	**45.35**	14.81
1/8	114614	100	**50.59**	19.71
9/64	113098	100	**50.59**	26.91
5/32	114630	100	**58.71**	33.92
3/16	114647	100	**73.72**	51.30
7/32	114679	50	**114.66**	75.42
1/4	114712	50	**186.82**	103.73
5/16	114728	50	**259.36**	179.98
3/8	114744	10	**387.66**	285.01
7/16	114761	10	**927.07**	423.06
1/2	114777	10	**1215.28**	598.47
9/16	114794	10	**1659.72**	814.00
5/8	107209	1	**2457.00**	1078.48
3/4	107225	1	**3412.50**	1873.23
7/8	107242	1	**4804.80**	2895.20
1	107258	1	**7371.00**	4219.60

Size	Part No.		$ Price /100	lbs /1000
6" Long Series				
5/64	107503	100	**238.88**	9.90
3/32	107504	100	**238.88**	14.30
7/64	107505	100	**238.88**	19.80
1/8	107507	100	**238.88**	26.40
9/64	107508	50	**259.35**	33.00
5/32	107509	50	**259.35**	41.80
3/16	107511	50	**286.65**	60.50
7/32	107513	25	**300.30**	85.80
1/4	107514	25	**313.95**	110.00
5/16	107515	10	**409.50**	176.00
3/8	107516	10	**573.30**	259.60

Note:

- The following Imperial are identical to Metric Sizes : 0.028 ins = 0.71mm, 0.035 ins = 0.89mm, 0.050 ins = 1.27mm. Please order by across flats dimensions and description.
- CAUTION: Unbrako advise that correct tools should be used for the application.
- Safety goggles should be worn for your security and protection.

Inch Wrenches Application Chart

size nom.	1960 Series socket head cap screws	1936 Series socket head cap screws	button head screws	flat head screws	shoulder screws	low heads and socket set screws	pressure* plugs
.028	-	-	-	-	-	#0	-
.035	-	-	#0	#0	-	#1, #2	-
.050	#0	-	#1, #2	#1, #2	-	#3, #4	-
1/16	#1	-	#3, #4	#3, #4	-	#5, #6	-
5/64	#2, #3	#4	#5, #6	#5, #6	-	#8	-
3/32	#4, #5	#5, #6	#8	#8	-	#10	-
7/64	#6		-	-	-	-	-
1/8	-	#8	#10	#10	1/4	1/4	-
9/64	#8		-	-	-	-	-
5/32	#10	#10	1/4	1/4	5/16	5/16	1/16
3/16	1/4	1/4	5/16	5/16	3/8	3/8	1/8
7/32	-	5/16	3/8	3/8	-	7/16	-
1/4	5/16		-	7/16	1/2	1/2	1/4
5/16	3/8	3/8, 7/16	1/2	1/2, 9/16	5/8	5/8	3/8
3/8	7/16,1/2	1/2, 5/16	5/8	5/8	3/4	3/4	1/2
7/16	9/16		-	-	-	-	-
1/2	5/8	5/8	-	3/4	7/8, 1	7/8	-
9/16	-	3/4, 7/8	-	7/8	-	1, 1/8	3/4
5/8	3/4	1	-	1	1 1/4	1 1/4, 1 3/8	1
3/4	7/8,1	-	-	-	-	1 1/2	1-1/4, 1-1/2
7/8	1 1/8, 1 1/4	-	-	-	1 1/2	-	-
1	1 3/8, 1 1/2	-	-	-	1 3/4	-	1/2, 2
1 1/4	1 3/4	-	-	-	2	-	-
1 1/2	2	-	-	-	-	-	-
1 3/4	2 1/4, 2 1/2	-	-	-	-	-	-
2	2 3/4	-	-	-	-	-	-

* 1 1/2 levl seal has 3/4" socket
1 1/2 dry seal has 1" socket

Pieces per Box

Unbrako
THE WORLD LEADER

HIGH-PERFORMANCE
STAINLESS STEEL FASTENERS

Unbrako fasteners are now available in all grades of Stainless Steel A2-70, A2-80, A4-70, A4-80, A4-90 and A4-100.

- Socket Head Cap Screws
- Socket Countersunk Head Screws
- Socket Button Head Screws
- Hex Head Screws
- Hex Nuts
- Plain Washer
- Spring Washer
- Socket Set Screws
- Threaded Rod
- Specials

Special Orders Only

Extra Strength Where it Counts

Corrosion Resistance

Unbrako Stainless Steel Fasteners - available in SS304 & SS316 - offer excellent corrosion resistance in a wide variety of environments.

LOW Magnetic Permeability

Not attracted by a magnet. Maximum permeability is 1.2. High valuable characteristic in electrical applications.

Performance at HIGH Temperature

Retention of a high percentage of tensile strength and good creep resistance up to 800°F (without scaling or oxidation).

Performance at LOW Temperature

Useful in cryogenic application (like Liquid Nitrogen Gas(LNG) Processing), especially SS304, because it dose not become brittle as it is chilled.

Unbrako
THE WORLD LEADER

Durlok

Page Contents

Durlok® Self-locking Anti-vibration Fasteners

Why do fasteners rotate loose under vibration?

The basic design & function of a threaded fastener is to join multi--component assemblies so that the whole assembly performs as a single component.

In most cases, even in preloaded joints, the external forces create minimal relative displacements between the clamped parts, resulting in small sliding movements both in threads and under the head. Thus, the fastener becomes free of friction in a circumferential direction and the internal loosening or “off-torque” created by the preload on the threads will rotate the fastener loose.

In addition to self-loosening, fatigue failures can occur because the fastener will lose preload as soon as partial loosening takes place.

How does DURLOK® work?

Durlok® Free Spinning Self-locking fasteners come with all the benefits of serrated fasteners but with none of the disadvantages. Unlike serrated fasteners, with the unique Durlok® tooth formation, the locking is caused by the elastic spring back of the material at clamping load. A little wall of material builds up behind each tooth thereby blocking the bolt from turning.

Durlok® is designed with long, ramp shaped, radial teeth blended evenly into a smooth slightly conical outer bearing surface. It is this plain outer bearing ring that prevents excessive penetration into the bearing material, together with the long radial teeth which embed with only moderate edge pressure just sufficient to guarantee self-locking.

Durlok® Bolts of strength grade 12.9 are manufactured from alloy steel and are through hardened to give the same hardness from the tooth surface to the core. These are typically heavy duty bolts and can be used for all joints subjected to high loads.

Advantages of DURLOK®

Durlok® Bolts & Nuts are suitable for multiple re-use because the serrations do not groove the clamped material and maintain locking ability.

The Durlok® fastener system is effective on a wide variety of engineering materials including steel both heat--treated and non heat-treated, cast irons including nodular types, non--ferrous metals and sheet materials.

The presence of oil or other lubricants, organic or inorganic coatings will not adversely affect the locking ability. In addition, the corrosion resistance of protected surfaces will generally be maintained because the smooth annular ring of Durlok® fastener shields the bearing area against liquid penetration.

Durlok® Fasteners can be used at elevated temperatures up to 300°C.

TÜV NORD AD 2000 · CE 15048 14399 · BSI ISO 9001 · BSI ISO/TS 16949 · BSI ISO 14001 · BSI OHSAS 18001

How can the self-locking ability be evaluated?

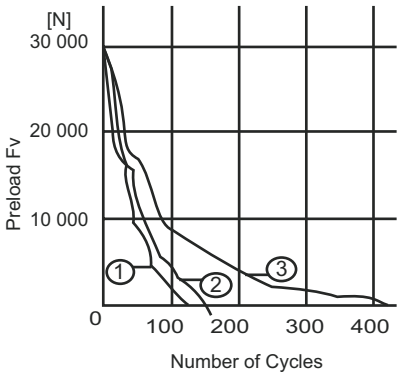
The most commonly used method for measuring locking ability has been by the indirect method of measuring & comparing the tightening & untightening torques. However, there is a growing realization that such a test in no way simulates the self-loosening mechanics of a fastener subjected to vibration. The only way this can be achieved is to apply a vibratory force to the bolted joint & determine whether the fastener rotates loose. This has been attempted but without achieving any real measure of the self-locking ability of the fastener.

There are numerous possibilities of recording test data. However, the clearest presentation of self-locking ability is shown by recording loss of preload versus number of cycles.

A typical recording for both unlocked bolts & bolts supposedly locked with spring washers shows that the initial bolt preload is completely lost after very few test cycles; conclusive evidence that the bolt has undergone total self-loosening.

These results clearly show that spring washers do not possess any genuine self-locking ability.

1. Hex Head Bolt M 10x30 DIN 933-8.8 unlocked.
2. Hex Head Bolt M 10x30 DIN 933-8.8 locked with spring washer according to DIN128B.
3. Hex Head Bolt M 10x30 DIN 933-8.8 locked with spring washer according to DIN 127A.



Other advantages of DURLOK.

DURLOK bolts and nuts are suitable for re-use because the serrations cause relatively little damage to the clamped material. This means that the locking ability can be maintained as shown by the original vibration test recorded (see table 3)

This recording shows that the minimal loss of preload due to embedding even decreases due to cold-working of the surface of the clamped material during retightening of the fastener. The DURLOK fastener system is effective on a wide variety of engineering material including steel-both heat-treated & non heat-treated, cast irons including nodular types, non-ferrous metals & sheet materials.

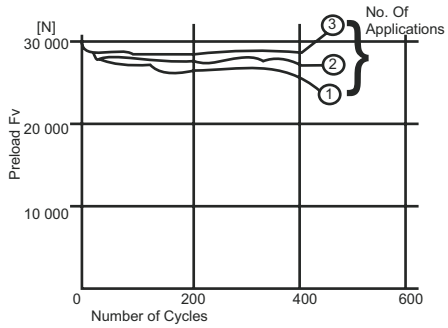


Table 3

DURLOK bolts, however do not rotate loose when tested in the same way, even under the heaviest amplitudes. Even when only half of the recommended preload was used. Durlok bolts still did not loosen. This is illustrated by the figure:2, which is an original recording of a vibration test on M 10 DURLOK bolts. This shows that there is a mineral loss of preload even when the fastener is re-used.

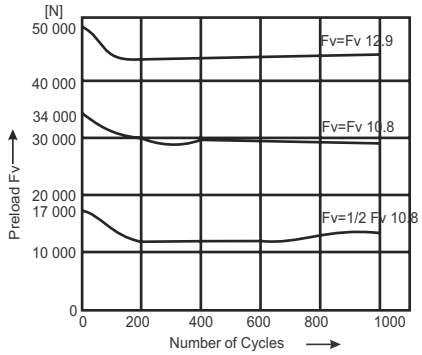


figure:2

Unbrako®
THE WORLD LEADER

Durlok® Self-locking Anti-vibration Fasteners

Will not loosen or unscrew even under the most severe transverse jarring and vibration.

Unique head design ensures absence of 'notch-effect' after assembly

Effectiveness at elevated temperatures upto 300° C is ensured.

Embedding is no greater than with standard types of fasteners.

Reusability is guaranteed with locking ability maintained.

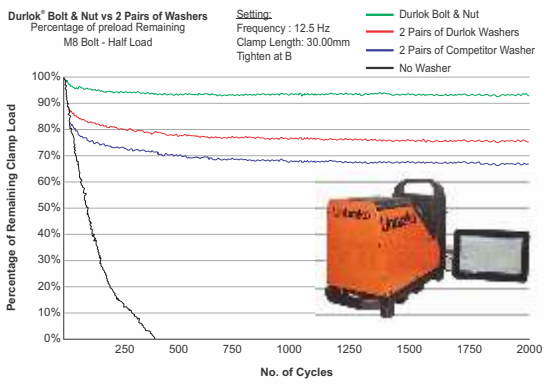
Closely controlled manufacturing for extra safety and reliability.

The DURLOK Advantage

During the 1960's, Dr. Junker while working in Unbrako's Koblenz facility in Germany completed his seminal work on the self-loosening behavior of bolted joints. This in turn led to the design of the original Durlok® anti-vibration nuts & bolts. The Durlok 12.9 nuts & bolts are designed for high-performance critical applications and do not require a washer. However, our industrial OEM customers requested a Durlok product in washer form for applications where it was deemed desirable to use a washer in the joint design. Thus we began researching and developed Unbrako's new Durlok locking wedge washer.

The Durlok® washer when used in combination with standard hex helps achieve self-locking properties. It is an anti-vibration solution that not only prevents bolted joint failure, but also enables the bolted joint to retain its pre-load, thus reducing maintenance requirements. The test regime highlighted this feature (fig 1).

Vibration Resistance Testing / Junker Test



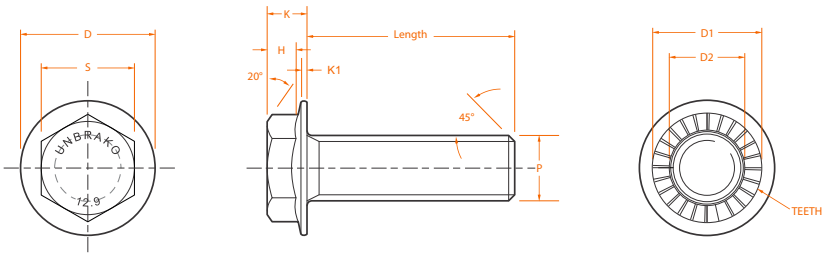
Typical Applications for DURLOK® Fasteners

- Automotive Engines
- Power Unit Accessories
- Transmission Units
- Frames and Chassis Units
- Bodywork
- Vibratory Feeders
- Shaking Chutes, Hoppers
- Electrical equipments
- Construction Machinery and Ancillary Equipments
- Agriculture Machinery
- Percussion Drilling Tools &Power Wrenches
- Domestic Appliance

Durlok free spinning self-locking bolts are designed with long, ramp shaped, radial teeth blended evenly into a smooth slightly conical outer surface. Reusable. Self-locking. Anti-vibration.

Mechanical Properties

Property Class: 12.9
Material: Alloy Steel ISO 898-1
Hardness: 40 - 43HRc
Tensile Strength: 1220N/mm² min
Thread class: 6g
Threads: ANSI B1.13M, ISO 261, ISO 262 (coarse series only)



Product Dimensions

Size	D max	D1 min	D2	K nom	K1 min	H min	S max	P max	Length ref
M5	12	11.0	5.5	4.5	1.0	2.09	8	3.65	50.0
M6	14	11.8	6.6	5.2	1.1	2.69	10	4.35	50.0
M8	18	15.2	9.0	7.2	1.3	4.21	13	5.90	60.0
M10	21	17.2	11.0	9.0	1.6	5.47	15	7.50	60.0
M12	25	20.6	14.0	11.0	1.9	6.71	17	9.10	80.0
M14	28	22.8	16.0	12.5	2.2	7.65	19	10.65	80.0
M16	32	25.5	18.0	16.0	3.8	9.27	22	12.55	100.0
M20	39	31.2	22.0	18.0	3.1	11.86	27	15.70	100.0

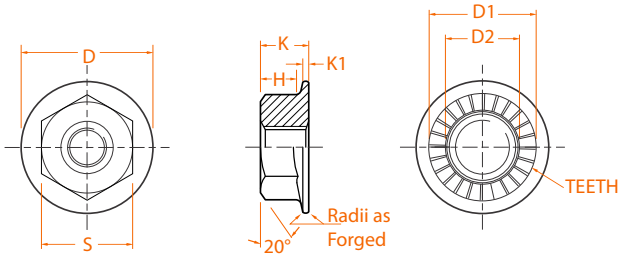
Application Data

Size	Stress Area mm2	Proof Load (N)	Load at yield (N)	load at min UTS (N)	Induced preload (N)	Tightening Torque Tmax (Nm) for μ head of		
						0.125	0.16	0.2
M5	14.2	13,750	15,600	17,300	11,300	10.8	12.4	14.2
M6	20.1	19,500	22,100	24,500	15,950	18.2	21.0	24.0
M8	36.6	35,500	40,300	44,600	29,300	44.0	50.0	58.0
M10	58.0	56,300	63,800	70,800	46,600	84.0	96.0	109.0
M12	84.3	81,800	92,700	102,800	68,000	148.0	169.0	194.0
M14	115.0	111,500	126,500	140,000	93,000	233.0	266.0	304.0
M16	157.0	152,000	172,500	191,500	129,000	362.0	413.0	472.0
M20	245.0	238,000	270,000	299,000	201,000	695.0	797.0	913.0

Note
*Fmax for μ thread =0.125

Marking

Unbrako



Durlok nuts are designed with long, ramp shaped, radial teeth blended evenly into a smooth slightly conical outer surface. For use with Durlok Bolts. Self-locking. Anti-vibration. Reusable.

Mechanical Properties

Material: Alloy Steel ISO 898-1
Hardness: 28-36HRc
Thread class: 6H
Head marking: U 12
Threads: ANSI B1.13M, ISO 261, ISO 262 (coarse series only)
Property Class: 12

Marking

Product Dimensions

Size	D max	D1 min	D2 max	S max	H min	K nom	K1 min
M5	12	10.0	6.2	8	2.46	4.5	1.0
M6	14	11.8	7.4	10	3.06	5.2	1.1
M8	18	15.2	9.5	13	4.60	7.2	1.3
M10	21	17.2	12.5	15	5.90	9.0	1.6
M12	25	20.6	15.0	19	7.45	11.0	1.9
M14	28	23.4	17.0	22	8.55	12.5	2.2
M16	32	26.4	19.0	24	10.25	16.0	2.3
M20	39	32.4	23.0	30	13.05	18.0	2.9

Technical Data

The Durlok fastener system is effective on a wide variety of engineering materials including steel - both heat treated and non-heat treated, cast irons including nodular types, non ferrous metals and sheet materials.

The Presence of oil or other lubricants, organic or inorganic coatings should not adversely affect the locking ability. Durlok Fasteners can be used at elevated temperatures up to 300ºC.

The Induced assembly pre-load Fmax and the corresponding tightening torques, T max are based on a 90% utilisation of the minimum yield strength by combined tension and torsional stresses. For cases where the yield strength must never be exceeded during tightening, the tightening torque must be reduced by a value equivalent to the scatter. Comprehensive investigation has shown that the scatter, due to variations in friction coefficient and torque scatter when tightening with torque wrench, must be accounted for by using a reduced torque T which is 90% of the tabulated value T max, T = 0.9 x Tmax Accordingly the induced pre-load Fmax will be reduced to the new pre-load F, Ff = 0.9 x Fmax

It should be noted that pre-load and tightening torque are a function of the joint stiffness. The tabulated values are valid for a joint stiffness which occurs under snug conditions with a clamping length of 2.5 - 4d. In addition , the values are based on an average friction co-efficent for the threads of μ = 0.125.

The value of the friction coefficient in the bearing area μh, has a different value to that of the friction coefficient in the threads μt, due to the serrations. As for all bolts the friction coefficient under the head is a function of the material, surface finish and lubrication condition of the contacting materials. To account for this the tightening torques are listed for various values of μh.

For guidance the following chart is designed to indicate the appropriate value of friction coefficient to be applied for various engineering materials and finishes. The value of μh are based on the results of comprehensive tests:

Coated Surface Bare Bolt Surface	Fine Turning Grinding	Turning, Boring, Milling	Rough Turning Rough Milling
Steel Hardness 250-350 HV	0.125 0.16	0.125 0.160	0.125 0.125
Steel Hardness 150-250HV	0.160 0.20	0.160 0.160	0.160 0.160
Grey cast Iron Nodular Cast Iron	0.20	0.160	0.125

Unbrako

Durlok® Bolts

Size	Part No.		$ Price /100	lbs /1000
M6 (1)				
M6 x 12	190540	200	**76.85**	13.42
16	190560	200	**58.81**	14.94
20	190160	200	**59.36**	16.46
25	190170	200	**72.17**	18.35
30	190180	200	**79.51**	20.24
M8 (1.25)				
M8 x 12	190570	200	**78.85**	28.49
16	190590	200	**69.50**	31.24
20	190210	200	**75.18**	33.99
25	190220	200	**83.13**	37.66
30	190230	200	**91.30**	40.88
35	190600	200	**98.23**	44.31
40	190240	200	**105.58**	47.76
45	408127	200	**123.62**	51.19
50	190610	100	**132.31**	54.63
60	407393	100	**148.69**	61.51
M10 (1.5)				
M10 x 16	190620	200	**96.35**	51.17
20	190270	200	**72.59**	55.53
25	190280	200	**78.18**	60.98
30	190290	200	**86.09**	66.42
35	190630	200	**106.24**	71.87
40	190300	100	**114.27**	77.31
45	190640	100	**122.28**	82.76
50	190310	100	**130.03**	88.20
M12 (1.75)				
M12 x 20	183640	100	**135.04**	86.06
25	190320	100	**135.65**	93.94
30	190330	100	**136.99**	101.84
35	190660	100	**140.32**	109.74
40	190340	50	**151.01**	117.63
45	190670	50	**161.04**	125.53
50	190350	50	**171.06**	133.43
55	190680	50	**181.09**	141.33
60	190360	50	**201.14**	149.23
70	190700	50	**222.51**	165.02
80	190710	50	**243.23**	180.80
M14 (2)				
M14 x 25	190730	25	**262.61**	131.32
30	190370	25	**273.97**	142.12
35	190740	25	**277.04**	152.92
40	190380	25	**294.01**	163.72

Size	Part No.		$ Price /100	lbs /1000
M14 (2)				
M14 x 45	190750	25	**302.70**	174.53
50	190760	25	**320.74**	185.33
60	190770	25	**344.80**	206.93
M16 (2)				
M16 x 30	190410	25	**459.03**	220.42
35	190420	25	**459.03**	234.92
40	190430	25	**459.03**	249.41
45	190820	25	**459.03**	263.91
50	190440	25	**473.10**	278.41
55	405105	25	**497.82**	292.91
60	190450	25	**558.46**	307.38
70	190460	25	**582.60**	336.38
80	190855	25	**608.07**	365.38
90	190860	25	**656.85**	392.48
100	190870	25	**704.97**	423.37
M20 (2.5)				
M20 x 40	190875	25	**1016.02**	403.92
45	405793	25	**851.98**	426.92
50	182991	25	**884.42**	449.28
60	190885	25	**955.54**	494.65
70	190890	25	**1002.32**	540.03
80	190900	25	**1089.19**	585.40
90	190910	25	**1176.05**	630.78
100	406937	25	**1662.87**	676.15

Durlok® Nuts

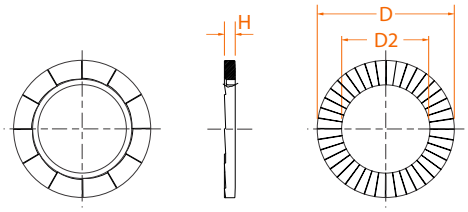
Size	Part No.		$ Price /100	lbs /1000
Nut				
M6 (1)	404916	200	**21.78**	5.50
M8 (1.25)	404917	200	**32.74**	13.86
M10 (1.5)	405202	200	**49.45**	23.59
M12 (1.75)	404918	100	**90.87**	39.60
M14 (2)	405240	50	**138.99**	69.52
M16 (2)	404915	50	**166.38**	88.00
M20 (2.5)	403618	50	**239.26**	166.96

Durlok® Washers - Metric

Durlok washers are designed for use with standard hex bolts & nuts. Self-locking. Anti-vibration.

Mechanical Properties

Material: SAE 4130 or equivalent alloy.
Through Hardened.
Plating: Zinc flake coating (Delta Protekt(R))
Heat treatment: 47-52 HRC



Product Dimensions

Size	D min.	D max	D2 min.	D2 max	H min.	H max
6mm	10.60	11.00	6.40	6.60	0.80	1.00
8mm	13.30	13.70	8.60	8.80	1.15	1.35
10mm	16.40	16.80	10.60	10.80	1.15	1.35
12mm	19.30	19.70	12.90	13.10	1.15	1.35
14mm	22.80	23.20	15.10	15.30	1.60	1.80
16mm	25.20	25.60	16.90	17.10	1.60	1.80
20mm	30.50	30.90	21.30	21.50	1.60	1.80
24mm	38.80	39.20	25.30	25.50	1.60	1.80

Product Range

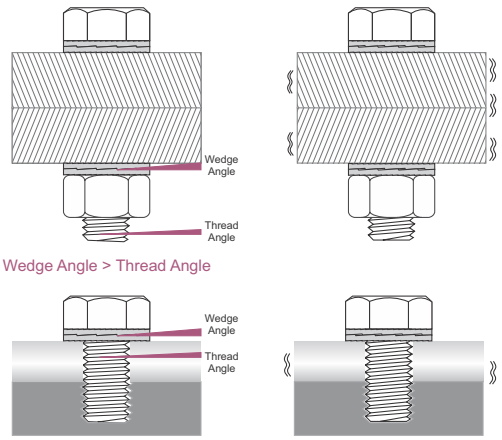
Size	Part No.		**$ Price /100**	lbs /1000
Zinc Flake Coated				
M6	183794	200	**57.70**	0.91
M8	183795	200	**61.40**	1.80
M10	183796	200	**69.90**	2.73
M12	183797	200	**114.30**	3.58
M14	183798	100	**140.30**	5.88
M16	183799	100	**166.30**	8.45
M20	183801	100	**249.40**	11.50

About Durlok Washers

Durlok® locking wedge washers when used with standard or high grade screws helps achieve self-locking properties. It utilizes tension instead of friction to secure bolted joints. Durlok washers come pre-assembled in pairs. They have wedge faces on the inside and radial teeth on the outside. They are designed such that the wedge angle is greater than the thread angle.

When the screw or the nut is tightened the radial teeth of Durlok washer locks itself onto the surface, allowing movement only across the wedge faces. During vibration, even a smallest turn of the screw causes an increase in pre-load force due to the wedge effect and the screw locks itself.

Thus the screw will not loosen or unscrew, even under severe jarring & vibration. Durlok washers are re-usable with locking ability maintained.



Note: the washers are always used in pairs. For through holes two pairs of Durlok washers should be used. For studbolt Durlok washers lock the nut. Durlok washers must not be used with other flat washers.

Unbrako
THE WORLD LEADER

Engineering Guide

Technical Section

NOTE:
The technical discussions represent typical applications only. The use of the information is at the sole discretion of the reader. Because applications vary enormously, UNBRAKO does not warrant the scenarios described are appropriate for any specific application. The reader must consider all variables prior to using this information.

INSTALLATION CONTROL

Several factors should be considered in designing a joint or selecting a fastener for a particular application.

JOINT DESIGN AND FASTENER SELECTION.

Joint Length

The longer the joint length, the greater the total elongation will occur in the bolt to produce the desired clamp load or preload. In design, if the joint length is increased, the potential loss of preload is decreased.

Joint Material

If the joint material is relatively stiff compared to the bolt material, it will compress less and therefore provide a less sensitive joint, less sensitive to loss of preload as a result of brinelling, relaxation and even loosening.

Thread Stripping Strength

Considering the material in which the threads will be tapped or the nut used, there must be sufficient engagement length to carry the load. Ideally, the length of thread engagement should be sufficient to break the fastener in tension. When a nut is used, the wall thickness of the nut as well as its length must be considered.

An estimate, a calculation or joint evaluation will be required to determine the tension loads to which the bolt and joint will be exposed. The size bolt and the number necessary to carry the load expected, along with the safety factor, must also be selected.

The safety factor selected will have to take into consideration the consequence of failure as well as the additional holes and fasteners. Safety factors, therefore, have to be determined by the designer.

SHEAR APPLICATIONS

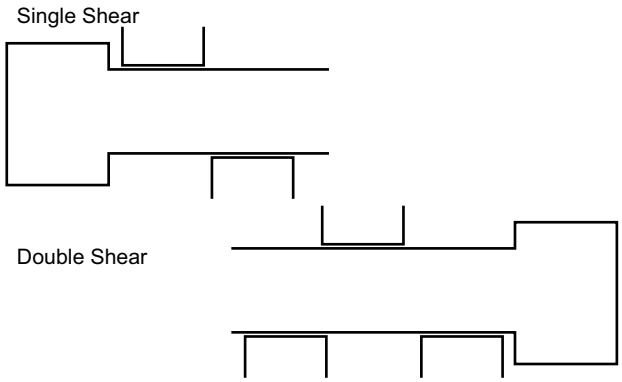
Shear Strength of Material

Not all applications apply a tensile load to the fastener. In many cases, the load is perpendicular to the fastener in shear. Shear loading may be single, double or multiple loading.

There is a relationship between the tensile strength of a material and its shear strength. For alloy steel, the shear strength is 60% of its tensile strength. Corrosion resistant steels (e.g. 300-Series stainless steels) have a lower tensile/shear relationship and it is usually 50-55%

Single/Double Shear

Single shear strength is exactly one-half the double shear value. Shear strength listed in pounds per square inch (psi) is the shear load in pounds divided by the cross sectional area in square inches.



OTHER DESIGN CONSIDERATIONS

Application Temperature

For elevated temperature, standard alloy steels are useful to about 550°F–600°F. However, if plating is used, the maximum temperature may be less (eg. cadmium should not be used over 450°F.

Austenitic stainless steels (300 Series) may be useful to 800°F. They can maintain strength above 800°F but will begin to oxidize on the surface.

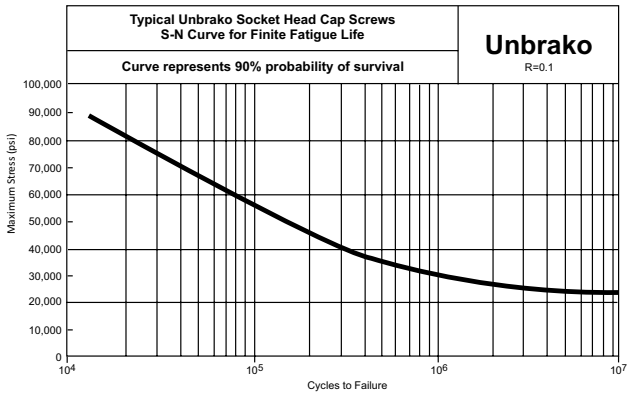
Corrosion Environment

A plating may be selected for mild atmospheres or salts. If plating is unsatisfactory, a corrosion resistant fastener may be specified. The proper selection will be based upon the severity of the corrosive environment.

FATIGUE STRENGTH

S/N Curve

Most comparative fatigue testing and specification fatigue test requirements are plotted on an S/N curve. In this curve, the test stress is shown on the ordinate (y-axis) and the number of cycles is shown on the abscissa (x-axis) in a logarithmic scale. On this type curve, the high load to low load ratio must be shown. This is usually R =.1, which means the low load in all tests will be 10% of the high load.



Effect of Preload

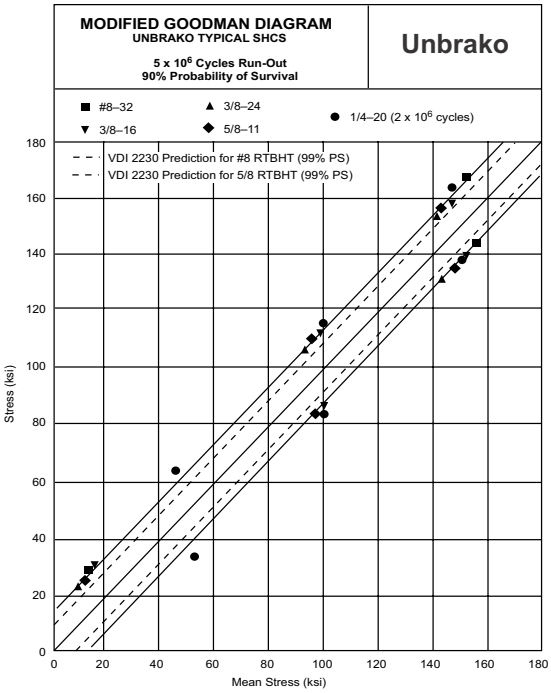
Increasing the R to .2, .3 or higher will change the curve shape. At some point in this curve, the number of cycles will reach 10 million cycles. This is considered the

endurance limit or the stress at which infinite life might be expected.

Modified Goodman/ Haigh Soderberg Curve

The S/N curve and the information it supplies will not provide the information needed to determine how an individual fastener will perform in an actual application. In application, the preload should be higher than any of the preloads on the S/N curve.

Therefore, for application information, the modified Goodman Diagram and/or the Haigh Soderberg Curve are more useful. These curves will show what fatigue performance can be expected when the parts are properly preloaded.



METHODS OF PRELOADING

Elongation

The modulus for steel of 30,000,000 (thirty million) psi means that a fastener will elongate .001 in/in of length for every 30,000 psi in applied stress. Therefore, if 90,000 psi is the desired preload, the bolt must be stretched .003 inches for every inch of length in the joint.

This method of preloading is very accurate but it requires that the ends of the bolts be properly prepared and also that all measurements be very carefully made. In addition, direct measurements are only possible where both ends of the fastener are available for measurement after installation. Other methods of measuring lengths changes are ultrasonic, strain gages and turn of the nut.

Torque

By far, the most popular method of preloading is by torque. Fastener manufacturers usually have recommended seating torques for each size and material fastener. The only requirement is the proper size torque wrench, a conscientious operator and the proper torque requirement.

Strain

Since stress/strain is a constant relationship for any given material, we can use that relationship just as the elongation change measurements were used previously.

Now, however, the strain can be detected from strain gages applied directly to the outside surface of the bolt or by having a hole drilled in the center of the bolt & the strain gage installed internally. The output from these gages need instrumentation to convert the gage electrical measurement method. It is, however, an expensive method and not always practical.

Turn of the Nut

The nut turn method also utilizes change in bolt length. In theory, one bolt revolution (360° rotation) should increase the bolt length by the thread pitch. There are at least two variables, however, which influence this relationship. First, until a snug joint is obtained, no bolt elongation can be measured. The snugging produces a large variation in preload. Second, joint compression is also taking place so the relative stiff nesses of the joint and bolt influences the load obtained.

VARIABLES IN TORQUE

Coefficient of Friction

Since the torque applied to a fastener must overcome all friction before any loading takes place, the amount of friction present is important.

In a standard unlubricated assembly, the friction to be overcome is the head bearing area and the thread-to-thread friction. Approximately 50% of the torque applied will be used to overcome this head-bearing friction and approximately 35% to overcome the thread friction. So 85% of the torque is overcoming friction and only 15% is available to produce bolt load.

If these interfaces are lubricated (cadmium plate, molybdenum disulfide, anti-seize compounds, etc.), the friction is reduced and thus greater preload is produced with the same torque.

The change in the coefficient of friction for different conditions can have a very significant effect on the slope of the torque tension curve. If this is not taken into consideration, the proper torque specified for a plain unlubricated bolt may be sufficient to yield or break a lubricated fastener.

Thread Pitch

The thread pitch must be considered when a given stress is to be applied, since the cross-sectional area used for stress calculations is the thread tensile stress area and is different for coarse and fine threads. The torque recommendations, therefore, are slightly higher for fine threads than for coarse threads to achieve the same stress.

Differences between coarse and fine threads.
Coarse Threads are...

- more readily available in industrial fasteners.
- easier to assemble because of larger helix angle.
- require fewer turns and reduce cross threading.
- higher thread stripping strength per given length.
- less critical of tap drill size.
- not as easily damaged in handling

Their disadvantages are...
- lower tensile strength.
- reduced vibrational resistance.
- coarse adjustment.

Fine Threads provide...
- higher tensile strength.
- greater vibrational resistance.
- finer adjustment.

Their disadvantages are…
- easier cross threaded.
- threads damaged more easily by handling.
- tap drill size slightly more critical.
- slightly lower thread stripping strength.

Other Design Guidelines

In addition to the joint design factors discussed, the following considerations are important to the proper use of high-strength fasteners.

- Adequate thread engagement should be guaranteed by use of the proper mating nut height for the system. Minimum length of engagement recommended in a tapped hole depends on the strength of the material, but in all cases should be adequate to prevent stripping.

- Specify nut of proper strength level. The bolt and nut should be selected as a system.

- Specify compatible mating female threads. 2B tapped holes or 3B nuts are possibilities.

- Corrosion, in general, is a problem of the joint, and not just of the bolt alone. This can be a matter of galvanic action between dissimilar metals. Corrosion of the fastener material surrounding the bolt head or nut can be critical with high-strength bolting. Care must be exercised in the compatibility of joint materials and/or coatings to protect dissimilar metals.

PROCESSING CONTROL

The quality of the raw material and the processing control will largely affect the mechanical properties of the finished parts.

MATERIAL SELECTION

The selection of the type of material will depend on its end use. However, the control of the analysis and quality is a critical factor in fastener performance. The material must yield reliable parts with few hidden defects such as cracks, seams, decarburization and internal flaws.

FABRICATION METHOD

Head

There are two general methods of making bolt heads, forging and machining. The economy and grain flow resulting from forging make it the preferred method.

The temperature of forging can vary from room temperature to 2000°F. By far, the greatest number of parts are cold upset on forging machines known as headers or bolt makers. For materials that do not have enough formability for cold forging, hot forging is used. Hot forging is also used for bolts too large for cold upsetting due to machine capacity. The largest cold forging machines can make bolts up to 1-1/2 inch diameter. For large quantities of bolts, hot forging is more expensive then cold forging.

Some materials, such as stainless steel, are warm forged at temperatures up to 1000°F. The heating results in two benefits, lower forging pressures due to lower yield strength and reduced work hardening rates.

Machining is the oldest method and is used for very large diameters or small production runs.

The disadvantage is that machining cuts the metal grain flow, thus creating planes of weakness at the critical head-to-shank fillet area. This can reduce tension fatigue performance by providing fracture planes.

Fillets

The head-to-shank transition (fillet) represents a sizable change in cross section at a critical area of bolt performance. It is important that this notch effect be minimized. A generous radius in the fillet reduces the notch effect. However, a compromise is necessary because too large a radius will reduce load-bearing area under the head.

Composite radii such as elliptical fillets, maximize curvature on the shank side of the fillet and minimize it on the head side to reduce loss of bearing area on the load-bearing surface.

Critical Fastener Features

Head-Shank-Fillet: This area on the bolt must not be restricted or bound by the joint hole. A sufficient chamfer or radius on the edge of the hole will prevent interference that could seriously reduce fatigue life. Also, if the bolt should seat on an unchamfered edge, there might be serious loss of preload if the edge breaks under load.

Threads

Threads can be produced by grinding, cutting or rolling. In a rolled thread, the material is caused to flow into the thread die contour, which is ground into the surface during the manufacture of the die. Machines with two or three circular dies or two flat dies are most common.

Thread cutting requires the least tooling costs and is by far the most popular for producing internal threads. It is the most practical method for producing thin wall parts and the only technique available for producing large diameter parts (over 3 inches in diameter).

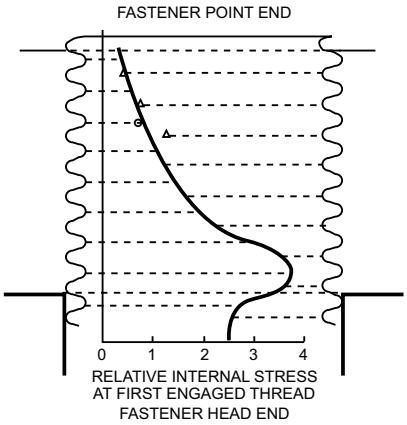
Thread grinding yields high dimensional precision and affords good control of form and finish. It is the only practical method for producing thread plug gages.

Both machining and grinding have the disadvantage of cutting material fibers at the most critical point of performance.

The shape or contour of the thread has a great effect on the resulting fatigue life. The thread root should be large and well rounded without sharp corners or stress risers. Threads with larger roots should always be used for harder materials.

In addition to the benefits of grain flow and controlled shape in thread rolling, added fatigue life can result when the rolling is performed after heat treatment.

This is the accepted practice for high fatigue performance bolts such as those used in aircraft and space applications.



EVALUATING PERFORMANCE

Mechanical Testing

In the fastener industy, a system of tests and examinations has evolved which yields reliable parts with proven performance.

Some tests are conducted on the raw material; some on the finished product.

There always seems to be some confusion regarding mechanical versus metallurgical properties. Mechanical properties are those associated with elastic or inelastic reaction when force is applied, or that involve the relationship between stress and strain. Tensile testing stresses the fastener in the axial direction. The force at which the fastener breaks is called the breaking load or ultimate tensile strength. Load is designated in pounds, stress in pounds per square inch and strain in inches per inch.

When a smooth tensile specimen is tested, the chart obtained is called a Stress-Strain Curve. From this curve, we can obtain other useful data such as yield strength. The method of determining yield is known as the offset method and consists of drawing a straight line parallel to the stress strain curve but offset from the zero point by a specified amount. This value is usually 0.2% on the strain ordinate. The yield point is the intersection of the stress-strain curve and the straight line. This method is not applicable to fasteners because of the variables introduced by their geometry.

When a fastener tensile test is plotted, a load/ elongation curve can be obtained. From this curve, a yield determination known as Johnson‘s 2/3 approximate method for determination of yield strength is used to establish fastener yield, which will be acceptable for design purposes. It is not recommended for quality control or specification requirements.

Torque-tension testing is conducted to correlate the required torque necessary to induce a given load in a mechanically fastened joint. It can be performed by hand or machine. The load may be measured by a tensile machine, a load cell, a hydraulic tensile indicator or by a strain gage.

Fatigue tests on threaded fasteners are usually alternating tension-tension loading. Most testing is done at more severe strain than its designed service load but usually below the material yield strength.

Shear testing, as previously mentioned, consists of loading a fastener perpendicular to its axis. All shear testing should be accomplished on the un-threaded portion of the fastener.

Checking hardness of parts is an indirect method for testing tensile strength. Over the years, a correlation of tensile strength to hardness has been obtained for most materials. See page 136 for more detailed information. Since hardness is a relatively easy and inexpensive test, it makes a good inspection check. In hardness checking, it is very important that the specimen be properly prepared and the proper test applied.

Stress durability is used to test parts which have been subjected to any processing which may have an embrittling effect. It requires loading the parts to a value higher than the expected service load and maintaining that load for a specified time after which the load is removed and the fastener examined for the presence of cracks.

Impact testing has been useful in determining the ductile brittle transformation point for many materials. However, because the impact loading direction is transverse to a fastener's normal longitude loading, its usefulness for fastener testing is minimal. It has been shown that many fastener tension impact strengths do not follow the same pattern or relationship of Charpy or Izod impact strength.

Metallurgical Testing

Metallurgical testing includes chemical composition, micro structure, grain size, carburization and decarburization, and heat treat response.

The chemical composition is established when the material is melted. Nothing subsequent to that process will influence the basic composition.

The microstructure and grain size can be influenced by heat treatment. Carburization is the addition of carbon to the surface which increases hardness. It can occur if heat treat furnace atmospheres are not adequately controlled. Decarburization is the loss of carbon from the surface, making it softer. Partial decarburization is preferable to carburization, and most industrial standards allow it within limits.

In summary, in order to prevent service failures, many things must be considered:

The Application Requirements

Strength Needed – Safety Factors

- Tension/Shear/Fatigue
- Temperature
- Corrosion
- Proper Preload

The Fastener Requirements

- Material
- Fabrication Controls
- Performance Evaluations

AN EXPLANATION OF JOINT DIAGRAMS

When bolted joints are subjected to external tensile loads, what forces and elastic deformation really exist? The majority of engineers in both the fastener manufacturing and user industries still are uncertain. Several papers, articles, and books, reflecting various stages of research into the problem have been published and the volume of this material is one reason for confusion. The purpose of this article is to clarify the various explanations that have been offered and to state the fundamental concepts which apply to forces and elastic deformations in concentrically loaded joints. The article concludes with general design formulae that take into account variations in tightening, preload loss during service, and the relation between preloads, external loads and bolt loads.

The Joint Diagram

Forces less than proof load cause elastic strains. Conversely, changes in elastic strains produce force variations. For bolted joints this concept is usually demonstrated by joint diagrams.

The most important deformations within a joint are elastic bolt elongation and elastic joint compression in the axial direction. If the bolted joint in Fig. 1 is subjected to the preload F_i the bolt elongates as shown by the line OB in Fig. 2A and the joint compresses as shown by the line OJ. These two lines, representing the spring characteristics of the bolt and joint, are combined into one diagram in Fig. 2B to show total elastic deformation.

If a concentric external load F_e is applied under the bolt head and nut in Fig. 1, the bolt elongates an additional amount while the compressed joint members partially relax. These changes in deformation with external loading are the key to the interaction of forces in bolted joints.

In Fig. 3A the external load F_e is added to the joint diagram Fe is located on the diagram by applying the upper end to an extension of OB and moving it in until the lower end contacts OJ. Since the total amount of elastic deformation (bolt plus joint) remains constant for a given preload, the external load changes the total bolt elongation to $\Delta l_B + \lambda$ and the total joint compression to $\Delta l_J - \lambda$.

In Fig. 3B the external load F_e is divided into an additional bolt load F_{eB} and the joint load $F_{eJ,}$ which unloads the compressed joint members. The maximum bolt load is the sum of the load preload and the additional bolt load:

$$F_{B\,max} = F_i + F_{eB}$$

If the external load Fe is an alternating load, F_{eB} is that part of F_e working as an alternating bolt load, as shown in Fig. 3B. This joint diagram also illustrates that the joint absorbs more of the external load than the bolt subjected to an alternating external load.

The importance of adequate preload is shown in Fig. 3C. Comparing Fig. 3B and Fig. 3C, it can be seen that F_{eB} will remain relatively small as long as the preload F_i is greater than $F_{eJ,}$ Fig. 3C represents a joint with insufficient preload. Under this condition, the amount of external load that the joint can absorb is limited, and the excess load must then be applied to the bolt. If the external load is alternating, the increased stress levels on the bolt producea greatly shortened fatigue life.

When seating requires a certain minimum force or when transverse loads are to be transformed by friction, the minimum clamping load $F_{J\,min}$ is important.

$$F_{J\,min} = F_{B\,max} - F_e$$

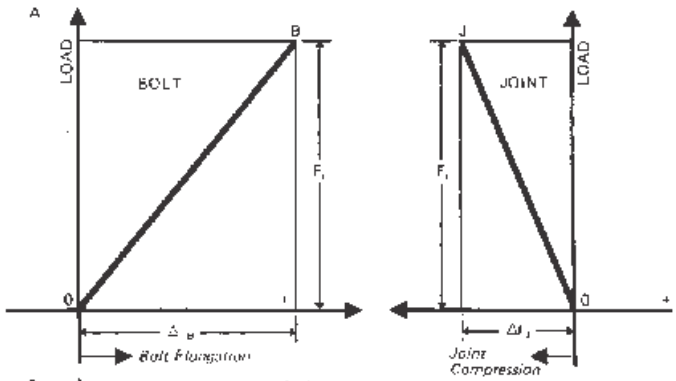


Fig. 1 (above) Joint components

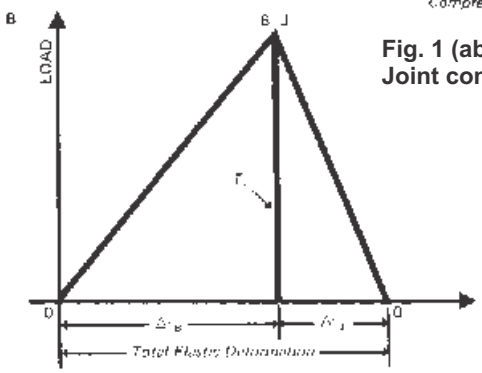


Fig. 2 Joint diagram is obtained by combining load vs. deformation diagrams of bolt and joints.

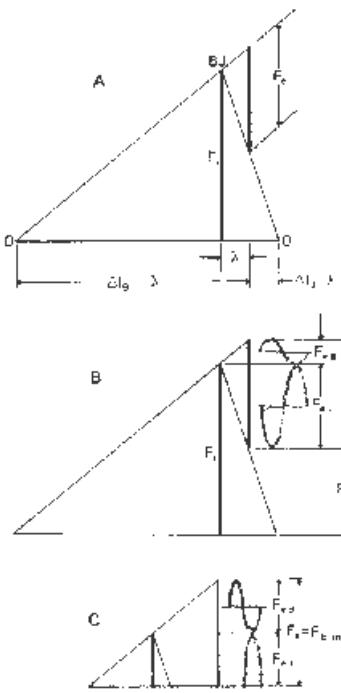


Fig. 3 The complete simple joint diagrams show external load F_e added (A), and external load divided into an additional bolt load F_{eB} and reduction in joint compression F_{eJ} (B). Joint diagram (C) shows how insufficient preload F_i causes excessive additional bolt load F_{eB}

Spring Constants

To construct a joint diagram, it is necessary to determine the spring rates of both bolt and joint. In general, spring rate is defined as:

$$K = \frac{F}{\Delta l}$$

From Hook's law:

$$\Delta l = \frac{lF}{EA}$$

Therefore:

$$K = \frac{EA}{l}$$

To calculate the spring rate of bolts with different cross sections, the reciprocal spring rates, or compliances, of each section are added:

$$\frac{1}{K_B} = \frac{1}{K_1} + \frac{1}{K_2} + \ldots + \frac{1}{K_n}$$

Thus, for the bolt shown in Fig. 4:

$$\frac{1}{K_B} = \frac{1}{E}\left(\frac{0.4d}{A_1} + \frac{l_1}{A_1} + \frac{l_2}{A_2} + \frac{l_3}{A_m} + \frac{0.4d}{A_m}\right)$$

where

d = the minor thread diameter and

A_m = the area of the minor thread diameter

This formula considers the elastic deformation of the head and the engaged thread with a length of 0.4d each.

Calculation of the spring rate of the compressed joint members is more difficult because it is not always obvious which parts of the joint are deformed and which are not. In general, the spring rate of a clamped part is:

$$K_J = \frac{EA_S}{l_J}$$

where A_S is the area of a substitute cylinder to be determined.

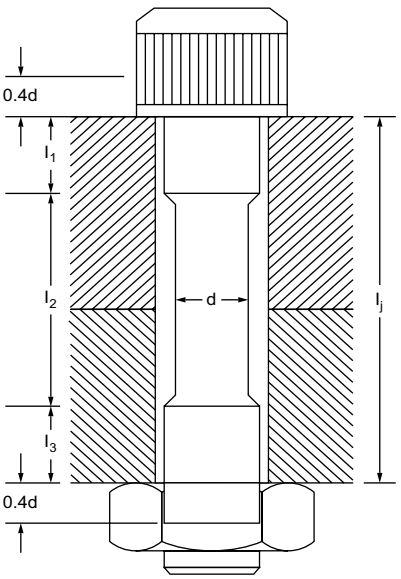


Fig. 4 Analysis of bolt lengths contributing to the bolt spring rate.

When the outside diameter of the joint is smaller than or equal to the bolt head diameter, i.e.,as in a thin bushing, the normal cross sectioned area is computed:

$$A_s = \frac{\pi}{4}(D_c^2 - D_h^2)$$

where

D_c = OD of cylinder or bushing and

D_h = hole diameter

When the outside diameter of the joint is larger than head or washer diameter D_H, the stress distribution is in the shape of a barrel, Fig 5. A series of investigations proved that the areas of the following substitute cylinders are close approximations for calculating the spring contents of concentrically loaded joints.

When the joint diameter D_J is greater than D_H but less than $3D_H$;

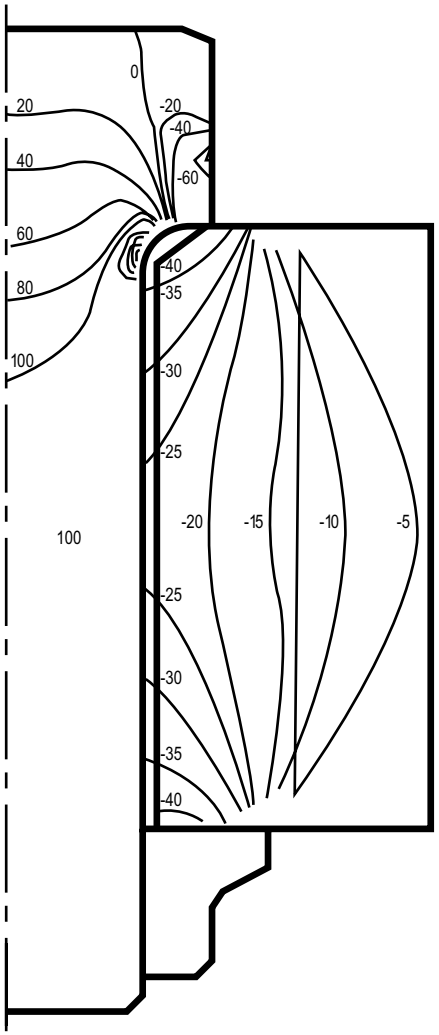


Fig. 5 Lines of equal axial stresses in a bolted joint obtained by the axisymmetric finite element method are shown for a 9/16—18 bolt preloaded to 100 KSI. Positive numbers are tensile stresses in KSI; negative numbers are compressive stresses in KSI.

$$A_s = \frac{\pi}{4}(D_H^2 - D_h^2) + \frac{\pi}{8}\left(\frac{D_J}{DH} - 1\right)\left(\frac{D_H l_J}{5} + \frac{l_J^2}{100}\right)$$

When the joint diameter D_J is equal to or greater than $3D_H$:

$$A_s = \frac{\pi}{4}[(D_H + 0.1\, l_J)^2 - D_h^2]$$

These formulate have been verified in laboratories by finite element method and by experiments.

Fig. 6 shows joint diagrams for springy bolt and stiff joint and for a stiff bolt and springy joint. These diagrams demonstrate the desirability of designing with springy bolt and a stiff joint to obtain a low additional bolt load F_{eB} and thus a low alternating stress.

The Force Ratio

Due to the geometry of the joint diagram, Fig. 7,

$$F_{eB} = \frac{K_e K_B}{K_B + K_J}$$

Defining $\Phi = \frac{K_B}{K_B + K_J}$

$F_{eB} = F_e\Phi$ and
Φ , called the Force Ratio, $= \frac{F_{eB}}{F_e}$

For complete derivation of Φ see Fig. 7.

To assure adequate fatigue strength of the selected fastener the fatigue stress amplitude of the bolt resulting from an external load F_e is computed as follows:

$$\sigma_B = \pm \frac{F_{eB}/2}{A_m} \quad \text{or}$$

$$\sigma_B = \pm \frac{\Phi F_e}{2 A_m}$$

Effect of Loading Planes

The joint diagram in Fig 3, 6 and 7 is applicable only when the external load F_e is applied at the same loading planes as the preloaded F_i , under the bolt head and the nut. However, this is a rare case, because the external load usually affects the joint somewhere between the center of the joint and the head and the nut.

When a preloaded joint is subjected to an external load F_e at loading planes 2 and 3 in Fig. 8, F_e relieves the compression load of the joint parts between planes 2 and 3. The remainder of the system, the bolt and the joint parts between planes 1-2 and 3-4, feel additional load due to F_e applied planes 2 and 3, the joint material between planes 2 and 3 is the clamped part and all other joint members, fastener and remaining joint material, are clamping parts. Because of the location of the loading planes, the joint diagram changes from black line to the blue line. Consequently, both the additional bolt load $F_{B\,max}$ decrease significantly when the loading planes of F_e shift from under the bolt head and nut toward the joint center.

Determination of the length of the clamped parts is, however, not that simple. First, it is assumed that the external load is applied at a plane perpendicular to the bolt axis. Second, the distance of the loading planes from each other has to be estimated. This distance may be expressed as the ratio of the length of clamped parts to the total joint length. Fig. 9 shows the effect of two different loading planes on the bolt load, both joints having the same preload F_i and the same external load F_e . The lengths of the clamped parts are estimated to be $0.75/_J$ for joint A, and $0.25/_J$ for joint B.

In general, the external bolt load is somewhere between $F_{eB} = 1\Phi F_e$ for loading planes under head and nut and $F_{eB} = 0\Phi F_e = 0$ when loading planes are in the joint center, as shown in Fig. 10. To consider the loading planes in calculation, the formula:

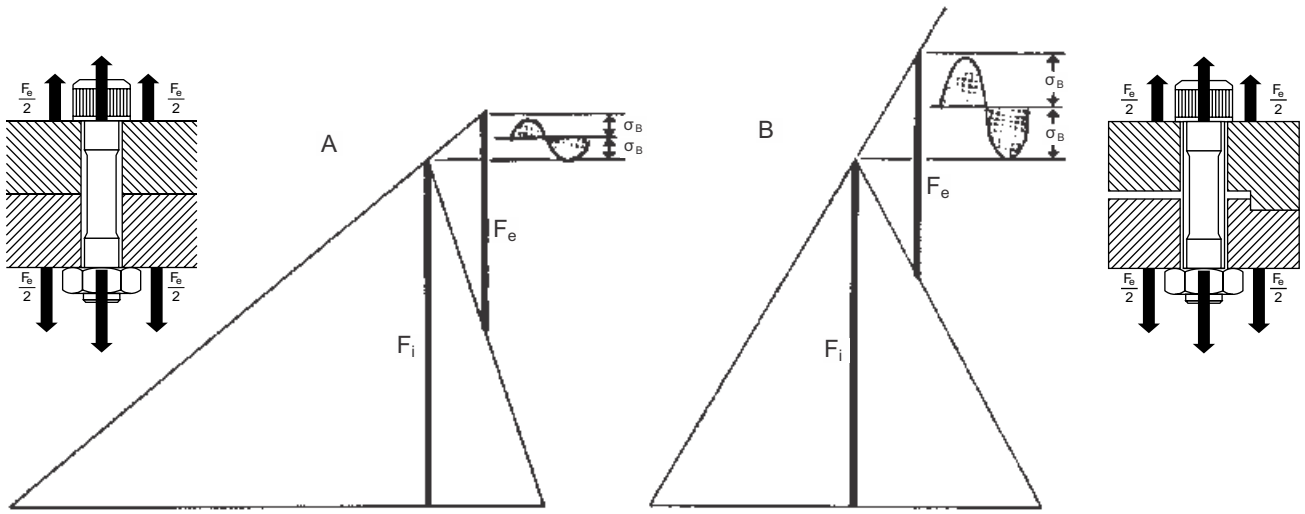


Fig. 6 Joint diagram of a springy bolt in a stiff joint (A), is compared to a diagram of a stiff bolt in a springy joint (B). Preload F_i and external load F_e are the same but diagrams show that alternating bolt stresses are significantly lower with a spring bolt in a stiff joint.

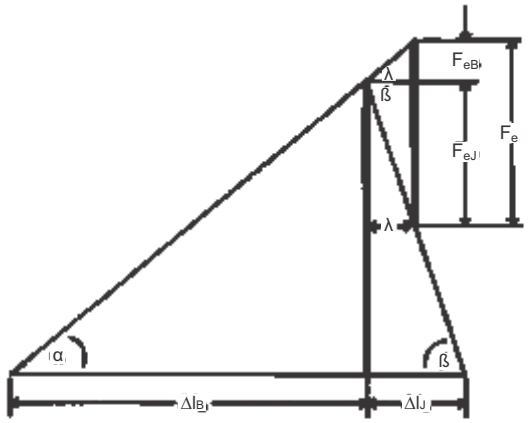


Fig. 7 Analysis of external load F_e and derivation of Force Ratio Φ.

$$\tan\alpha = \frac{F_i}{\Delta l_B} = K_B \text{ and } \tan ß = \frac{Fi}{\Delta l_J} = K_J$$

$$\lambda = \frac{F_{eB}}{\tan\alpha} = \frac{F_{eJ}}{\tan ß} = \frac{FeB}{K_B} = \frac{F_{eJ}}{K_J} \text{ or}$$

$$F_{eJ} = \lambda \tan ß \text{ and } F_{eB} = \lambda \tan\alpha$$

Since $F_e = F_{eB} + F_{eJ}$

$F_e = F_{eB} + \lambda \tan ß$

Substituting $\frac{F_{eB}}{\tan\alpha}$ for λ produces:

$$F_e = F_{eB} + \frac{F_{eB} \tan ß}{\tan\alpha}$$

Multiplying both sides by tan α :

$F_e \tan\alpha = F_{eB} (\tan\alpha + \tan ß)$ and

$$F_{eB} = \frac{F_e \tan\alpha}{\tan\alpha \tan ß}$$

Substituting K_B for tan α and K_J for tan ß

$$F_{eB} = F_e \frac{F_B}{K_B + K_B}$$

Defining $\Phi = \frac{K_B}{K_B + K_J}$

$$F_{eB} = \Phi F_e$$

$\Phi = \frac{F_{eB}}{F_e}$ and it becomes obvious why Φ is called force ratio.

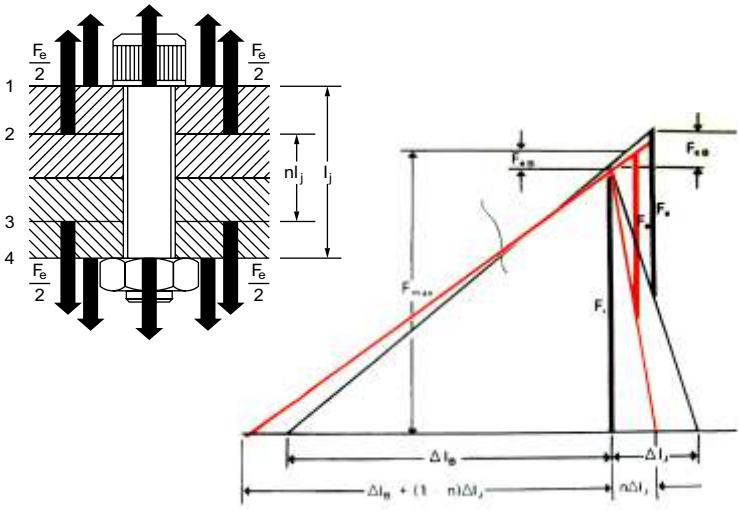


Fig. 8 Joint diagram shows effect of loading planes of F_e on bolt loads F_{eB} and $F_{B\,max}$. Black diagram shows F_{eB} and $F_{B\,max}$ resulting from F_e applied in planes 1 and 4. Orange diagram shows reduced bolt loads when Fe is applied in planes 2 and 3.

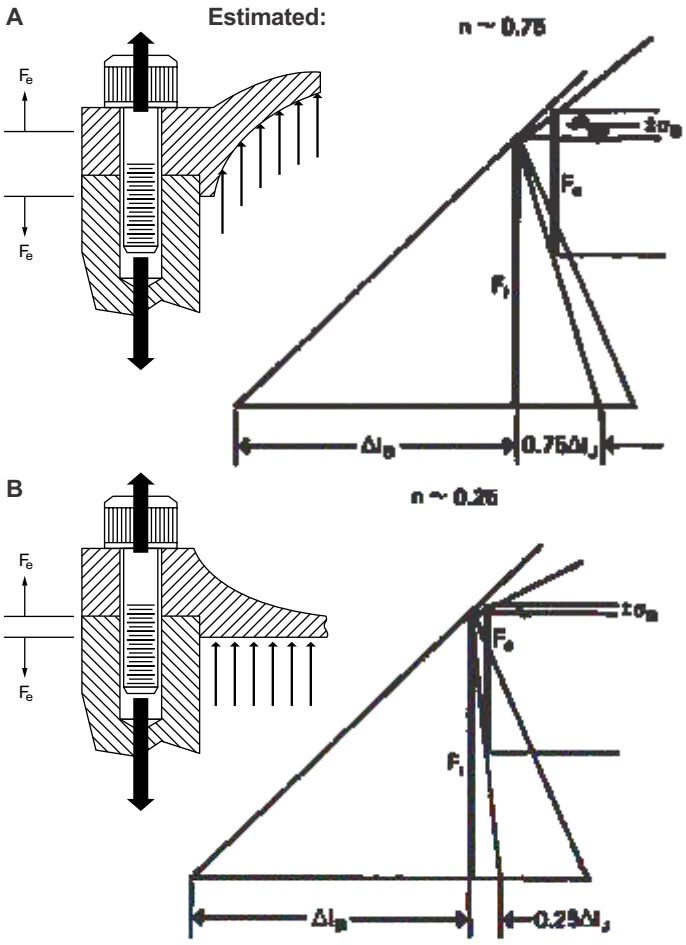


Fig. 9 When external load is applied relatively near bolt head, joint diagram shows resulting alternating stress α_B (A). When same value external load is applied relatively near joint center, lower alternating stress results (B).

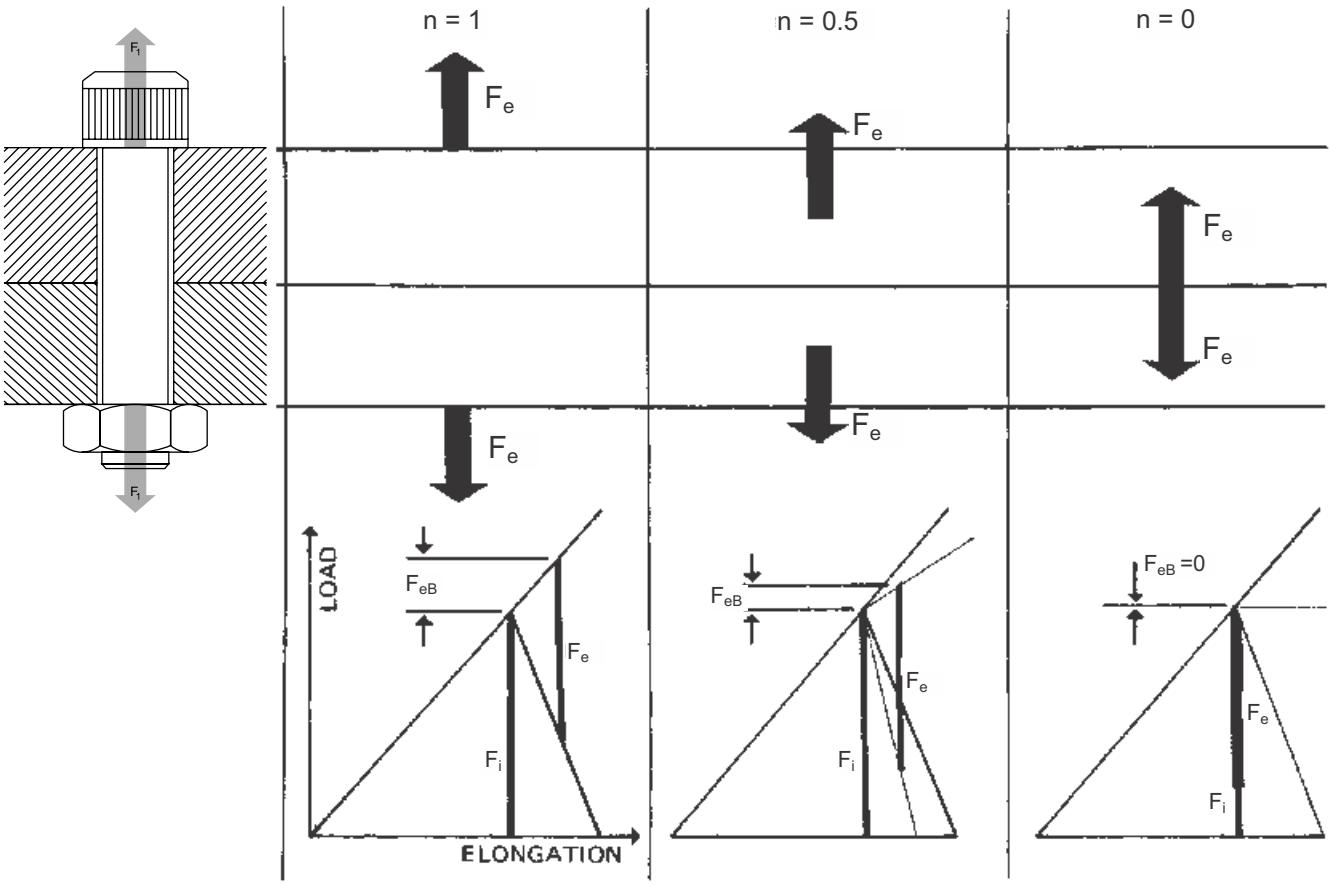


Fig. 10 Force diagrams show the effect of the loading planes of the external load on the bolt load.

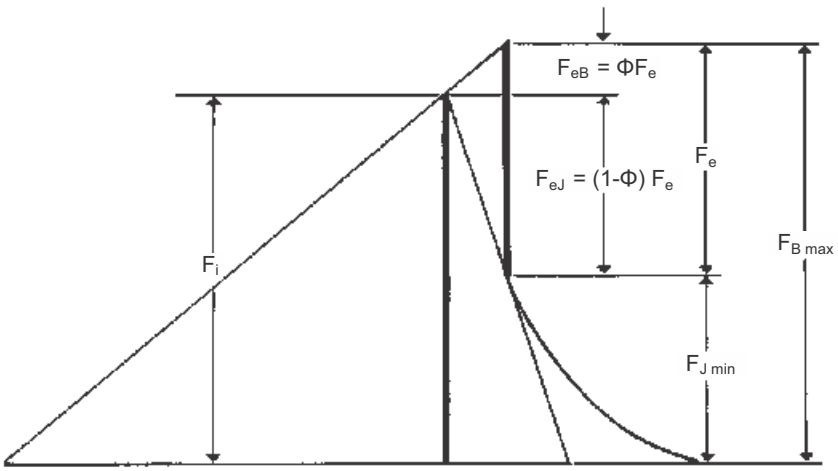


Fig. 11 Modified joint diagram shows nonlinear compression of joint at low preloads.

$F_{eB} = \Phi F_e$ must be modified to :

$F_{eB} = n \Phi F_e$

where n equals the ratio of the length of the clamped parts due to F_e to the joint length l_j. The value of n can range from 1, when Fe is applied under the head and nut, to O, when F_e is applies at the joint center. Consequently the stress amplitude:

$$\sigma_B = \pm \frac{\Phi F_e}{2 A_m}$$ becomes

$$\sigma_B = \pm \frac{n \Phi F_e}{2 A_m}$$

General Design Formulae

Hitherto, construction of the joint diagram has assumed linear resilience of both bolt and joint members. However, recent investigations have shown that this assumption is not quite true for compressed parts.

Taking these investigations into account, the joint diagram is modified to Fig. 11. The lower portion of the joint spring rate is nonlinear, and the length of the linear portion depends on the preload level F_i. The higher F_i the longer the linear portion. By choosing a sufficiently high minimum load, $F_{min}>2F_e$, the non-linear range of the joint spring rate is avoided and a linear relationship between F_{eB} and F_e is maintained.

Also from Fig. 11 this formula is derived:
$F_{i\,min} = F_{J\,min} + (1 - \Phi) F_e + \Delta F_i$

where ΔF_i is the amount of preload loss to be expected. For a properly designed joint, a preload loss ΔF_i = - (0.005 to 0.10) F_i should be expected.

The fluctuation in bolt load that results from tightening is expressed by the ratio:

$$a = \frac{F_{i\,max}}{F_{i\,min}}$$

where a varies between 1.25 and 3.0 depending on the tightening method.

Considering a the general design formulae are:

$F_{i\,nom} = F_{J\,min} = (1 - \Phi) F_e$

$F_{i\,max} = a [F_{j\,min} + (1 - \Phi) F_e + \Delta F_i]$

$F_{B\,max} = a [F_{j\,min} + (1 - \Phi) F_e + \Delta F_i] + \Phi F_e$

Conclusion

The three requirements of concentrically loaded joints that must be met for an integral bolted joint are:

1. The maximum bolt load FB max must be less than the bolt yield strength.

2. If the external load is alternating, the alternating stress must be less than the bolt endurance limit to avoid fatigue failures.

3. The joint will not lose any preload due to permanent set or vibration greater than the value assumed for ΔF_i .

SYMBOLS

A	Area (in.^{2})
A_m	Area of minor thread diameter (in.^{2})
A_s	Area of substitute cyliner (in.^{2})
A_x	Area of bolt part 1_x (in.^{2})
d	Diameter of minor thread (in.)
D_c	Outside diameter of bushing (cylinder) (in.)
D_H	Diameter of Bolt head (in.)
D_h	Diameter of hole (in.)
D_J	Diameter of Joint
E	Modulus of Elasticity (psi)
F	Load (lb)
F_e	External load (lb.)
F_{eB}	Additinal Bolt Load due to external load (lb)
F_{eJ}	Reduced Joint load due to external load (lb)
F_i	Preload on Bolt and Joint (lb)
ΔF_i	Preload loss (–lb)
$F_{i\,min}$	Minimum preload (lb)
$F_{i\,max}$	Maximum preload (lb)
$F_{j\,nom}$	Nominal preload (lb)
$F_{B\,max}$	Maximum Bolt load (lb)
$F_{J\,min}$	Minimum Joint load (lb)
K	Spring rate (lb/in.)
K_B	Spring rate of Bolt (lb/in.)
K_J	Spring rate of Joint (lb/in.)
K_x	Spring rate of Bolt part l_x (lb/in.)
l	Length (in.)
Δl	Change in length (in.)
l_B	Length of Bolt (in.)
Δl_B	Bolt elongation due to F_i (in.)
l_J	Length of Joint (in.)
Δl_J	Joint compression to F_i (in.)
l_x	Length of Bolt part x (in.)
n	$\frac{\text{Length of clamped parts}}{\text{Total Joint Length}}$
α	Tightening factor
Φ	Force ratio
λ	Bolt and Joint elongation due to F_e (in.)
σ_B	Bolt stress amplitude (± psi)

TIGHTENING TORQUES AND THE TORQUE-TENSION RELATIONSHIP

All of the analysis and design work done in advance will have little meaning if the proper preload is not achieved. Several discussions in this technical section stress the importance of preload to maintaining joint integrity. There are many methods for measuring preload (see Table 12). However, one of the least expensive techniques that provides a reasonable level of accuracy versus cost is by measuring torque. The fundamental characteristic required is to know the relationship between torque and tension for any particular bolted joint. Once the desired design preload must be identified and specified first, then the torque required to induce that preload is determined.

Within the elastic range, before permanent stretch is induced, the relationship between torque and tension is essentially linear (see figure 13). Some studies have found up to 75 variables have an effect on this relationship: materials, temperature, rate of installation, thread helix angle, coefficients of friction, etc. One way that has been developed to reduce the complexity is to depend on empirical test results. That is, to perform experiments under the application conditions by measuring the induced torque and recording the resulting tension. This can be done with relatively simple, calibrated hydraulic pressure sensors, electric strain gages, or piezoelectric load cells. Once the data is gathered and plotted on a chart, the slope of the curve can be used to calculate a correlation factor. This technique has created an accepted formula for relating torque to tension.

$$T = K \times D \times P$$

T = torque, lbf.-in.
D = fastener nominal diameter, inches
P = preload, lbf.
K = “nut factor,” “tightening factor,” or “k-value”

If the preload and fastener diameter are selected in the design process, and the K-value for the application conditions is known, then the necessary torque can be calculated. It is noted that even with a specified torque, actual conditions at the time of installation can result in variations in the actual preload achieved (see Table 12).

One of the most critical criteria is the selection of the K-value. Accepted nominal values for many industrial applications are:

K = 0.20 for as-received steel bolts into steel holes

K = 0.15 steel bolts with cadmium plating, which acts like a lubricant,

K = 0.28 steel bolts with zinc plating.

The K-value is not the coefficient of the friction (μ); it is an empirically derived correlation factor.

It is readily apparent that if the torque intended for a zinc plated fastener is used for cadmium plated fastener, the preload will be almost two times that intended; it may actually cause the bolt to break.

Another influence is where friction occurs. For steel bolts holes, approximately 50% of the installation torque is consumed by friction under the head, 35% by thread friction, and only the remaining 15% inducing preload tension. Therefore, if lubricant is applied just on the fastener underhead, full friction reduction will not be achieved. Similarly, if the material against which the fastener is bearing, e.g. aluminum, is different than the internal thread material, e.g. cast iron, the effective friction may be difficult to predict, These examples illustrate the importance and the value of identifying the torque-tension relationship. It is a recommend practice too contact the lubricant manufacturer for K-value information if a lubricant will be used.

The recommended seating torques for Unbrako headed socket screws are based on inducing preloads reasonably expected in practice for each type. The values for Unbrako metric fasteners are calculated using VDI2230, a complex method utilized extensively in Europe. All values assume use in the received condition in steel holes. It is understandable the designer may need preloads higher than those listed. The following discussion is presented for those cases.

TORSION-TENSION YIELD AND TENSION CAPABILITY AFTER TORQUING

Once a headed fastener has been seated against a bearing surface, the inducement of torque will be translated into both torsion and tension stresses. These stresses combine to induce twist. If torque continues to be induced, the stress along the angle of twist will be the largest stress *while the bolt is being torqued*. Consequently, the stress along the bolt axis (axial tension) will be something less. This is why a bolt can fail at a lower tensile stress *during installation* than when it is pulled in straight tension alone, eg . a tensile test. Research has indicated the axial tension can range from 135,000 to 145,000 PSI for industry socket head cap screws at torsion-tension yield, depending on diameter. Including the preload variation that can occur with various installation techniques, eg. up to 25%, it can be understood why some recommended torques induce preload reasonably lower than the yield point.

Figure 13 also illustrates the effect of straight tension applied after installation has stopped. Immediately after stopping the installation procedure there will be some relaxation, and the torsion component will drop toward zero. This leaves only the axial tension, which keeps the joint clamped together. Once the torsion is relieved, the axial tension yield value and ultimate value for the fastener will be appropriate.

Table 12
Industrial Fasteners Institute’s Torque-Measuring Method

Preload Measuring Method	Accuracy Percent	Relative Cost
Feel (operator’s judgement)	±35	1
Torque wrench	±25	1.5
Turn of the nut	±15	3
Load-indicating washers	±10	7
Fastener elongation	±3 to 5	15
Strain gages	±1	20

Fig. 14

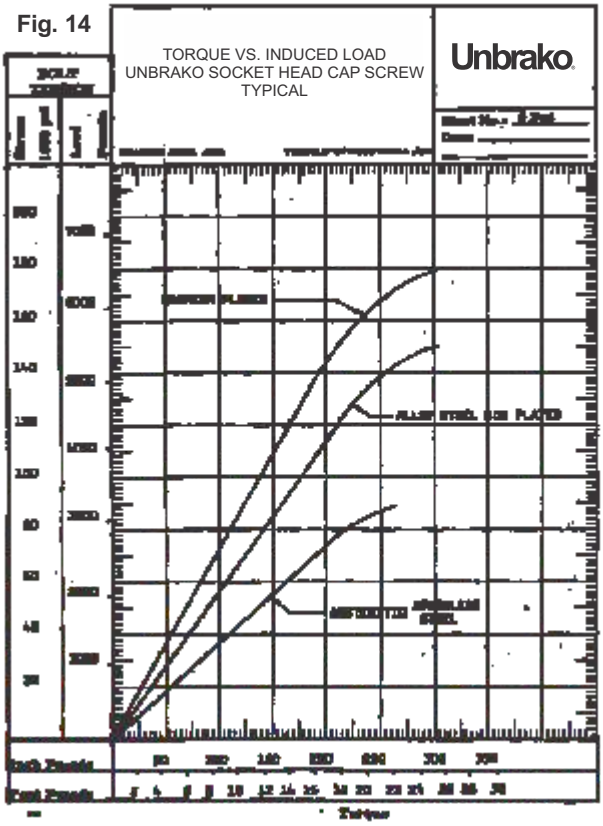


Fig. 13 Torque/Tension Relationship

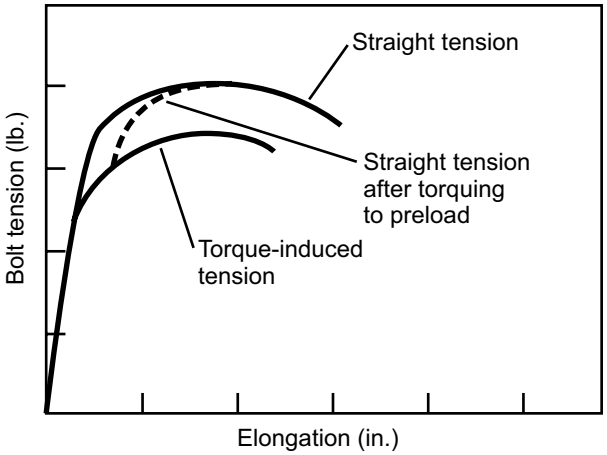


Fig. 15 Recommended Seating Torques (Inch-Lb.) for Application in Various Materials
UNBRAKO pHd (1960 Series) Socket Head Cap Screws

	mild steel Rb 87 cast iron Rb 83 note 1		brass Rb 72 note 2		aluminum Rb 72 (2024-T4) note 3	
	UNC	UNF	UNC	UNF	UNC	UNF
screw size	plain	plain	plain	plain	plain	plain
#0	–	*2.1	–	*2.1	–	*2.1
#1	*3.8	*4.1	*3.8	*4.1	*3.8	*4.1
#2	*6.3	*6.8	*6.3	*6.8	*6.3	*6.8
#3	*9.6	*10.3	*9.6	*10.3	*9.6	*10.3
#4	*13.5	*14.8	*13.5	*14.8	*13.5	*14.8
#5	*20	*21	*20	*21	*20	*21
#6	*25	*28	*25	*28	*25	*28
#8	*46	*48	*46	*48	*46	*48
#10	*67	*76	*67	*76	*67	*76
1/4	*158	*180	136	136	113	113
5/16	*326	*360	228	228	190	190
3/8	*580	635	476	476	397	397
7/16	*930	*1,040	680	680	570	570
1/2	*1,420	*1,590	1,230	1,230	1,030	1,030
9/16	*2,040	2,250	1,690	1,690	1,410	1,410
5/8	*2,820	3,120	2,340	2,340	1,950	1,950
3/4	*5,000	5,340	4,000	4,000	3,340	3,340
7/8	*8,060	8,370	6,280	6,280	5,230	5,230
1	*12,100	12,800	9,600	9,600	8,000	8,000
1 1/8	*13,800	*15,400	13,700	13,700	11,400	11,400
1 1/4	*19,200	*21,600	18,900	18,900	15,800	15,800
1 3/8	*25,200	*28,800	24,200	24,200	20,100	20,100
1 1/2	*33,600	*36,100	32,900	32,900	27,400	27,400

NOTES:
1. Torques based on 80,000 psi bearing stress under head of screw.
2. Torques based on 60,000 psi bearing stress under head of screw.
3. Torques based on 50,000 psi bearing stress under head of screw.

*Denotes torques based on 100,000 psi tensile stress in screw threads up to 1" dia., and 80,000 psi for sizes 1 1/8" dia. and larger.
To convert inch-pounds to inch-ounces — multiply by 16.
To convert inch-pounds to foot-pounds — divide by 12.

STRIPPING STRENGTH OF TAPPED HOLES

Charts and sample problems for obtaining minimum thread engagement based on applied load, material, type of thread and bolt diameter.

Knowledge of the thread stripping strength of tapped holes is necessary to develop full tensile strength of the bolt or, for that matter, the minimum engagement needed for any lesser load.

Conversely, if only limited length of engagement is available, the data help determine the maximum load that can be safely applied without stripping the threads of the tapped hole.

Attempts to compute lengths of engagement and related factors by formula have not been entirely satisfactory-mainly because of subtle differences between various materials. Therefore, strength data has been empirically developed from a series of tensile tests of tapped specimens for seven commonly used metals including steel, aluminum, brass and cast iron.

The design data is summarized in the six accompanying charts, (Charts E504-E509), and covers a range of screw thread sizes from #0 to one inch in diameter for both coarse and fine threads. Though developed from tests of Unbrako socket head cap screws having minimum ultimate tensile strengths (depending on the diameter) from 190,000 to 180,000 psi , these stripping strength values are valid for all other screws or bolts of equal or lower strength having a standard thread form. Data are based on static loading only.

In the test program, bolts threaded into tapped specimens of the metal under study were stressed in tension until the threads stripped. Load at which stripping occurred and the length of engagement of the specimen were noted. Conditions of the tests, all of which are met in a majority of industrial bolt applications, were:

- Tapped holes had a basic thread depth within the range of 65 to 80 per cent. Threads of tapped holes were Class 2B fit or better.
- Minimum amount of metal surrounding the tapped hole was 2 1/2 times the major diameter.
- Test loads were applied slowly in tension to screws having standard Class 3A threads. (Data, though, will be equally applicable to Class 2A external threads as well.)
- Study of the test results revealed certain factors that greatly simplified the compilation of thread stripping strength data:
- Stripping strengths are almost identical for loads applied either by pure tension or by screw torsion. Thus data are equally valid for either condition of application.
- Stripping strength values vary with diameter of screw. For a given load and material, larger diameter bolts required greater engagement.
- Minimum length of engagement (as a percent of screw diameter) is a straight line function of load. This permits easy interpolation of test data for any intermediate load condition.
- When engagement is plotted as a percentage of bolt diameter, it is apparent that stripping strengths for a wide range of screw sizes are close enough to be grouped in a single curve. Thus , in the accompanying charts, data for sizes #0 through #12 have been represented by a single set of curves.

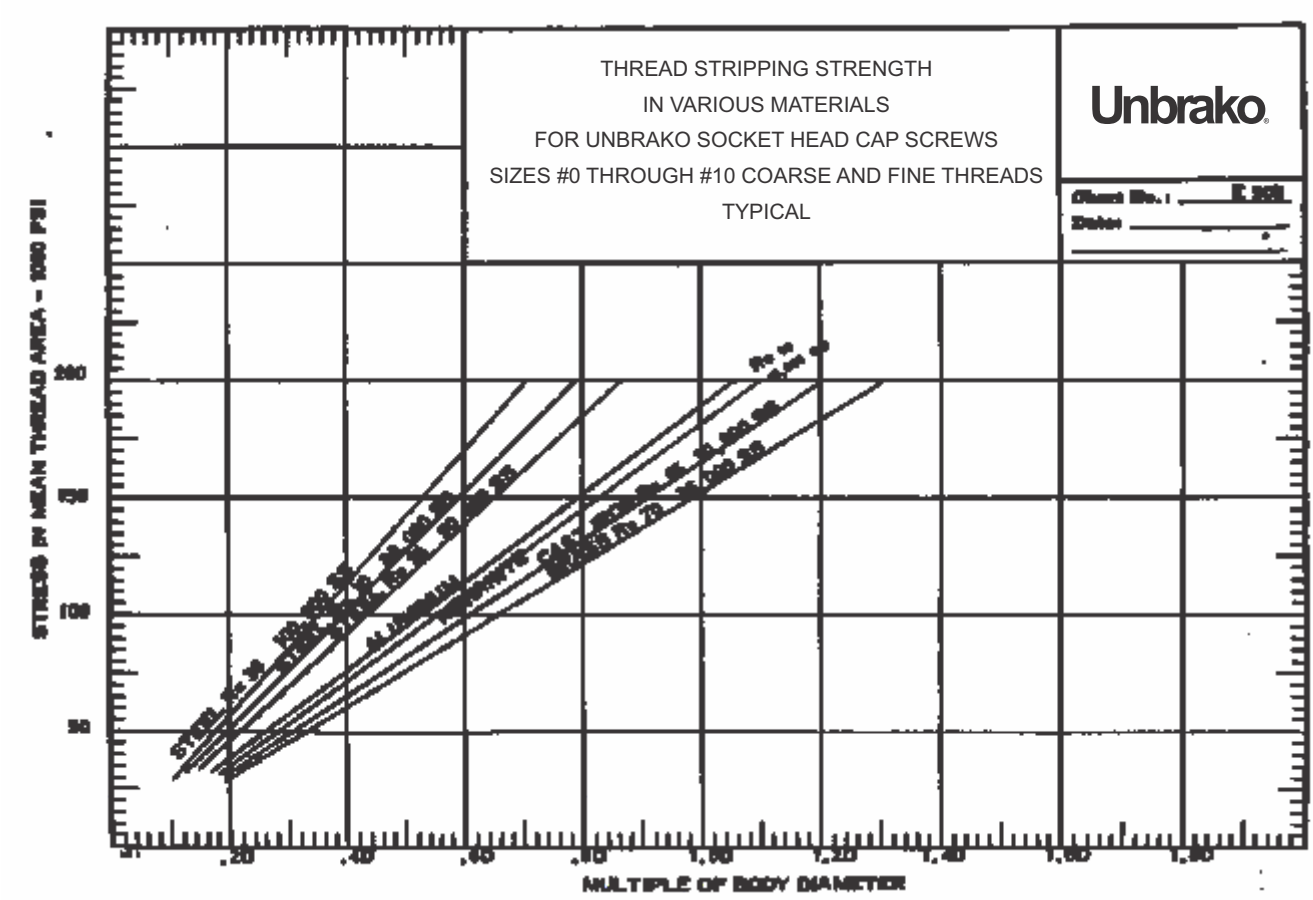
With these curves, it becomes a simple matter to determine stripping strengths and lengths of engagement for any condition of application. A few examples are given below:

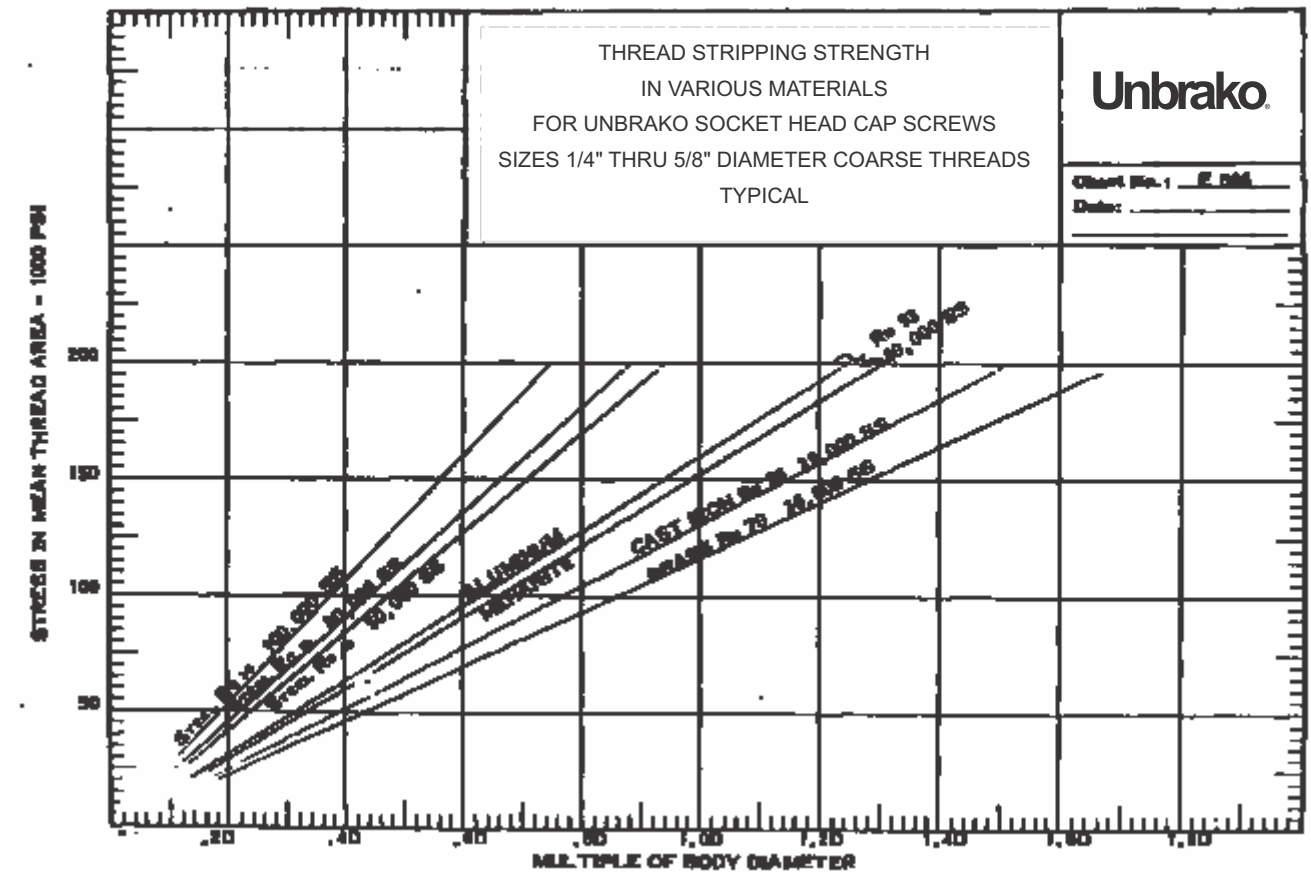
Example 1. Calculate length of thread engagement necessary to develop the minimum ultimate tensile strength (190,000 psi) of a 1/2–13 (National Coarse) Unbrako cap screw in cast iron having an ultimate shear strength of 30,000 psi. E505 is for screw sizes from #0 through #10; E506 and E507 for sizes from 1/4 in. through 5/8 in.; E508 and E509 for sizes from 3/4 in. through 1 in. Using E506 a value 1.40D is obtained. Multiplying nominal bolt diameter (0.500 in.) by 1.40 gives a minimum length of engagement of 0.700 in.

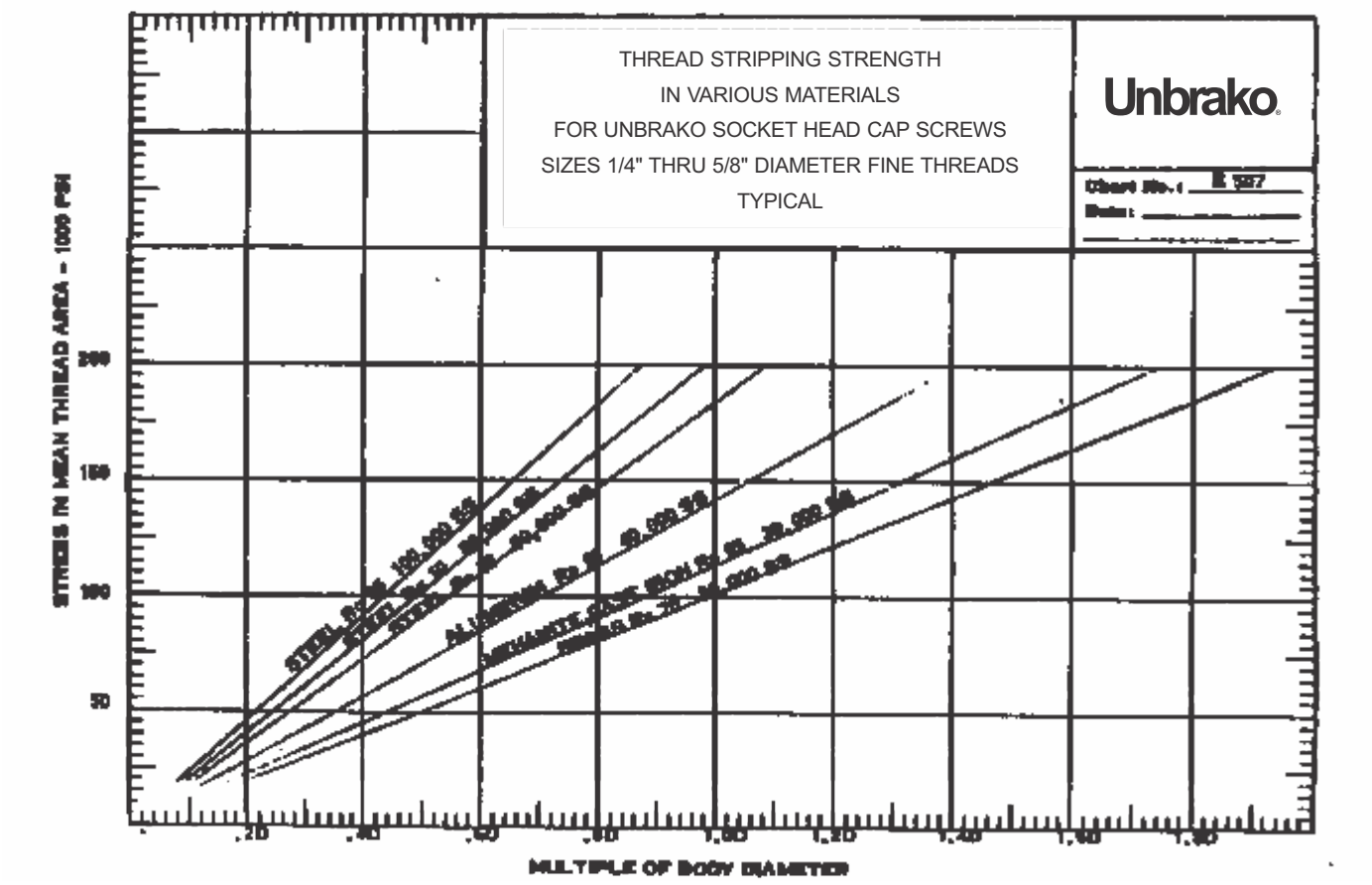
Example 2. Calculate the length of engagement for the above conditions if only 140,000 psi is to be applied. (This is the same as using a bolt with a maximum tensile strength of 140,000psi.) From E506 obtain value of 1.06D Minimum length of engagement = (0.500) (1.06) = 0.530.

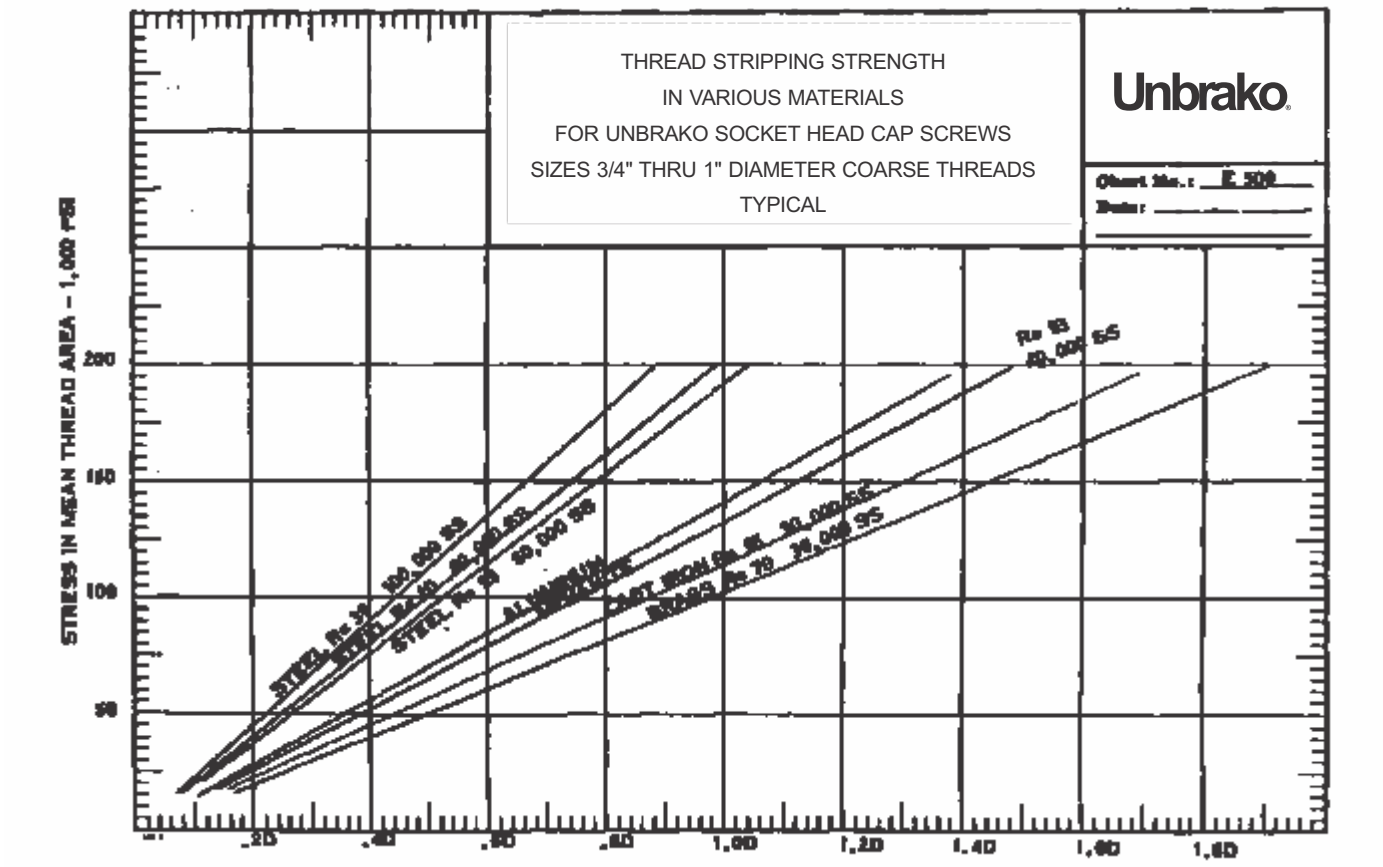
Example 3. Suppose in Example 1 that minimum length of engagement to develop full tensile strength was not available because the thickness of metal allowed a tapped hole of only 0.600 in. Hole depth in terms of bolt dia. = 0.600/0.500 = 1.20D. By working backwards in Fig. 2, maximum load that can be carried is approximately 159,000 psi.

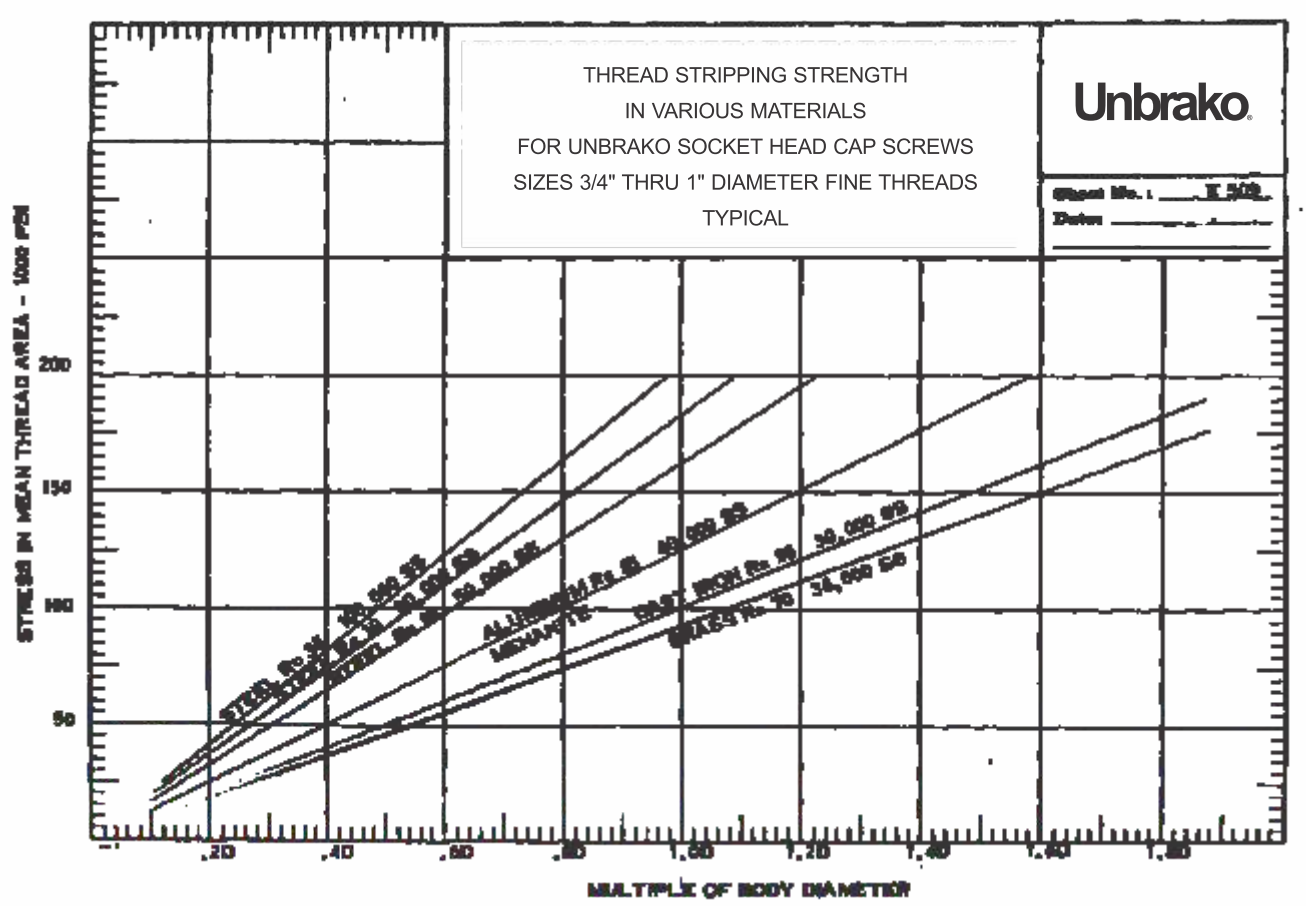
Example 4. Suppose that the hole in Example 1 is to be tapped in steel having an ultimate shear strength 65,000 psi. There is no curve for this steel in E506 but a design value can be obtained by taking a point midway between curves for the 80,000 psi and 50,000 psi steels that are listed. Under the conditions of the example, a length of engagement of 0.825D or 0.413 in. will be obtained.

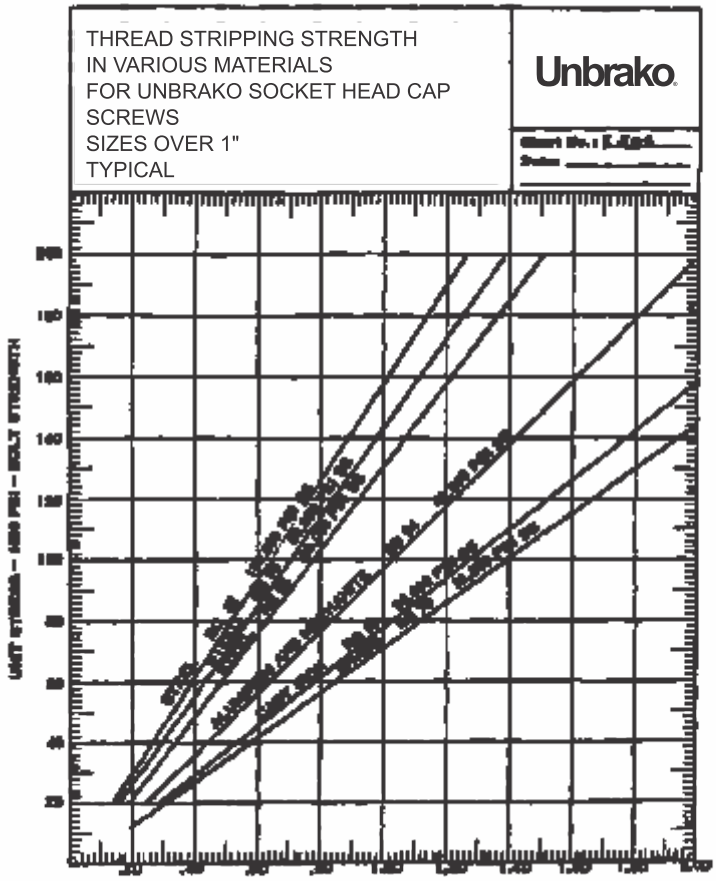

THREAD STRIPPING STRENGTH
IN VARIOUS MATERIALS
FOR UNBRAKO SOCKET HEAD CAP SCREWS
SIZES #0 THROUGH #10 COARSE AND FINE THREADS
TYPICAL
Unbrako
STRESS IN MEAN THREAD AREA - 1000 PSI
MULTIPLE OF BODY DIAMETER


THREAD STRIPPING STRENGTH
IN VARIOUS MATERIALS
FOR UNBRAKO SOCKET HEAD CAP SCREWS
SIZES 1/4" THRU 5/8" DIAMETER COARSE THREADS
TYPICAL
Unbrako
STRESS IN MEAN THREAD AREA - 1000 PSI
MULTIPLE OF BODY DIAMETER


THREAD STRIPPING STRENGTH
IN VARIOUS MATERIALS
FOR UNBRAKO SOCKET HEAD CAP SCREWS
SIZES 1/4" THRU 5/8" DIAMETER FINE THREADS
TYPICAL
Unbrako
STRESS IN MEAN THREAD AREA – 1000 PSI
MULTIPLE OF BODY DIAMETER


THREAD STRIPPING STRENGTH
IN VARIOUS MATERIALS
FOR UNBRAKO SOCKET HEAD CAP SCREWS
SIZES 3/4" THRU 1" DIAMETER COARSE THREADS
TYPICAL
Unbrako
STRESS IN MEAN THREAD AREA – 1,000 PSI


THREAD STRIPPING STRENGTH
IN VARIOUS MATERIALS
FOR UNBRAKO SOCKET HEAD CAP SCREWS
SIZES 3/4" THRU 1" DIAMETER FINE THREADS
TYPICAL
Unbrako
STRESS IN MEAN THREAD AREA – 1000 PSI
200
150
100
50
.20
.40
.60
.80
1.00
1.20
1.40
1.60
MULTIPLE OF BODY DIAMETER


THREAD STRIPPING STRENGTH
IN VARIOUS MATERIALS
FOR UNBRAKO SOCKET HEAD CAP
SCREWS
SIZES OVER 1"
TYPICAL
Unbrako

HIGH-TEMPERATURE JOINTS

Bolted joints subjected to cyclic loading perform best if an initial preload is applied. The induced stress minimizes the external load sensed by the bolt, and reduces the chance of fatigue failure. At high temperature, the induced load will change, and this can adversely affect the fastener performance. It is therefore necessary to compensate for high-temperature conditions when assembling the joint at room temperature. This article describes the factors which must be considered and illustrates how a high-temperature bolted joint is designed.

In high-temperature joints, adequate clamping force or preload must be maintained in spite of temperature-induced dimensional changes of the fastener relative to the joint members. the change in preload at any given temperature for a given time can be calculated, and the affect compensated for by proper fastener selection and initial preload.

Three principal factors tend to alter the initial clamping force in a joint at elevated temperatures, provided that the fastener material retains requisite strength at the elevated temperature. These factors are: Modulus of elasticity, coefficient of thermal expansion, and relaxation.

Modulus Of Elasticity: As temperature increases, less stress or load is needed to impart a given amount of elongation or strain to a material than at lower temperatures. This means that a fastener stretched a certain amount at room temperature to develop a given preload will exert a lower clamping force at higher temperature if there is no change in bolt elongation.

Coefficient of Expansion: With most materials, the size of the part increases as the temperature increases. In a joint, both the structure and the fastener grow with an increase in temperature, and this can result, depending on the materials, in an increase or decrease in the clamping force. Thus, matching of materials in joint design can assure sufficient clamping force at both room and elevated temperatures. Table 16 lists mean coefficient of thermal expansion of certain fastener alloys at several temperatures.

Relaxation: At elevated temperatures, a material subjected to constant stress below its yield strength will flow plastically and permanently change size. This phenomenon is called creep. In a joint at elevated temperature, a fastener with a fixed distance between the bearing surface of the head and nut will produce less and less clamping force with time. This characteristic is called relaxation. It differs from creep in that stress changes while elongation or strain remains constant. Such elements as material, temperature, initial stress, manufacturing method, and design affect the rate of relaxation.

Relaxation is the most important of the three factors. It is also the most critical consideration in design of elevated-temperature fasteners. A bolted joint at 1200°F can lose as much as 35 per cent of preload. Failure to compensate for this could lead to fatigue failure through a loose joint even though the bolt was properly tightened initially.

If the coefficient of expansion of the bolt is greater than that of the joined material, a predictable amount of clamping force will be lost as temperature increases. Conversely, if the coefficient of the joined material is greater, the bolt may be stressed beyond its yield or even fracture strength. Or, cyclic thermal stressing may lead to thermal fatigue failure.

Changes in the modulus of elasticity of metals with increasing temperature must be anticipated, calculated, and compensated for in joint design. Unlike the coefficient of expansion, the effect of change in modulus is to reduce clamping force whether or not bolt and structure are the same material, and is strictly a function of the bolt metal.

Since the temperature environment and the materials of the structure are normally “fixed,” the design objective is to select a bolt material that will give the desired clamping force at all critical points in the operating range of the joint. To do this, it is necessary to balance out the three factors-relaxation, thermal expansion, and modulus-with a fourth, the amount of initial tightening or clamping force.

In actual joint design the determination of clamping force must be considered with other design factors such as ultimate tensile, shear, and fatigue strength of the fastener at elevated temperature. As temperature increases the inherent strength of the material decreases. Therefore, it is important to select a fastener material which has sufficient strength at maximum service temperature.

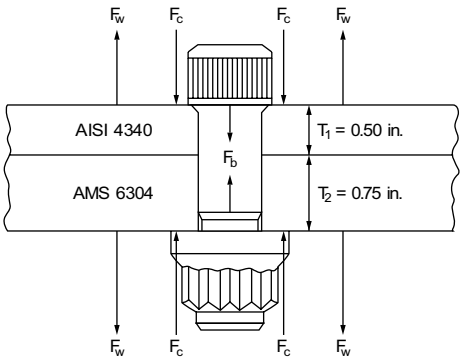
Example

The design approach to the problem of maintaining satisfactory elevated-temperature clamping force in a joint can be illustrated by an example. The example chosen is complex but typical. A cut-and-try process is used to select the right bolt material and size for a given design load under a fixed set of operating loads and environmental conditions, Fig.17.

The first step is to determine the change in thickness, Δt, of the structure from room to maximum operating temperature.

For the AISI 4340 material:
$\Delta t_1 = t_1(T_2 - T_1)\alpha$
$\Delta t_1 = (0.05)(800 - 70)\ (7.4 \times 10^{-6})$
$\Delta t_1 = 0.002701$ in.
For the AMS 6304 material:
$\Delta t_2 = (0.75)(800 - 70)(7.6 \times 10^{-6})$
$\Delta t_2 = 0.004161$ in.
The total increase in thickness for the joint members is 0.00686 in.

The total effective bolt length equals the total joint thickness plus one-third of the threads engaged by the nut. If it is assumed that the smallest diameter bolt should be used for weight saving, then a 1/4-in. bolt should be tried. Thread engagement is approximately one diameter, and the effective bolt length is:



d = Bolt diam, in.

E = Modulus of elasticity, psi

F_b = Bolt preload, lb

F_c = Clamping force, lb ($F_b = F_c$)

F_w = Working load=1500 lb static + 100 lb cyclic

L = Effective bolt length, inc.

T_1 = Room temperature= 70°F

T_2 = Maximum operatng temperature for 1000 hr = 800°F

t = Panel thickness, in.

a = Coefficient of thermal expansion

Fig. 17 — Parameters for joint operating at 800°F.

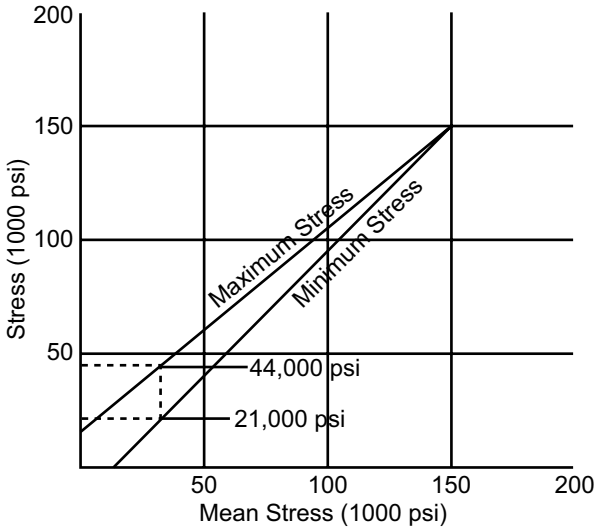


Fig. 18 – Goodman diagram of maximum and minimum operating limits for H-11 fastener at 800°F. Bolts stressed within these limits will give infinite fatigue life.

$L = t_1 + t_2 + (1/3\ d)$

$L = 0.50 + 0.75 + (1/3 \times 0.25)$

$L = 1.333$ in.

The ideal coefficient of thermal expansion of the bolt material is found by dividing the total change in joint thickness by the bolt length times the change in temperature.

$$\alpha b = \frac{\Delta t}{L \times \Delta t}$$

$$\alpha = \frac{.00686}{(1.333)(800 - 70)} = 7.05 \times 10^{-6} \text{ in./in./deg. F}$$

The material, with the nearest coefficient of expansion is with a value of 9,600,000 at 800°F.

To determine if the bolt material has sufficient strength and resistance to fatigue, it is necessary to calculate the stress in the fastener at maximum and minimum load. The bolt load plus the cyclic load divided by the tensile stress of the threads will give the maximum stress. For a 1/4-28 bolt, tensile stress area, from thread handbook H 28, is 0.03637 sq. in. The maximum stress is

$$S_{max} = \frac{\text{Bolt load}}{\text{Stress area}} = \frac{1500 + 100}{0.03637}$$

$S_{max} = 44{,}000$ psi

and the minimum bolt stress is 41,200 psi.

H-11 has a yield strength of 175,000 psi at 800°F, Table 3, and therefore should be adequate for the working loads.

A Goodman diagram, Fig. 18, shows the extremes of stress within which the H-11 fastener will not fail by fatigue. At the maximum calculated load of 44,000 psi, the fastener will withstand a minimum cyclic loading at 800°F of about 21,000 psi without fatigue failure.

Because of relaxation, it is necessary to determine the initial preload required to insure 1500-lb. clamping force in the joint after 1000 hr at 800°F.

When relaxation is considered, it is necessary to calculate the maximum stress to which the fastener is subjected. Because this stress is not constant in dynamic joints, the resultant values tend to be conservative. Therefore, a maximum stress of 44,000 psi should be considered although the necessary stress at 800°F need be only 41,200 psi. Relaxation at 44,000 psi can be interpolated from the figure, although an actual curve could be constructed from tests made on the fastener at the specific conditions.

The initial stress required to insure a clamping stress of 44,000 psi after 1000 hr at 800°F can be calculated by interpolation.

$x = 61{,}000 - 44{,}000 = 17{,}000$
$y = 61{,}000 - 34{,}000 = 27{,}000$
$B = 80{,}000 - 50{,}000 = 30{,}000$
$A = 80{,}000 - C$

$$\frac{x}{y} = \frac{A}{B} \quad \frac{17{,}000}{27{,}000} = \frac{80{,}000 - C}{30{,}000}$$

$C = 61{,}100$ psi

The bolt elongation required at this temperature is calculated by dividing the stress by the modulus at temperature and multiplying by the effective length of the bolt. That is: $(61{,}000 \times 1.333)/24.6 \times 10^6 = 0.0033$

Since the joint must be constructed at room temperature, it is necessary to determine the stresses at this state. Because the modulus of the fastener material changes with temperature, the clamping force at room temperature will not be the same as at 800°F. To determine

the clamping stress at assembly conditions, the elongation should be multiplied by the modulus of elasticity at room temperature.

$.0033 \times 30.6 \times 10^6 = 101{,}145$ psi

The assembly conditions will be affected by the difference between th ideal and actual coefficients of expansion of the joint. The ideal coeffienct for the fastener material was calculated to be 7.05 but the closest material — H-11 — has a coefficient of 7.1. Since this material has a greater expansion than calculated, there will be a reduction in clamping force resulting from the increase in temperature. This amount equals the difference between the ideal and the actual coefficients multiplied by the change in temperature, the length of the fastener, and the modulus of elasticity at 70°F.

$[(7.1 - 7.05) \times 10^{-6}] [800 - 70] [1.333] \times [30.6 \times 10^6] = 1{,}490$ psi

The result must be added to the initial calculated stresses to establish the minimum required clamping stress needed for assembling the joint at room temperature.

101,145 + 1,490 = 102,635 psi

Finally, the method of determining the clamping force or preload will affect the final stress in the joint at operating conditions. For example, if a torque wrench is used to apply preload (the most common and simplest method available), a plus or minus 25 per cent variation in induced load can result. Therefore, the maximum load which could be expected in this case would be 1.5 times the minimum, or:

(1.5)(102,635) = 153,950 psi

This value does not exceed the room-temperature yield strength for H-11 given in Table 19.

Since there is a decrease in the clamping force with an increase in temperature and since the stress at operating temperature can be higher than originally calculated because of variations in induced load, it is necessary to ascertain if yield strength at 800°F will be exceeded

$$\frac{(\text{max stress at } 70°F + \text{change in stress}) \times E \text{ at } 800°F}{E \text{ at } 70°F}$$

$$\frac{[153{,}950 + (-1490)] \times 24.6 \times 10^6}{30.6 \times 10^6} = 122{,}565$$

This value is less than the yield strength for H-11 at 800°F, Table 19. Therefore, a 1/4-28 H-11 bolt stressed between 102,635 psi and 153,950 psi at room temperature will maintain a clamping load 1500 lb at 800°F after 1000 hr of operation. A cyclic loading of 100 lb, which results in a bolt loading between 1500 and 1600 lb will not cause fatigue failure at the operating conditions.

Table 16

PHYSICAL PROPERTIES OF MATERIALS USED TO MANUFACTURE ALLOY STEEL SHCS'S

Coefficient of Thermal Expansion, µm/m/°K[1]

20°C to 68°F to	100 212	200 392	300 572	400 752	500 932	600 1112
Material						
5137M, 51B37M[2]	–	12.6	13.4	13.9	14.3	14.6
4137[3]	11.2	11.8	12.4	13.0	13.6	–
4140[3]	12.3	12.7	–	13.7	–	14.5
4340[3]	–	12.4	–	13.6	–	14.5
8735[3]	11.7	12.2	12.8	13.5	–	14.1
8740[3]	11.6	12.2	12.8	13.5	–	14.1

Modulus of Elongation (Young's Modulus)
E = 30,000,000 PSI/in/in

Table 19 - Yield Strength at Various Temperatures

Alloy	Temperature (F) 70	800	1000	1200
Stainless Steels				
Type 302	35,000	35,000	34,000	30,000
Type 403	145,000	110,000	95,000	38,000
PH 15-7 Mo	220,000	149,000	101,000	–
High Strength Iron-Base Stainless Alloys				
A 286	95,000	95,000	90,000	85,000
AMS 5616	113,000	80,000	60,000	40,000
Unitemp 212	150,000	140,000	135,000	130,000
High Strength Iron-Base Alloys				
AISI 4340	200,000	130,000	75,000	–
H-11 (AMS 6485)	215,000	175,000	155,000	–
AMS 6340	160,000	100,000	75,000	–
Nickel-Base Alloys				
Iconel X	115,000	–	-	98,000
Waspaloy	115,000	–	106,000	100,000

NOTES:
1. Developed from ASM, Metals HDBK, 9th Edition, Vol. 1 (°C = °K for values listed)
2. ASME SA574
3. AISI
4. Multiply values in table by .556 for µin/in/°F.

All fastened joints are, to some extent, subjected to corrosion of some form during normal service life. Design of a joint to prevent premature failure due to corrosion must include considerations of the environment, conditions of loading , and the various methods of protecting the fastener and joint from corrosion.

Three ways to protect against corrosion are:
1. Select corrosion-resistant material for the fastener.
2. Specify protective coatings for fastener, joint interfaces, or both.
3. Design the joint to minimize corrosion.

The solution to a specific corrosion problem may require using one or all of these methods. Economics often necessitate a compromise solution.

Fastener Material

The use of a suitably corrosion-resistant material is often the first line of defense against corrosion. In fastener design, however, material choice may be only one of several important considerations. For example, the most corrosion-resistant material for a particular environment may just not make a suitable fastener.

Basic factors affecting the choice of corrosion resistant threaded fasteners are:

- Tensile and fatigue strength.
- Position on the galvanic series scale of the fastener and materials to be joined.
- Special design considerations: Need for minimum weight or the tendency for some materials to gall.
- Susceptibility of the fastener material to other types of less obvious corrosion. For example, a selected material may minimize direct attack of a corrosive environment only to be vulnerable to fretting or stress corrosion.

Some of the more widely used corrosion-resistant materials, along with approximate fastener tensile strength ratings at room temperature and other pertinent properties, are listed in Table 1. Sometimes the nature of corrosion properties provided by these fastener materials is subject to change with application and other conditions.For example, stainless steel and aluminum resist corrosion only so long as their protective oxide film remains unbroken. Alloy steel is almost never used, even under mildly corrosive conditions, without some sort of protective coating. Of course, the presence of a specific corrosive medium requires a specific corrosion-resistant fastener material, provided that design factors such as tensile and fatigue strength can be satisfied.

Protective Coating

A number of factors influence the choice of a corrosion-resistant coating for a threaded fastener. Frequently, the corrosion resistance of the coating is not a principal consideration. At times it is a case of economics. Often, less-costly fastener material will perform satisfactorily in a corrosive environment if given the proper protective coating.

Factors which affect coating choice are:

- Corrosion resistance
- Temperature limitations
- Embrittlement of base metal
- Effect on fatigue life
- Effect on locking torque
- Compatibility with adjacent material
- Dimensional changes
- Thickness and distribution
- Adhesion characteristics

Conversion Coatings: Where cost is a factor and corrosion is not severe, certain conversion-type coatings are effective. These include a black-oxide finish for alloy-steel screws and various phosphate base coatings for carbon and alloy-steel fasteners. Frequently, a rust-preventing oil is applied over a conversion coating.

Paint: Because of its thickness, paint is normally not considered for protective coatings for mating threaded fasteners. However, it is sometimes applied as a supplemental treatment at installation. In special cases, a fastener may be painted and installed wet, or the entire joint may be sealed with a coat of paint after installation.

TABLE 1 — TYPICAL PROPERTIES OF CORROSION RESISTANT FASTENER MATERIALS

Materials Stainless Steel	Tensile Strength (1000 psi)	Yield Strength at 0.2% offset (1000 psi)	Maximum Service Temp (F)	Mean Coefficient of Thermal Expan. (in./in./deg F)	Density (lbs/cu in.)	Base Cost Index	Position on Galvanic Scale
303, passive	80	40	800	10.2	0.286	Medium	8
303, passive, cold worked	125	80	800	10.3	0.286	Medium	9
410, passive	170	110	400	5.6	0.278	Low	15
431, passive	180	140	400	6.7	0.280	Medium	16
17-4 PH	200	180	600	6.3	0.282	Medium	11
17-7 PH	200	185	600	6.7	0.276	Medium	14
AM 350	200	162	800	7.2	0.282	Medium	13
15-7 Mo	200	155	600	–	0.277	Medium	12
A-286	150	85	1200	9.72	0.286	Medium	6
A-286, cold worked	220	170	1200	–	0.286	High	7

Electroplating: Two broad classes of protective electroplating are: 1. The barrier type-such as chrome plating-which sets up an impervious layer or film that is more noble and therefore more corrosion resistant than the base metal. 2. The sacrificial type, zinc for example, where the metal of the coating is less noble than the base metal of the fastener. This kind of plating corrodes sacrificially and protects the fastener.

Noble-metal coatings are generally not suitable for threaded fasteners-especially where a close-tolerance fit is involved. To be effective, a noble-metal coating must be at least 0.001 in. thick. Because of screw-thread geometry, however, such plating thickness will usually exceed the tolerance allowances on many classes of fit for screws.

Because of dimensional necessity, threaded fastener coatings, since they operate on a different principle, are effective in layers as thin as 0.0001 to 0.0002 in.

The most widely used sacrificial platings for threaded fasteners are cadmium, zinc, and tin. Frequently, the cadmium and zinc are rendered even more corrosion resistant by a posting-plating chromate-type conversion treatment. Cadmium plating can be used at temperatures to 450°F. Above this limit, a nickel cadmium or nickel-zinc alloy plating is recommended. This consists of alternate deposits of the two metals which are heat-diffused into a uniform alloy coating that can be used for applications to 900°F. The alloy may also be deposited directly from the plating bath.

Fastener materials for use in the 900 to 1200°F range (stainless steel, A-286), and in the 1200° to 1800°F range (high-nickel-base super alloys) are highly corrosion resistant and normally do not require protective coatings, except under special environment conditions.

Silver plating is frequently used in the higher temperature ranges for lubrication to prevent galling and seizing, particularly on stainless steel. This plating can cause a galvanic corrosion problem, however, because of the high nobility of the silver.

Hydrogen Embrittlement: A serious problem, known as hydrogen embrittlement, can develop in plated alloy steel fasteners. Hydrogen generated during plating can diffuse into the steel and embrittle the bolt. The result is often a delayed and total mechanical failure, at tensile levels far below the theoretical strength, high-hardness structural parts are particularly susceptible to this condition. The problem can be controlled by careful selection of plating formulation, proper plating procedure, and sufficient baking to drive off any residual hydrogen.

Another form of hydrogen embrittlement, which is more difficult to control, may occur after installation. Since electrolytic cell action liberates hydrogen at the cathode, it is possible for either galvanic or concentration-cell corrosion to lead to embrittling of the bolt material.

Joint Design

Certain precautions and design procedures can be followed to prevent, or at least minimize, each of the various types of corrosion likely to attack a threaded joint. The most important of these are:

For Direct Attack: Choose the right corrosion resistant material. Usually a material can be found that will provide the needed corrosion resistance without sacrifice of other important design requirements. Be sure that the fastener material is compatible with the materials being joined.

Corrosion resistance can be increased by using a conversion coating such as black oxide or a phosphate-base treatment. Alternatively, a sacrificial coating such as zinc plating is effective

For an inexpensive protective coating, lacquer or paint can be used where conditions permit.

For Galvanic Corrosion: If the condition is severe, electrically insulate the bolt and joint from each other..

The fastener may be painted with zinc chromate primer prior to installation, or the entire joint can be coated with lacquer or paint.

Another protective measure is to use a bolt that is cathodic to the joint material and close to it in the galvanic series. When the joint material is anodic, corrosion will spread over the greater area of the fastened materials. Conversely, if the bolt is anodic, galvanic action is most severe.

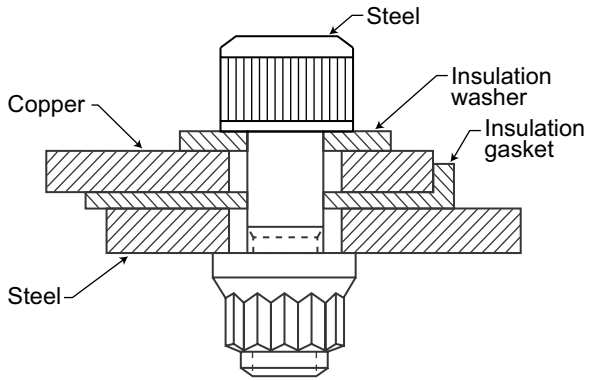


FIG. 1.1— A method of electrically insulating a bolted joint to prevent galvanic corrosion.

For Concentration-Cell Corrosion: Keep surfaces smooth and minimize or eliminate lap joints, crevices, and seams. Surfaces should be clean and free of organic material and dirt. Air trapped under a speck of dirt on the surface of the metal may form an oxygen concentration cell and start pitting.

For maximum protection, bolts and nuts should have smooth surfaces, especially in the seating areas. Flush-head bolts should be used where possible. Further, joints can be sealed with paint or other sealant material.

For Fretting Corrosion: Apply a lubricant (usually oil) to mating surfaces. Where fretting corrosion is likely to occur: 1. Specify materials of maximum practicable hardness. 2. Use fasteners that have residual compressive stresses on the surfaces that may be under attack. 3. Specify maximum preload in the joint. A higher clamping force results in a more rigid joint with less relative movement possible between mating services.

For Stress Corrosion: Choose a fastener material that resists stress corrosion in the service environment. Reduce fastener hardness (if reduced strength can be tolerated), since this seems to be a factor in stress corrosion.

Minimize crevices and stress risers in the bolted joint and compensate for thermal stresses. Residual stresses resulting from sudden changes in temperature accelerate stress corrosion.

If possible, induce residual compressive stresses into the surface of the fastener by shot-peening or pressure rolling.

For Corrosion Fatigue: In general, design the joint for high fatigue life, since the principal effect of this form of corrosion is reduced fatigue performance. Factors extending fatigue performance are: 1. Application and maintenance of a high preload. 2. Proper alignment to avoid bending stresses.

If the environment is severe, periodic inspection is recommended so that partial failures may be detected before the structure is endangered.

As with stress and fretting corrosion, compressive stresses induced on the fastener surfaces by thread rolling, fillet rolling, or shot peening will reduce corrosion fatigue. Further protection is provided by surface coating.

TYPES OF CORROSION

Direct Attack…most common form of corrosion affecting all metals and structural forms. It is a direct and general chemical reaction of the metal with a corrosive medium-liquid, gas, or even a solid.

Galvanic Corrosion…occurs with dissimilar metals contact. Presence of an electrolyte, which may be nothing more than an individual atmosphere, causes corrosive action in the galvanic couple. The anodic, or less noble material, is the sacrificial element. Hence, in a joint of stainless steel and titanium, the stainless steel corrodes. One of the worst galvanic joints would consist of magnesium and titanium in contact.

Concentration Cell Corrosion…takes place with metals in close proximity and, unlike galvanic corrosion, does not require dissimilar metals. When two or more areas on the surface of a metal are exposed to different concentrations of the same solution, a difference in electrical potential results, and corrosion takes place.

If the solution consists of salts of the metal itself, a metal-ion cell is formed, and corrosion takes place on the surfaces in close contact. The corrosive solution between the two surfaces is relatively more stagnant (and thus has a higher concentration of metal ions in solution) than the corrosive solution immediately outside the crevice.

A variation of the concentration cell is the oxygen cell in which a corrosive medium, such as moist air, contains different amounts of dissolved oxygen at different points. Accelerated corrosion takes place between hidden surfaces (either under the bolt head or nut, or between bolted materials) and is likely to advance without detection.

Fretting…corrosive attack or deterioration occurring between containing, highly-loaded metal surfaces subjected to very slight (vibratory) motion. Although the mechanism is not completely understood, it is probably a highly accelerated form of oxidation under heat and stress. In threaded joints, fretting can occur between mating threads, at the bearing surfaces under the head of the screw, or under the nut. It is most likely to occur in high tensile, high-frequency, dynamic-load applications. There need be no special environment to induce this form of corrosion...merely the presence of air plus vibratory rubbing. It can even occur when only one of the materials in contact is metal.

Stress Corrosion Cracking…occurs over a period of time in high-stressed, high-strength joints. Although not fully understood, stress corrosion cracking is believed to be caused by the combined and mutually accelerating effects of static tensile stress and corrosive environment. Initial pitting somehow tales place which, in turn, further increases stress build-up. The effect is cumulative and, in a highly stressed joint, can result in sudden failure.

Corrosion Fatigue…accelerated fatigue failure occurring in the presence of a corrosive medium. It differs from stress corrosion cracking in that dynamic alternating stress, rather than static tensile stress, is the contributing agent.

Corrosion fatigue affects the normal endurance limit of the bolt. The conventional fatigue curve of a normal bolt joint levels off at its endurance limit, or maximum dynamic load that can be sustained indefinitely without fatigue failure. Under conditions of corrosion fatigue, however, the curve does not level off but continues downward to a point of failure at a finite number of stress cycles.

GALVANIC CORROSION

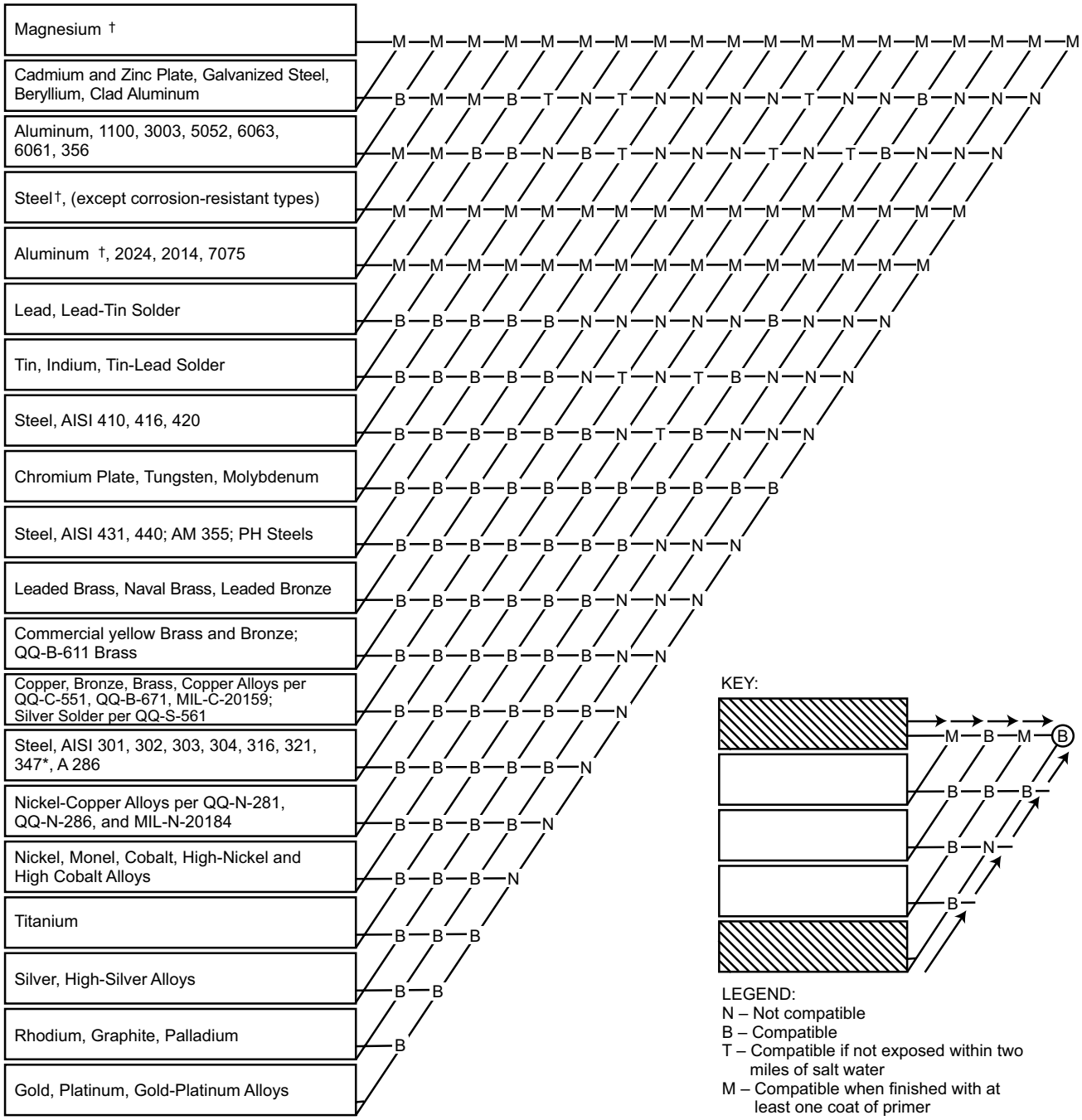


FIG. 19— Metals compatibility chart

THE IMPACT PERFORMANCE OF THREADED FASTENERS

Much has been written regarding the significance of the notched bar impact testing of steels and other metallic materials. The Charpy and Izod type test relate notch behavior (brittleness versus ductility) by applying a single overload of stress. The results of these tests provide quantitive comparisons but are not convertible to energy values useful for engineering design calculations. The results of an individual test are related to that particular specimen size, notch geometry and testing conditions and cannot be generalized to other sizes of specimens and conditions.

The results of these tests are useful in determining the susceptibility of a material to brittle behavior when the applied stress is perpendicular to the major stress.

In externally threaded fasteners, however, the loading usually is applied in a longitudinal direction. The impact test, therefore, which should be applicable would be one where the applied impact stress supplements the major stress. Only in shear loading on fasteners is the major stress in the transverse direction.

Considerable testing has been conducted in an effort to determine if a relationship exists between the Charpy V notch properties of a material and the tension properties of an externally threaded fastener manufactured from the same material.

Some conclusions which can be drawn from the extensive impact testing are as follows:

1. The tension impact properties of externally threaded fasteners do not follow the Charpy V notch impact pattern.

2. Some of the variables which effect the tension impact properties are:
   A. The number of exposed threads
   B. The length of the fastener
   C. The relationship of the fastener shank diameter to the thread area.
   D. The hardness or fastener ultimate tensile strength

Following are charts showing tension impact versus Charpy impact properties, the effect of strength and diameter on tension impact properties and the effect of test temperature.

Please note from figure 21 that while the Charpy impact strength of socket head cap screw materials are decreasing at sub-zero temperatures, the tension impact strength of the same screws is increasing. This compares favorable with the effect of cryogenic temperatures on the tensile strength of the screws. Note the similar increase in tensile strength shown in figure 22.

It is recommended, therefore, that less importance be attached to Charpy impact properties of materials which are intended to be given to impact properties for threaded fasteners. If any consideration is to be given to impact properties of bolts or screws, it is advisable to investigate the tension impact properties of full size fasteners since this more closely approximates the actual application.

TABLE 20
LOW-TEMPERATURE IMPACT PROPERTIES OF SELECTED ALLOY STEELS

AISI no.	Composition, %					Heat Temperature*		Hardness Rc	Impact Energy, Ft.-lb					Transition Temp. (50% Brittle) °f
	C	Mn	Ni	Cr	Mo	Quenching Temp. F+	Tempering Temp. F		–300°F	–200°F	–100°F	O°F	100°F	
4340	0.38	0.77	1.65	0.93	0.21	1550	400	52	11	15	20	21	21	–
							600	48	10	14	15	15	16	–
							800	44	9	13	16	21	25	–
							1000	38	15	18	28	36	36	–130
							1200	30	15	28	55	55	55	–185
4360	0.57	0.87	1.62	1.08	0.22	1475	800	48	5	6	10	11	14	–
							1000	40	9	10	13	18	23	–10
							1200	30	12	15	25	42	43	–110
4380	0.76	0.91	1.67	1.11	0.21	1450	800	49	4	5	8	9	10	–
							1000	42	8	8	10	12	15	60
							1200	31	5	11	19	33	38	–50
4620	0.20	0.67	1.85	0.30	0.18	1650	300	42	14	20	28	35	35	–
							800	34	11	16	33	55	55	–
							1000	29	16	34	55	78	78	–
							1200	19	17	48	103	115	117	–
4640	0.43	0.69	1.78	0.29	0.20	1550	800	42	16	17	20	25	27	–
							1000	37	17	22	35	39	69	–190
							1200	29	17	30	55	97	67	–180
4680	0.74	0.77	1.81	0.30	0.21	1450	800	46	5	8	13	15	16	–
							1000	41	11	12	15	19	22	–
							1200	31	11	13	17	39	43	–
8620	0.20	0.89	0.60	0.68	0.20	1650	300	43	11	16	23	35	35	–
							800	36	8	13	20	35	45	–20
							1000	29	25	33	65	76	76	–150
							1200	21	10	85	107	115	117	–195
8630	0.34	0.77	0.66	0.62	0.22	1575	800	41	7	12	17	25	31	0
							1000	34	11	20	43	53	54	–155
							1200	27	18	28	74	80	82	–165
8640	0.45	0.78	0.65	0.61	0.20	1550	800	46	5	10	14	20	23	–
							1000	38	11	15	24	40	40	–110
							1200	30	18	22	49	63	66	–140
8660	0.56	0.81	0.70	0.56	0.25	1475	800	47	4	6	10	13	16	–
							1000	41	10	12	15	20	30	–10
							1200	30	16	18	25	54	60	–90

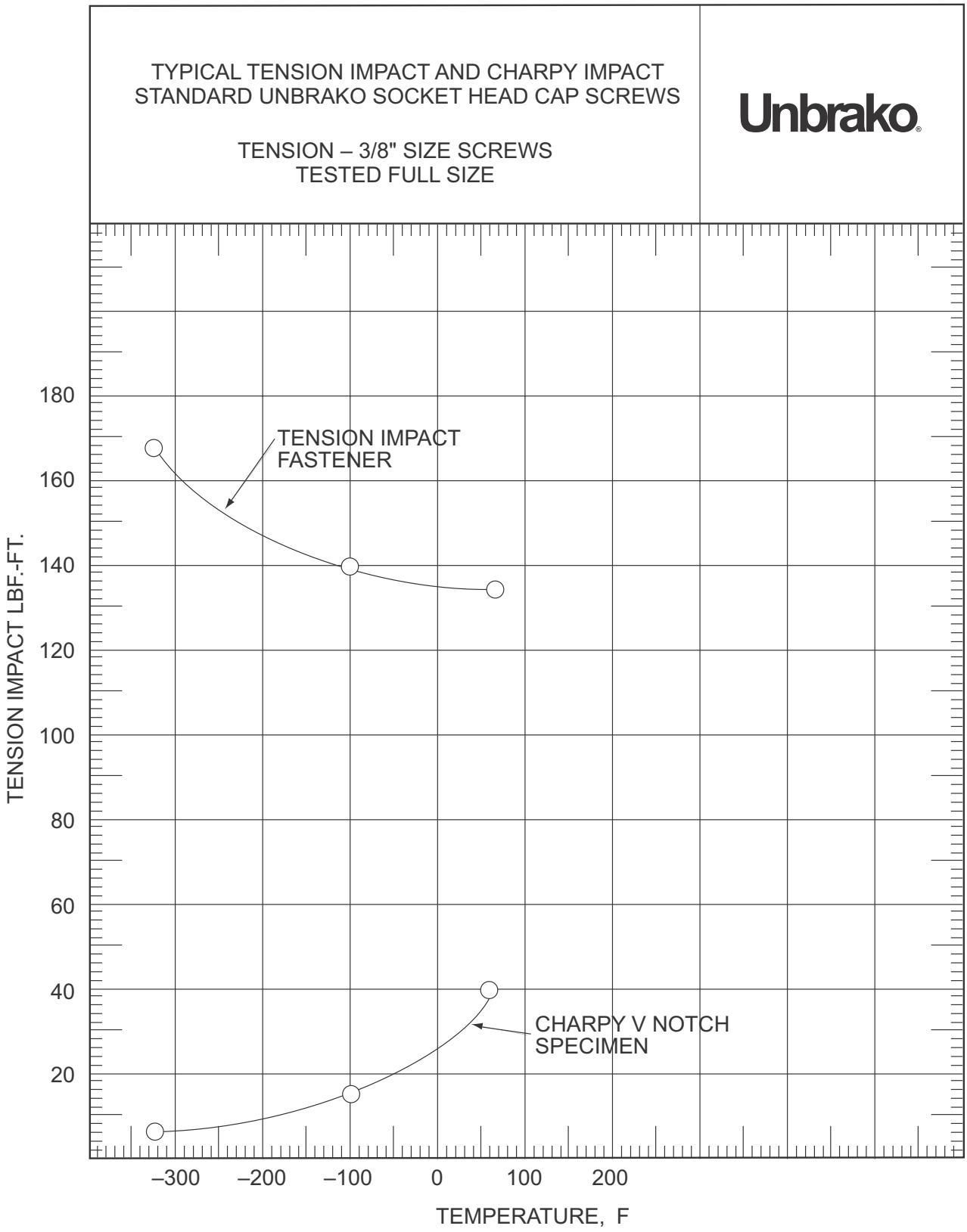

TYPICAL TENSION IMPACT AND CHARPY IMPACT
STANDARD UNBRAKO SOCKET HEAD CAP SCREWS
TENSION – 3/8" SIZE SCREWS
TESTED FULL SIZE
Unbrako
TENSION IMPACT LBF.-FT.
180
160
140
120
100
80
60
40
20
TENSION IMPACT
FASTENER
CHARPY V NOTCH
SPECIMEN
–300
–200
–100
0
100
200
TEMPERATURE, F

FIG. 21

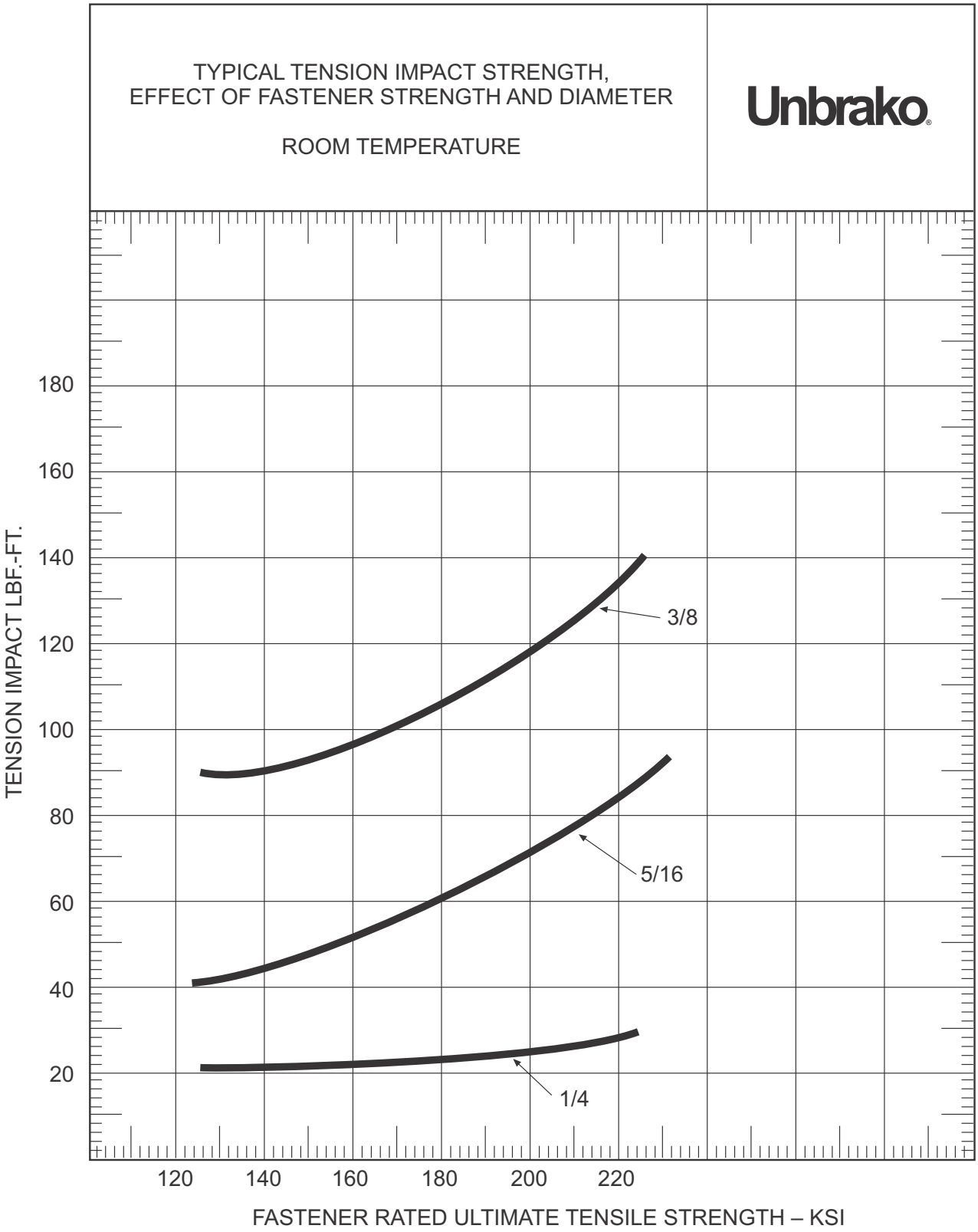

TYPICAL TENSION IMPACT STRENGTH,
EFFECT OF FASTENER STRENGTH AND DIAMETER
ROOM TEMPERATURE
Unbrako
TENSION IMPACT LBF.-FT.
180
160
140
120
100
80
60
40
20
3/8
5/16
1/4
120
140
160
180
200
220
FASTENER RATED ULTIMATE TENSILE STRENGTH – KSI

FIG. 22

Standard Inch Socket Head Cap Screws Are Not Grade 8 Fasteners

There is a common, yet reasonable, misconception that standard, inch, alloy steel socket head cap screws are “Grade 8”. This is not true. The misconception is reasonable because “Grade 8” is a term generally associated with “high strength” fasteners. A person desiring a “high strength” SHCS may request a “Grade 8 SHCS”. This is technically incorrect for standard SHCSs. The term Grade 8 defines specific fastener characteristics which must be met to be called “Grade 8”. Three of the most important characteristics are not consistent with requirements for industry standard SHCSs: tensile strength, hardness, and head marking. Some basic differences between several fastener classifications are listed below. The list is not comprehensive but intended to provide a general understanding. SHCSs can be manufactured to meet Grade 8 requirements on a special order basis.

Fastener Designation	Grade2	Grade5	Grade8	Industry SHCS	Unbrako SHCS
Strength Level, UTS KSI, min.	74 (1/4-3/4) 60 (7/8-1 1/2)	120 (1/4 - 1) 105 (1 1/8 - 1 1/2)	150 (1/4 - 1 1/2)	180 (≤ 1/2) 170 (> 1/2)	190 (≤ 1/2) 180 (> 1/2)
Hardness, Rockwell	B80-B100 B70-B100	C25-C34 C19-C30	C33-C39	C39-C45 C37-C45	C39-C43 C38-C43
General Material Type	Low or Medium Carbon Steel	Medium Carbon Steel	Medium Carbon Alloy Steel	Medium Carbon Alloy Steel	Medium Carbon Alloy Steel
Identification Requirement	None	Three Radial Lines	Six Radial Lines	SHCS Configuration	Mfr’s ID
Typical Fasteners	Bolts Screws Studs Hex Heads	Bolts Screws Studs Hex Heads	Bolts Screws Studs Hex Heads	Socket Head Cap Screw	Socket Head Cap Screw

THREADS IN BOTH SYSTEMS

Thread forms and designations have been the subject of many long and arduous battles through the years. Standardization in the inch series has come through many channels, but the present unified thread form could be considered to be the standard for many threaded products, particularly high strength ones such as socket head cap screws, etc. In common usage in U.S.A., Canada and United Kingdom are the Unified National Radius Coarse series, designated UNRC, Unified National Radius Fine series, designated UNRF, and several special series of various types, designated UNS.

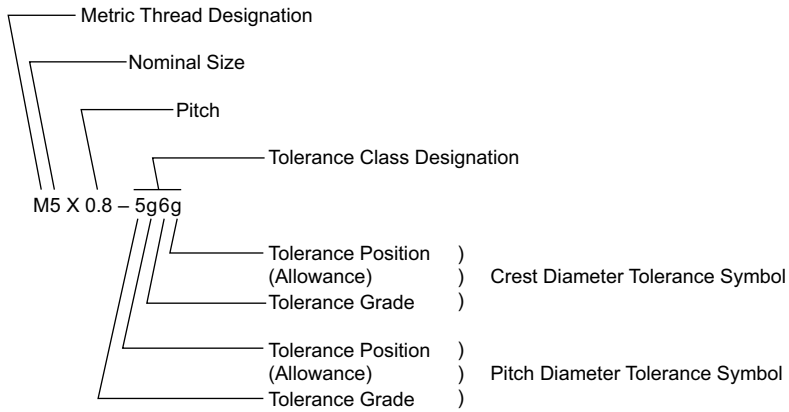
This thread, UNRC or UNRF, is designated by specifying the diameter and threads per inch along with the suffix indicating the thread series, such as 1/4 - 28 UNRF. For threads in Metric units, a similar approach is used, but with some slight variations. A diameter and pitch are used to designate the series, as in the Inch system, with modifications as follows: For coarse threads, only the prefix M and the diameter are necessary, but for fine threads, the pitch is shown as a suffix. For example, M16 is a coarse thread designation representing a diameter of 16 mm with a pitch of 2 mm understood. A similar fine thread part would be M16 x 1.5 or 16 mm diameter with a pitch of 1.5 mm.

For someone who has been using the Inch system, there are a couple of differences that can be a little confusing. In the Inch series, while we refer to threads per inch as pitch; actually the number of threads is 1/pitch. Fine threads are referenced by a larger number than coarse threads because they “fit” more threads per inch.

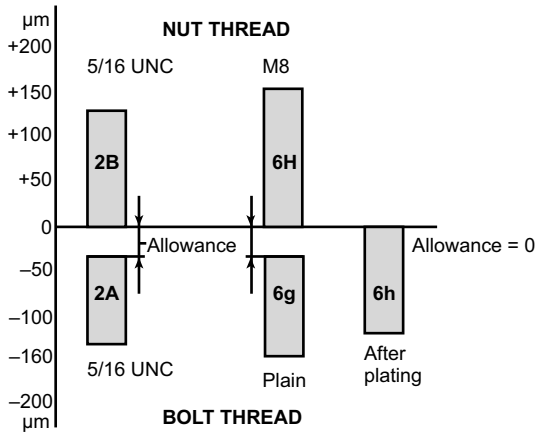
In Metric series, the diameters are in millimeters, but the pitch is really the pitch. Consequently the coarse thread has the large number. The most common metric thread is the coarse thread and falls generally between the inch coarse and fine series for a comparable diameter.

Also to be considered in defining threads is the tolerance and class of fit to which they are made. The International Standards Organization (ISO) metric system provides for this designation by adding letters and numbers in a certain sequence to the callout. For instance, a thread designated as M5 x 0.8 5g6g would define a thread of 5 mm diameter, 0.8 mm pitch, with a pitch diameter tolerance grade 6 and allowance “g”. These tolerances and fields are defined as shown below, similar to the Federal Standard H28 handbook, which defines all of the dimensions and tolerances for a thread in the inch series. The callout above is similar to a designation class 3A fit, and has a like connotation.

COMPLETE DESIGNATIONS



Example of thread tolerance positions and magnitudes.
Comparision 5/16 UNC and M8. Medium tolerance grades — Pitch diameter.



DEVIATIONS

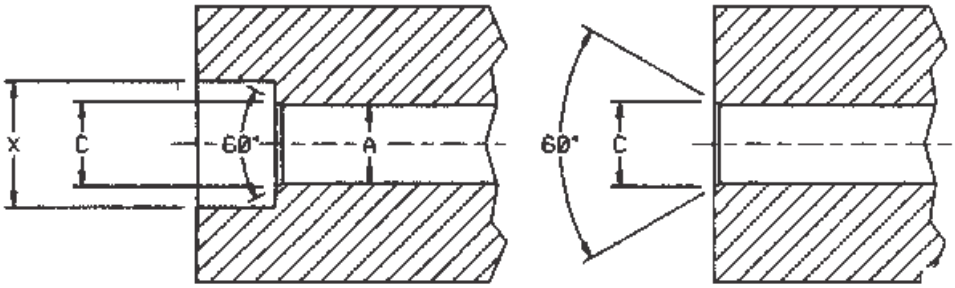
external	internal	basic clearance
h g e	H G	none small large

NOTES:
Lower case letters = external threads
Capital letters = internal threads

Close Fit: Normally limited to holes for those lengths of screws threaded to the head in assemblies in which: (1) only one screw is used; or (2) two or more screws are used and the mating holes are produced at assembly or by matched and coordinated tooling.

Normal Fit: Intended for: (1) screws of relatively long length; or (2) assemblies that involve two or more screws and where the mating holes are produced by conventional tolerancing methods. It provides for the maximum allowable eccentricity of the longest standard screws and for certain deviations in the parts being fastened, such as deviations in hole straightness; angularity between the axis of the tapped hole and that of the hole for the shank; differences in center distances of the mating holes and other deviations.

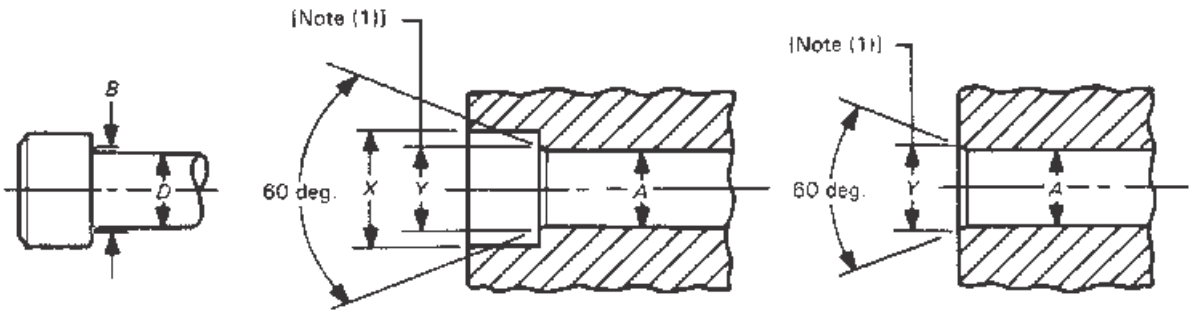
Chamfering: It is considered good practice to chamfer or break the edges of holes that are smaller than "F" maximum in parts in which hardness approaches, equals or exceeds the screw hardness. If holes are not chamfered, the heads may not seat properly or the sharp edges may deform the fillets on the screws, making them susceptible to fatigue in applications that involve dynamic loading. The chamfers, however, should not be larger than needed to ensure that the heads seat properly or that the fillet on the screw is not deformed. Normally, the chamfers do not need to exceed "F" maximum. Chamfers exceeding these values reduce the effective bearing area and introduce the possibility of indentation when the parts fastened are softer than screws, or the possibility of brinnelling of the heads of the screws when the parts are harder than the screws.



nominal size	basic screw diameter	A				X	C	hole dimensions			
		drill size for hole A				counter-bore diameter	countersink diameter D Max.+2F(Max.)	tap drill size		**body drill size	counter-bore size
		close fit		normal fit							
		nom.	dec.	nom.	dec.			UNRC	UNRF		
0	0.0600	51*	0.0670	49*	0.0730	1/8	0.074	–	3/64	#51	1/8
1	0.0730	46*	0.0810	43*	0.0890	5/32	0.087	1.5mm	#53	#46	5/32
2	0.0860	3/32	0.0937	36*	0.1065	3/16	0.102	#50	#50	3/32	3/16
3	0.0990	36*	0.1065	31*	0.1200	7/32	0.115	#47	#45	#36	7/32
4	0.1120	1/8	0.1250	29*	0.1360	7/32	0.130	#43	#42	1/8	7/32
5	0.1250	9/64	0.1406	23*	0.1540	1/4	0.145	#38	#38	9/64	1/4
6	0.1380	23*	0.1540	18*	0.1695	9/32	0.158	#36	#33	#23	9/32
8	0.1640	15*	0.1800	10	0.1935	5/16	0.188	#29	#29	#15	5/16
10	0.1900	5*	0.2055	2*	0.2210	3/8	0.218	#25	#21	#5	3/8
1/4	0.2500	17/64	0.2656	9/32	0.2812	7/16	0.278	#7	#3	17/64	7/16
5/16	0.3125	21/64	0.3281	11/32	0.3437	17/32	0.346	F	I	21/64	17/32
3/8	0.0375	25/64	0.3906	13/32	0.4062	5/8	0.415	5/16	Q	25/64	5/8
7/16	0.4375	29/64	0.4531	15/32	0.4687	23/32	0.483	U	25/64	29/64	23/32
1/2	0.5000	33/64	0.5156	17/32	0.5312	13/16	0.552	27/64	29/64	33/64	13/16
5/8	0.6250	41/64	0.6406	21/32	0.6562	1	0.689	35/64	14.5mm	41/64	1
3/4	0.7500	49/64	0.7656	25/32	0.7812	1-3/16	0.828	21/32	11/16	49/64	1-3/16
7/8	0.8750	57/64	0.8906	29/32	0.9062	1-3/8	0.963	49/64	20.5mm	57/64	1-3/8
1	1.0000	1-1/64	1.0156	1-1/32	1.0312	1-5/8	1.100	7/8	59/64	1-1/64	1-5/8
1-1/4	1.2500	1-9/32	1.2812	1-5/32	1.3125	2	1.370	1-7/64	1-11/64	1-9/32	2
1-1/2	1.5000	1-17/32	1.5312	1-9/16	1.5625	2-3/8	1.640	34mm	36mm	1-17/32	2-3/8

** Break edge of body drill hole to clear screw fillet.

DRILL AND COUNTERBORE SIZES FOR METRIC SOCKET HEAD CAP SCREWS



Nominal Size or Basic Screw Diameter	A		X	Y
	Nominal Drill Size		Counterbore Diameter	Countersink Diameter [Note (1)]
	Close Fit [Note (2)]	Normal Fit [Note (3)]		
M1.6	1.80	1.95	3.50	2.0
M2	2.20	2.40	4.40	2.6
M2.5	2.70	3.00	5.40	3.1
M3	3.40	3.70	6.50	3.6
M4	4.40	4.80	8.25	4.7
M5	5.40	5.80	9.75	5.7
M6	6.40	6.80	11.25	6.8
M8	8.40	8.80	14.25	9.2
M10	10.50	10.80	17.25	11.2
M12	12.50	12.80	19.25	14.2
M14	14.50	14.75	22.25	16.2
M16	16.50	16.75	25.50	18.2
M20	20.50	20.75	31.50	22.4
M24	24.50	24.75	37.50	26.4
M30	30.75	31.75	47.50	33.4
M36	37.00	37.50	56.50	39.4
M42	43.00	44.00	66.00	45.6
M48	49.00	50.00	75.00	52.6

ASTM Hardness Conversion Tables

ASTM Spec. E140 Based on Rockwell C (Non-austenitic steels)

Rockwell C 150 Kg Diamond	Rockwell A 60 Kg Diamond	Rockwell D 100 Kg Diamond Cone	Superficial Rockwell 15 Kg N Diamond	Superficial Rockwell 30 Kg N Diamond	Superficial Rockwell 45 Kg N Diamond	BHN Brinell Hardness * 3000 KG 10mm Ball	Vickers Hardness 500g	Tensile Strength ** KSI
C	A	D	15N	30N	45N	HB	HV	KSI
68	85.6	76.9	93.2	844	75.4		940	
67	85	76.1	92.9	83.6	74.2		900	
66	84.5	75.4	92.5	82.8	73.3		865	
65	83.9	74.5	92.2	81.9	72	739	832	
64	83.4	73.8	91.8	81.1	71	722	800	
63	82.8	73	91.4	80.1	69.9	705	772	
62	82.3	72.2	91.1	79.3	68.8	688	746	
61	81.8	71.5	90.7	78.4	67.7	670	720	
60	81.2	70.7	90.2	77.5	66.6	654	697	
59	80.7	69.9	89.8	76.6	65.5	634	674	
58	80.1	69.2	89.3	75.7	64.3	615	653	
57	79.6	68.5	88.9	74.8	63.2	595	633	
56	79	67.7	88.3	73.9	62	577	613	
55	78.5	66.9	87.9	73	60.9	560	595	301
54	78	66.1	87.4	72	59.8	543	577	291
53	77.4	65.4	86.9	71.2	58.6	525	560	283
52	76.8	64.6	86.4	70.2	57.4	512	544	273
51	76.3	63.8	85.9	69.4	56.1	496	528	264
50	75.9	63.1	85.5	68.5	55	481	513	256
49	75.2	62.1	85	67.6	53.8	469	498	246
48	74.7	61.4	84.5	66.7	52.5	455	484	237
47	74.1	60.8	83.9	65.8	51.4	443	471	231
46	73.6	60	83.5	64.8	50.3	432	458	221
45	73.1	59.2	83	64	49	421	446	215
44	72.5	68.5	82.5	63.1	47.8	409	434	208
43	72	57.7	82	62.2	46.7	400	423	201
42	71.5	56.9	81.5	61.3	45.5	390	412	194
41	70.9	56.2	80.9	60.4	44.3	381	402	188
40	70.4	55.4	80.4	59.5	43.1	371	392	181
39	69.9	54.6	79.9	58.6	41.9	362	382	176
38	69.4	53.8	79.4	57.7	40.8	353	372	170
37	68.9	53.1	78.8	56.8	39.6	344	363	165
36	68.4	52.3	78.3	55.9	38.4	336	354	160
35	67.9	51.5	77.7	55	37.2	327	345	155
34	67.4	50.8	77.2	54.2	36.1	319	336	150
33	66.8	50	76.6	53.3	34.9	311	327	147
32	66.3	49.2	76.1	52.1	33.7	301	318	142
31	65.8	48.4	75.6	51.3	32.5	294	310	139
30	65.3	47.7	75	50.4	31.3	286	302	136
29	64.6	47	74.5	49.5	30.1	279	294	132
28	64.3	46.1	73.9	48.6	28.9	271	286	129
27	63.8	45.2	73.3	47.7	27.8	264	279	126
26	63.3	44.6	72.8	46.8	26.7	258	272	123
25	62.8	43.8	72.2	45.9	25.5	253	266	120
24	62.4	43.1	71.6	45	24.3	247	260	118
23	62	42.1	71	44	23.1	243	254	115
22	61.5	41.6	70.5	43.2	22	237	248	112
21	61	40.9	69.9	42.3	20.7	231	243	110
20	60.5	40.1	69.4	41.5	19.6	226	238	104

* Numbers above BHN 615 are outside recommended range for Brinell testing ASTM method F10

** Tensile Strength in relation to hardness is inexact unless determined for specific material

Rockwell B 100 Kg 1/16" Ball	Rockwell A 60 Kg Diamond	Rockwell F 60 Kg 1/16" Ball	Superficial Rockwell 15 Kg Ball	Superficial Rockwell 30 Kg Ball	Superficial Rockwell 45 Kg Ball	BHN Brinell Hardness 3000 KG 10mm Ball	DPH Vickers 500g	Knoop Hardness 500g	Tensile Strength KSI
B	A	F	15T	30T	45T	HB	HV	HK	KSI
100	61.5		93.1	83.1	72.9	240	240	251	116
99	60.9		92.8	82.5	71.9	234	234	246	114
98	60.2		92.5	81.8	70.9	228	228	241	109
97	59.5		92.1	81.1	69.9	222	222	236	104
96	58.9		91.8	80.4	68.9	216	216	231	102
95	58.3		91.5	79.8	67.9	210	210	226	100
94	57.6		91.2	79.1	66.9	205	205	221	98
93	57		90.8	78.4	65.9	200	200	216	94
92	56.4		90.5	77.8	64.8	195	195	211	92
91	55.8		90.2	77.1	63.8	190	190	206	90
90	55.2		89.9	76.4	62.8	185	185	201	89
89	54.6		89.5	75.8	61.8	180	180	196	88
88	54		89.2	75.1	60.8	176	176	192	86
87	53.4		88.9	74.4	59.8	172	172	188	84
86	52.8		88.6	73.8	58.8	169	169	184	83
85	52.3		88.2	73.1	57.8	165	165	180	82
84	51.7		87.9	72.4	56.8	162	162	176	81
83	51.1		87.6	71.8	55.8	159	159	173	80
82	50.6		87.3	71.1	54.8	156	156	170	77
81	50		86.9	70.4	53.8	153	153	167	73
80	49.5		86.6	69.7	52.8	150	150	164	72
79	48.9		86.3	69.1	51.8	147	147	161	70
78	48.4		86	68.4	50.8	144	144	158	69
77	47.9		85.6	67.7	49.8	141	141	155	68
76	47.3		85.3	67.1	48.8	139	139	152	67
75	46.8	99.6	85	66.4	47.8	137	137	150	66
74	46.3	99.1	84.7	65.7	46.8	135	135	147	65
73	45.8	98.5	84.3	65.1	45.8	132	132	145	65
72	45.3	98	84	64.4	44.8	130	130	143	65
71	44.8	97.4	83.7	63.7	43.8	127	127	141	65
70	44.3	96.8	83.4	63.1	42.8	125	125	139	65
69	43.8	96.2	83	62.4	41.8	123	123	137	65
68	43.3	95.6	82.7	61.7	40.8	121	121	135	65
67	42.8	95.1	82.4	61	39.8	119	119	133	65
66	42.3	94.5	82.1	60.4	38.7	117	117	131	65
65	41.8	93.9	81.8	59.7	37.7	116	116	129	65
64	41.4	93.4	81.4	59	36.7	114	114	127	
63	40.9	92.8	81.1	58.4	35.7	112	112	125	
62	40.4	92.2	80.8	57.7	34.7	110	110	124	
61	40	91.7	80.5	57	33.7	108	108	122	
60	39.5	91.1	80.1	56.4	32.7	107	107	120	
59	39	90.5	79.8	55.7	31.7	106	106	118	
58	38.6	90	79.5	55	30.7	104	104	117	
57	38.1	89.4	79.2	54.4	29.7	103	103	115	
56	37.7	88.8	78.8	53.7	28.7	101	101	114	
55	37.2	88.2	78.5	53	27.7	100	100	112	
54	36.8	87.7	78.2	52.4	26.7			111	
53	36.3	87.1	77.9	51.7	25.7			110	
52	35.9	86.5	77.5	51	24.7			109	
51	35.5	86	77.2	50.3	23.7			108	
50	35	85.4	76.9	49.7	22.7			107	
49	34.6	84.8	76.6	49	21.7			106	
48	34.1	84.3	76.2	48.3	20.7			105	
47	33.7	83.7	75.9	47.7	19.7			104	
46	33.3	83.1	75.6	47	18.7			103	
45	32.9	82.6	75.3	46.3	17.7			102	
44	32.4	82	74.9	45.7	16.7			101	
43	32	81.4	74.6	45	15.7			100	
42	31.6	80.8	74.3	44.3	14.7			99	
41	31.2	80.3	74	43.7	13.6			98	
40	30.7	79.7	73.6	43	12.6			97	
39	30.3	79.1	73.3	42.3	11.6			96	
38	29.9	78.6	73	41.6	10.6			95	
37	29.5	78	72.7	41	9.6			94	
36	29.1	77.4	72.3	40.3	8.6			93	
35	28.7	76.9	72	39.6	7.6			92	
34	28.2	76.3	71.7	39	6.6			91	
33	27.8	75.7	71.4	38.3	5.6			90	
32	27.4	75.2	71	37.6	4.6			89	
31	27	74.6	70.7	37	3.6			88	
30	26.6	74	70.4	36.3	2.6			87	

STRESS AREAS FOR THREADED FASTENERS — INCH

Diameter (in.)		Diameter (mm)	Threads Per in.		Square Inches		
					Tensile Stress Area Per H-28		
			UNRC	UNRF	UNRC	UNRF	Nominal Shank
#0	0.06	1.52	–	80	–	0.00180	0.002827
#1	0.07	1.85	64	72	0.00263	0.00278	0.004185
#2	0.09	2.18	56	64	0.00370	0.00394	0.005809
#3	0.10	2.51	48	56	0.00487	0.00523	0.007698
#4	0.11	2.84	40	48	0.00604	0.00661	0.009852
#5	0.13	3.18	40	44	0.00796	0.00830	0.012272
#6	0.14	3.51	32	40	0.00909	0.01015	0.014957
#8	0.16	4.17	32	36	0.0140	0.01474	0.021124
#10	0.19	4.83	24	32	0.0175	0.0200	0.028353
1/4	0.25	6.35	20	28	0.0318	0.0364	0.049087
5/16	0.31	7.94	18	24	0.0524	0.0580	0.076699
3/8	0.38	9.53	16	24	0.0775	0.0878	0.11045
7/16	0.44	11.11	14	20	0.1063	0.1187	0.15033
1/2	0.50	12.70	13	20	0.1419	0.1599	0.19635
9/16	0.56	14.29	12	18	0.182	0.203	0.25
5/8	0.63	15.88	11	18	0.226	0.256	0.31
3/4	0.75	19.05	10	16	0.334	0.373	0.44179
7/8	0.88	22.23	9	14	0.462	0.509	0.60132
1	1.00	25.40	8	12	0.606	0.663	0.79
1-1/8	1.13	28.58	7	12	0.763	0.856	0.99402
1-1/4	1.25	31.75	7	12	0.969	1.073	1.2272
1-3/8	1.38	34.93	6	12	1.155	1.315	1.4849
1-1/2	1.50	38.10	6	12	1.405	1.581	1.7671
1-3/4	1.75	44.45	5	12	1.90	2.19	2.4053
2	2.00	50.80	4-1/2	12	2.50	2.89	3.1416
2-1/4	2.25	57.15	4-1/2	12	3.25	3.69	3.9761
2-1/2	2.50	63.50	4	12	4.00	4.60	4.9088
2-3/4	2.75	69.85	4	12	4.93	5.59	5.9396
3	3.00	76.20	4	12	5.97	6.69	7.0686

STRESS AREAS FOR THREADED FASTENERS — METRIC

Nominal Dia. Thread and Pitch (mm)	Thread Tensile Stress Area (mm^2)	Nominal Shank Area (mm^2)
1.6 x 0.35	1.27	2.01
2.0 x 0.4	2.07	3.14
2.5 x 0.45	3.39	4.91
3.0 x 0.5	5.03	7.07
4.0 x 0.7	8.78	12.6
5.0 x 0.8	14.2	19.6
6.0 x 1	20.1	28.3
8.0 x 1.25	36.6	50.3
10 x 1.5	58.00	78.5
12 x 1.75	84.3	113
14 x 2	115	154
16 x 2	157	201

Nominal Dia. Thread and Pitch (mm)	Thread Tensile Stress Area (mm^2)	Nominal Shank Area (mm^2)
18 x 2.5	192	254
20 x 2.5	245	314
22 x 2.5	303	380
24 x 3	353	452
27 x 3	459	573
30 x 3.5	561	707
33 x 3.5	694	855
36 x 4	817	1018
42 x 4.5	1120	1385
48 x 5	1470	1810

Thread Size Comparison

METRIC PRODUCTS						
SIZE	THREAD PITCH & T.P.I.				Major Dia	
	COARSE		FINE			
	PITCH mm	T.P.I.	PITCH mm	T.P.I.	mm	inch
M3	0.50	51	-	-	3.00	0.118
M4	0.70	36	-	-	4.00	0.157
M5	0.80	32	-	-	5.00	0.197
M6	1.00	25	-	-	6.00	0.236
M8	1.25	20	1.00	25	8.00	0.315
M10	1.50	17	1.25	20	10.00	0.394
M12	1.75	14.50	1.25	20	12.00	0.472
(M14)	2.00	12.50	1.50	17	14.00	0.551
M16	2.00	12.50	1.50	17	16.00	0.630
(M18)	2.50	10	1.50	17	18.00	0.709
M20	2.50	10	1.50	17	20.00	0.787
(M22)	2.50	10	1.50	17	22.00	0.866
M24	3.00	8.50	2.00	12.50	24.00	0.945
(M27)	3.00	8.50	2.00	12.50	27.00	1.063
M30	3.50	7.25	2.00	12.50	30.00	1.181
(M33)	3.50	7.25	2.00	12.50	33.00	1.299
M36	4.00	6.40	3.00	8.5	36.00	1.417
(M39)	4.00	6.40	3.00	8.5	39.00	1.535
M42	4.50	5.60	3.00	8.5	42.00	1.653

UNIFIED INCH PRODUCTS				B.S. INCH PRODUCTS			
SIZE	T.P.I.		Major Dia	SIZE	T.P.I.		Major Dia
	UNC	UNF	inch		BSW	BSF	inch
#5	40	44	0.125	1/8	40	-	0.125
#6	32	40	0.138				
#8	32	36	0.164				
#10	24	32	0.190	3/16	24	32	0.187
1/4	20	28	0.250	1/4	20	26	0.250
5/16	18	24	0.313	5/16	18	22	0.313
3/8	16	24	0.375	3/8	16	20	0.375
				7/16	14	18	0.438
1/2	13	20	0.500	1/2	12	16	0.500
5/8	11	18	0.625	5/8	11	14	0.625
3/4	10	16	0.750	3/4	10	12	0.750
7/8	9	14	0.875	7/8	9	11	0.875
1	8	12	1.000	1	8	10	1.000
1 1/8	7	12	1.125	1 1/8	7	9	1.125
1 1/4	7	12	1.250	1 1/4	7	9	1.250
1 1/2	6	12	1.500	1 1/2	6	8	1.500

Comparison of Different Strength Grades

SAE	I.S. I.S.O. DIN	ULTIMATE TENSILE STRENGTH		YIELD STRENGTH MIN.		HARDNESS		
		Newtons/mm² Min (kgf/mm²)	Pounds/in² Min (kgf/mm²)	Newtons/mm² (kgf/mm²)	Pounds/in² (kgf/mm²)	BHN	HRb	HRc
-	4.6	400 (40.8)	-	240 (24.5)	-	114 / 238	67 / 99.5	
Grade 1			60.000 (42.3)		36,000 (25.4)	(121) / (241)	70 / 100	
	4.8	420 (42.8)		340 (34.7)		124 / 238	71 / 99.5	
	5.6	500 (51.0)		300 (30.6)		147 / 238	79 / 99.5	
Grade 2			74.000 (52.1)		57,000 (40.2)	(154) / (241)	80 / 100	
	5.8	520 (53.0)		420 (42.8)		152 / 238	82 / 99.5	
	6.8	600 (61.2)		480 (48.9)		181 / 238	89 / 99.5	
	8.8	800 ⩽ M16 (81.6) 830 ⩾ M16 (84.6)		640 (65.2) 660 (67.3)		238 / 304 242 / 319		22 / 32 23 / 34
Grade 5			1,20.000 (84.6)		92,000 (64.8)	(266) / (318)		25 / 34
Grade 8			1,50.000 (105.7)		1,30,000 (91.6)	(311) / (362)		33 / 39
	10.9	1,040 (106.0)		940 (95.8)		304 / 362		32 / 39
	12.9	1,220 (124.4)		1100 (112.0)		366 / 412		39 / 44

NOTES

NOTES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