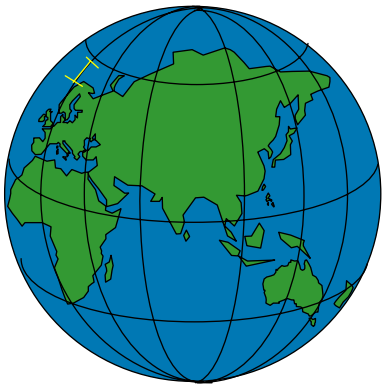
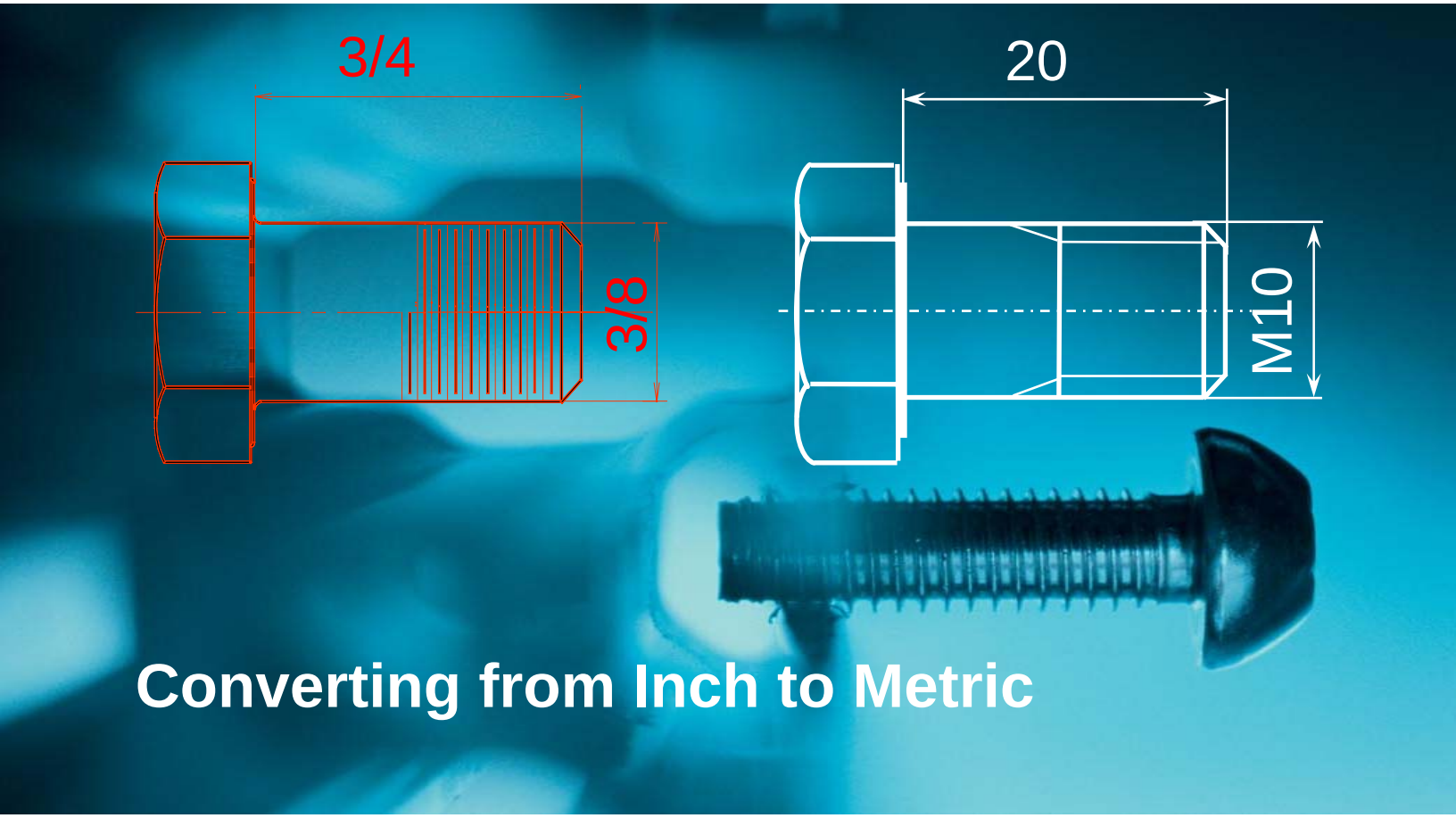


BOSSARD

Metric is simple

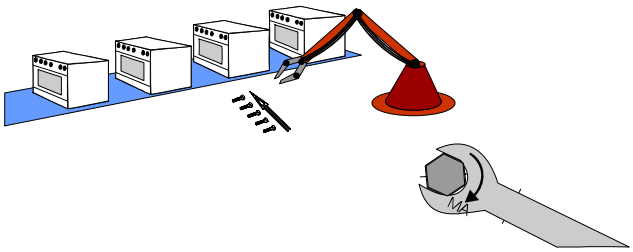


Converting from Inch to Metric

Metric Seminar from Bossard

Prepared by B. Marbacher revised 09-06

The international Market place

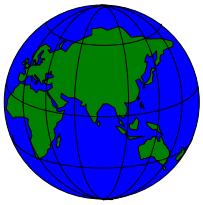


- US-companies have manufacturing facilities overseas.

- Overseas companies have manufacturing facilities in the US.

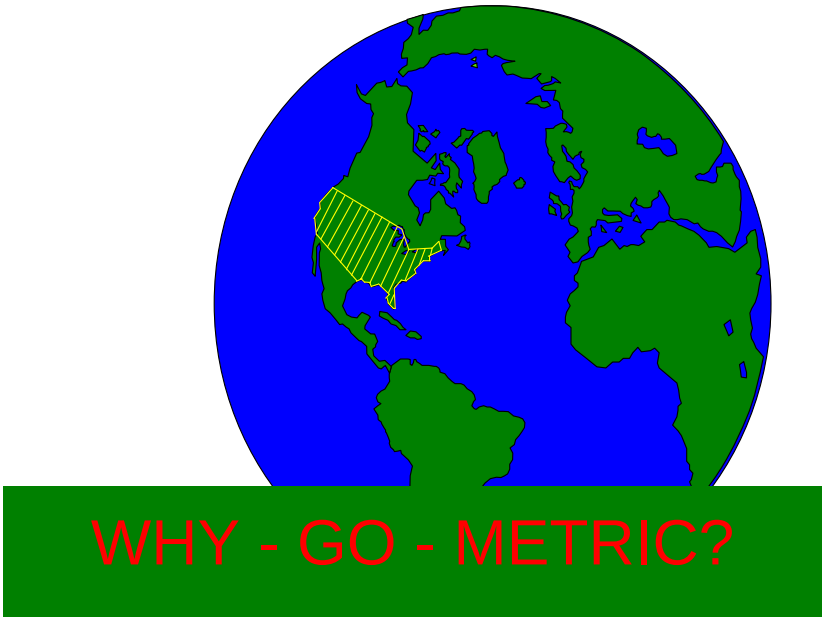
- US companies are involved in international projects.

- Work is being sub-contracted internationally. (Companies in 2, 3 or more countries are involved)

- Subassemblies are often made in different parts of the  world.

METRIC SYSTEM

Entire world, except.....

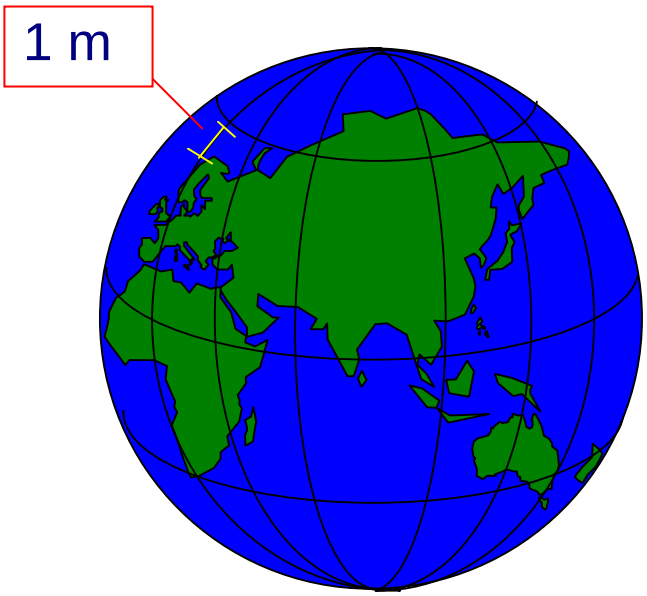


METRIC SYSTEM:

- FACILITATES INTERNATIONAL COMMUNICATION & TRADE.
- ENABLES INTERCHANGEABILITY OF PRODUCTS
- MAKES IT EASIER TO SERVICE & MAINTAIN US-MADE PRODUCTS.
- MAKES US-MADE PRODUCTS EASIER SELLABLE OVERSEAS.

THE METER

Basic unit : 1 meter



Original Definition:

$$1\ m = \frac{1}{40\ 000\ 000}\ \text{of a meridian}$$

Advantages of Metric System:

- Simple
- Logical
- Makes it easier to be accurate
- Enables interchangeability
- Applied by (almost) all Nations

METRIC SYSTEM

Common metric prefixes

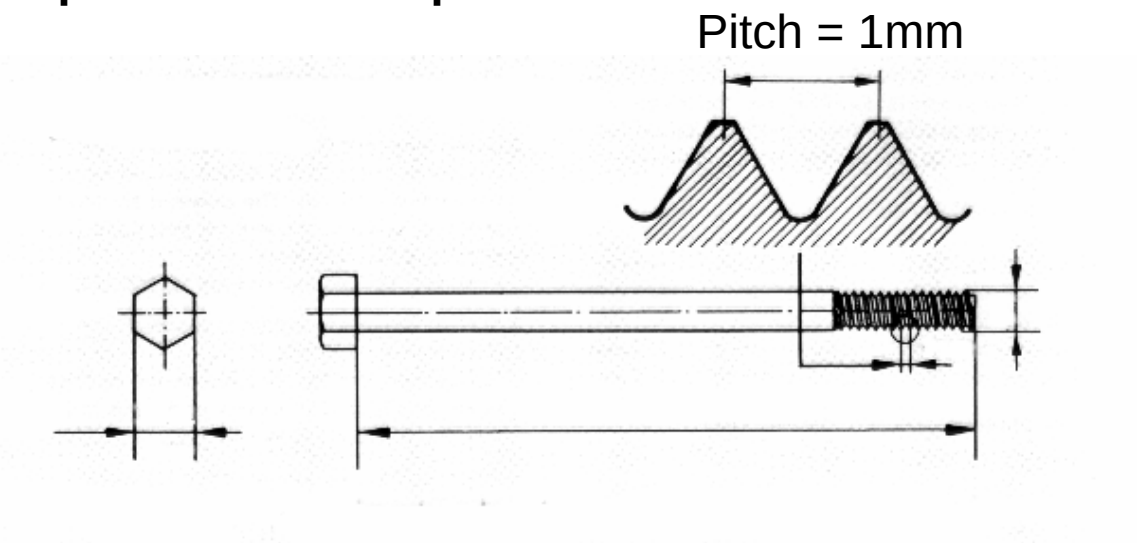
G (giga)	=	1 000 000 000
M (mega)	=	1 000 000
k (kilo)	=	1 000
h (hecto)	=	100
c (centi)	=	$1/100$
m (milli)	=	$1/1000$
μ (micro)	=	$1/1000000$

Examples:

1 Mt	(1 MEGATON)	=	1 000 000 t
1 kg	(1 KILOGRAM)	=	1 000 g
1 μm	(1 MICROMETER)	=	$1/1000000$ m

Metric system

Multiples & sub-multiples of 10



Hex cap screw M6 x 100

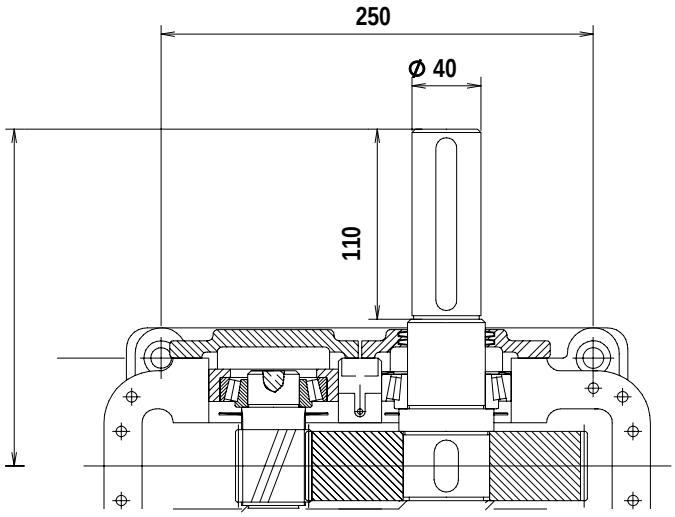
Pitch =1 mm

Examples:

1 m (meter)	**10 dm (decimeter)**
	100 cm (centimeter
	1 000 mm (millimeter)
	1 000 000 µm (micrometer)

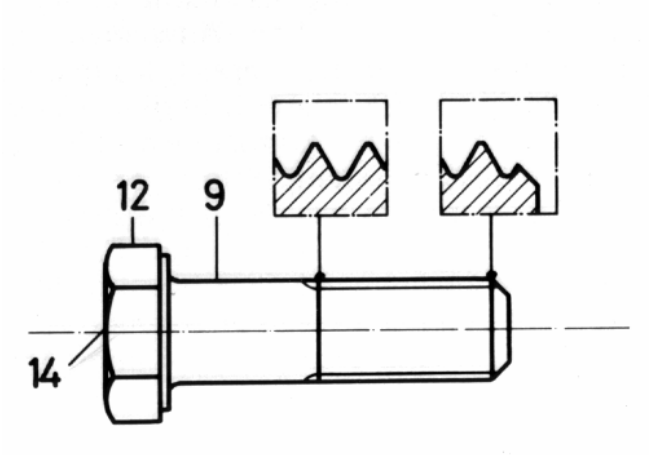
Use of Metric Unit Symbols

mm for dimensions in the mechanical field (on drawings)



µm for

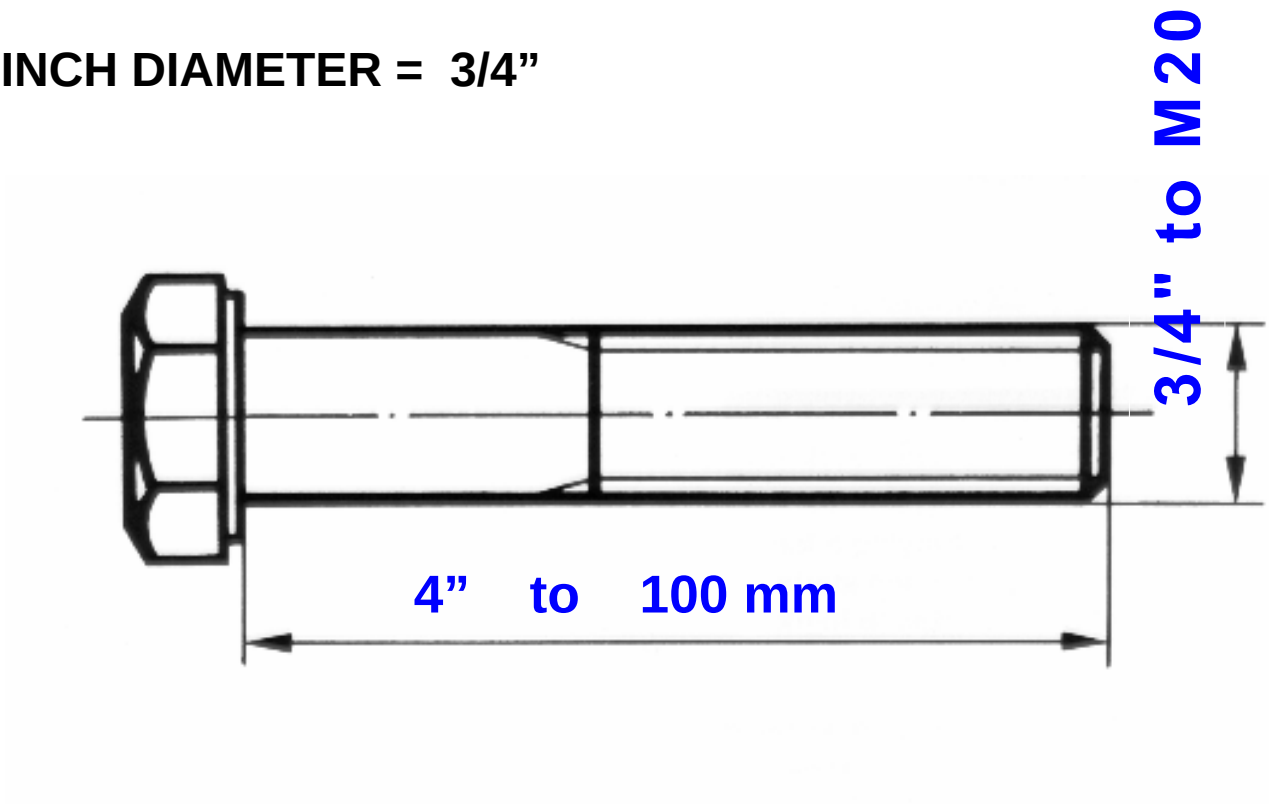
- **Precision tolerances**
- **Plating thicknesses,**
- **Surface roughnesses**



BOSSARD

INCH FASTENERS TO METRIC FASTENERS

INCH DIAMETER = 3/4”



DIAMETER

1ST POSSIBILITY:

1 INCH = 25.4 mm

3/4" MEANS 3/4 OF 25.4

FOR 1/4 " DEVIDE 25.4 BY 4 = 6.35 mm

FOR 3/4 " THEN MULTIPLY 6.35 BY 3 = 19.05 mm

2ND POSSIBILITY:

3/4 " = .750 " MULTIPLY .750 X 25.4 = 19.05 mm

NEXT COMMON METRIC BOLT DIAMETER = M 20

INCH FASTENERS TO METRIC FASTENERS

LENGTH:

4" = 4 X 25.4 = 101.6mm CHOOSE 100 mm

SIZE COMPARISON:

Metric sizes	Inch sizes	Pitch
M 3	4-40	0.5
M 3.5	6-32	0.6
M 4	8-32	0.7
M 5	10-24	0.8
M 6	1/4	1
M 7	1	1
M 8	5/16	1.25
M 10	3/8	1.5
M 12	1/2	1.75

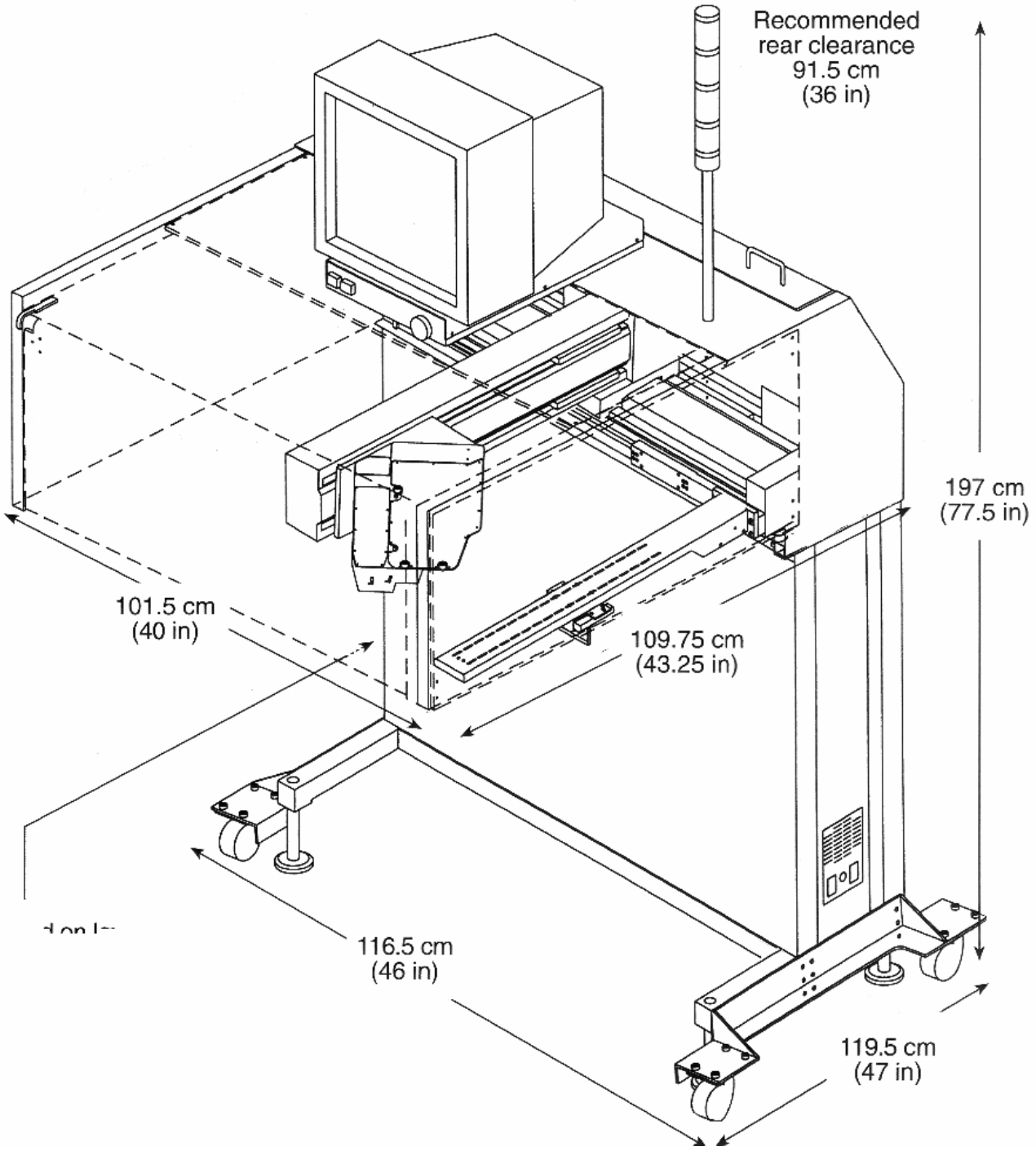
FINALLY, CHECK WHETHER FASTENERS MEET THE STRENGTH REQUIREMENTS.

YIELD LOAD COMPARISON

EXCERPTS FROM TECHNICAL SECTION OF BOSSARD CATALOG

					Yield load in kN: As x Rp 0.2 (kN = 224.8 lbs.)				
Thread size	Major diam. mm^2	Stress area mm^2	Thread size	Stress area mm^2	SAE Grade 2	4.6	4.8	SAE Grade 5	8.8
d	d_1	As	d	As					
5-40	3.175	5.14	M3	5.03	2.02	1.21	1.71	3.26	3.22
6-32	3.505	5.86	M3.5	6.78	2.30	1.63	2.31	3.72	4.34
8-32	4.166	9.04	M4	8.78	3.55	2.11	2.99	5.74	5.62
10-24	4.826	11.31	M5	14.20	4.45	3.41	4.83	7.18	9.09
1/4-20	6.350	20.50	M6	20.10	8.06	4.82	6.863	13.01	12.86
5/16-18	7.938	33.80	M8	36.60	13.29	8.78	12.44	21.45	23.42
3/8-16	9.525	50.00	M10	58.00	19.66	13.92	19.72	31.72	37.12

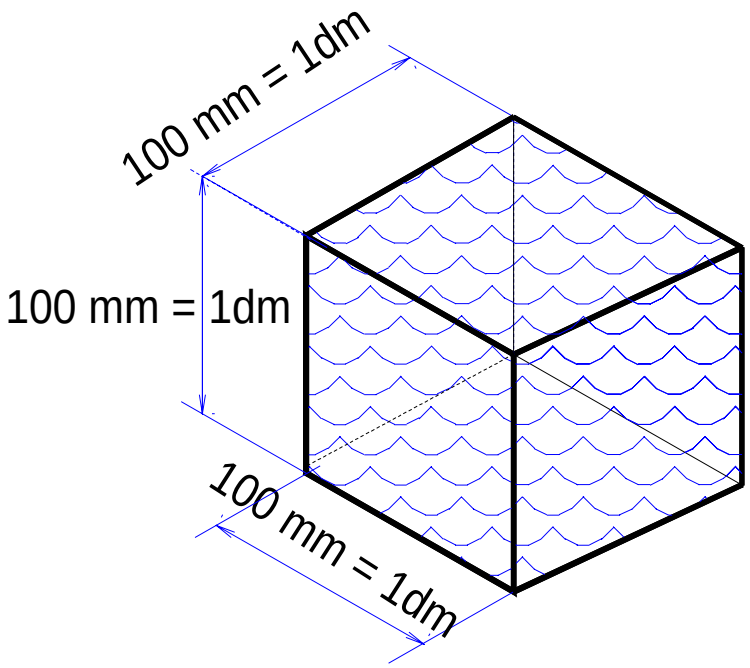
~~cm~~ ⇒ mm



BOSSARD

METRIC MASS (WEIGHT)

Metric Mass (weight) is indicated in kilograms (kg)



Definition:

1 cubic decimeter
(1 dm^3)

of water at 4° C

has

a mass of 1 kilogram

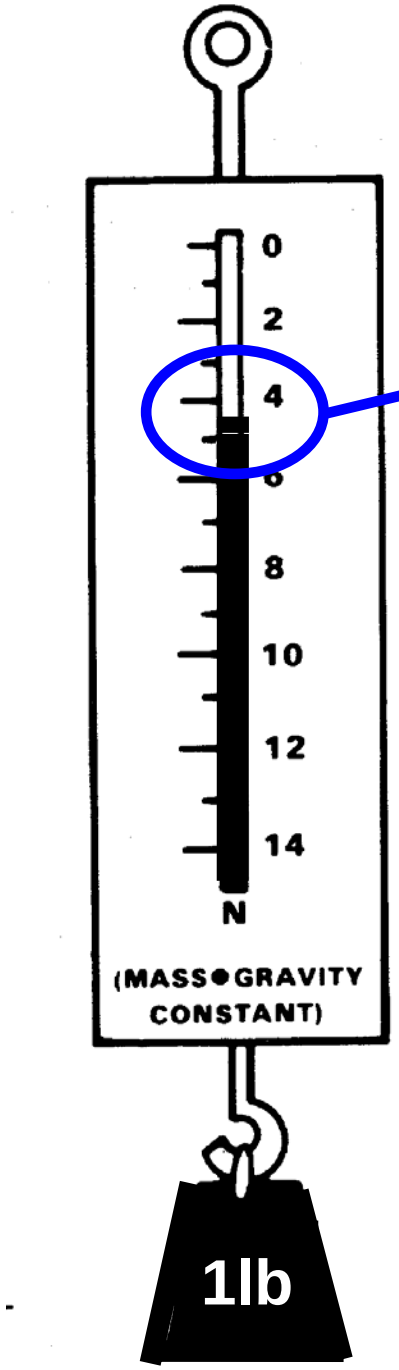
1 kilogram water = 1 liter

1 **kilogram mass** remains constant regardless:

⇒ on EARTH , SPACE or on other planet.
⇒ in BRAZIL or USA
⇒ in MIAMI or SEATTLE

1 kilogram (kg) = 2.204 pounds (lb.)

“Metric” force - quick reference



4.448 N

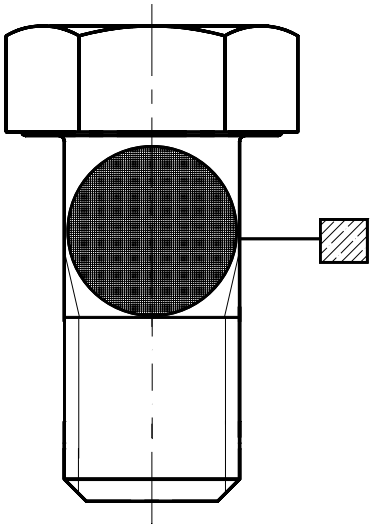
N = newton

1 pound = 4.448 newton

BOSSARD

METRIC SYSTEM

Strength



NEWTON per square millimeter

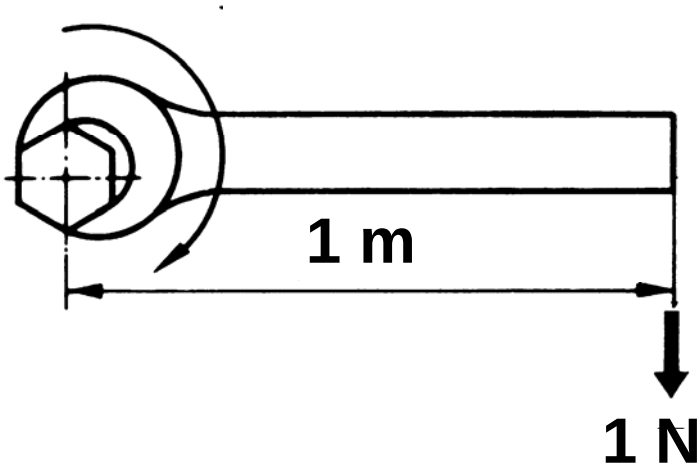
N / mm^2

1 newton per square millimeter = 1 mega pascal

$1\ N/mm^2$ = 1 MPa

1 MPa (N/mm^2) = approx. 145 psi

Torque:



Nm

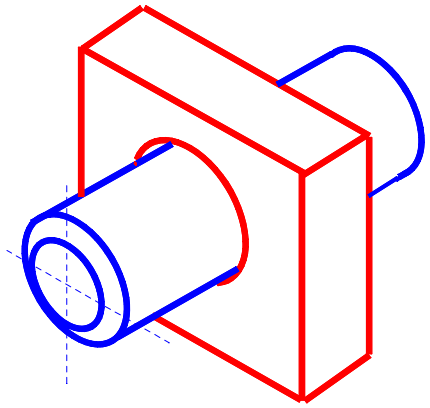
newton meter

1 Nm = 0.7376 ft lb.

BOSSARD

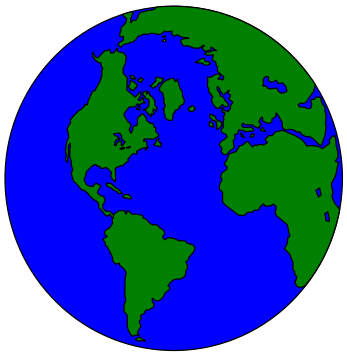
ISO TOLERANCES

Tolerance system for **LIMIT & FITS**



Tolerance system = key to interchangeability

Used for numerous applications



TOLERANCES ARE INDICATED BY:

Tolerance zones

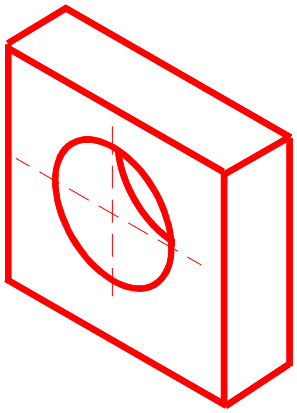
H7, H12, m6, h6, h8,

Charts are available per ANSI, ISO, DIN .... .

Tolerance Symbol

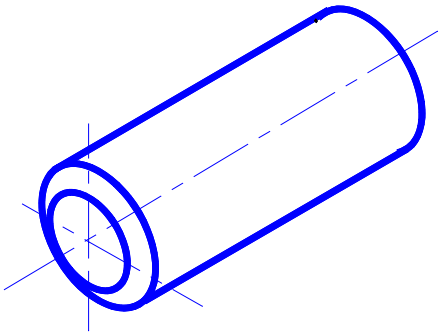
CAPITOL LETTERS **H7**

for INTERNAL FEATURES



small case letters m6

for external features



The bigger the NUMBER the bigger the TOLERANCE

INTERNAL FEATURES:

Letters A - H ⇒ feature = oversized **(+ tol.)**

Letters after K ⇒ feature = undersized **(- tol.)**

EXTERNAL FEATURES:

Letters a - h ⇒ feature = undersized **(- tol.)**

Letters after k ⇒ feature = oversized **(+ tol.)**

Example:

Hole diameter 10

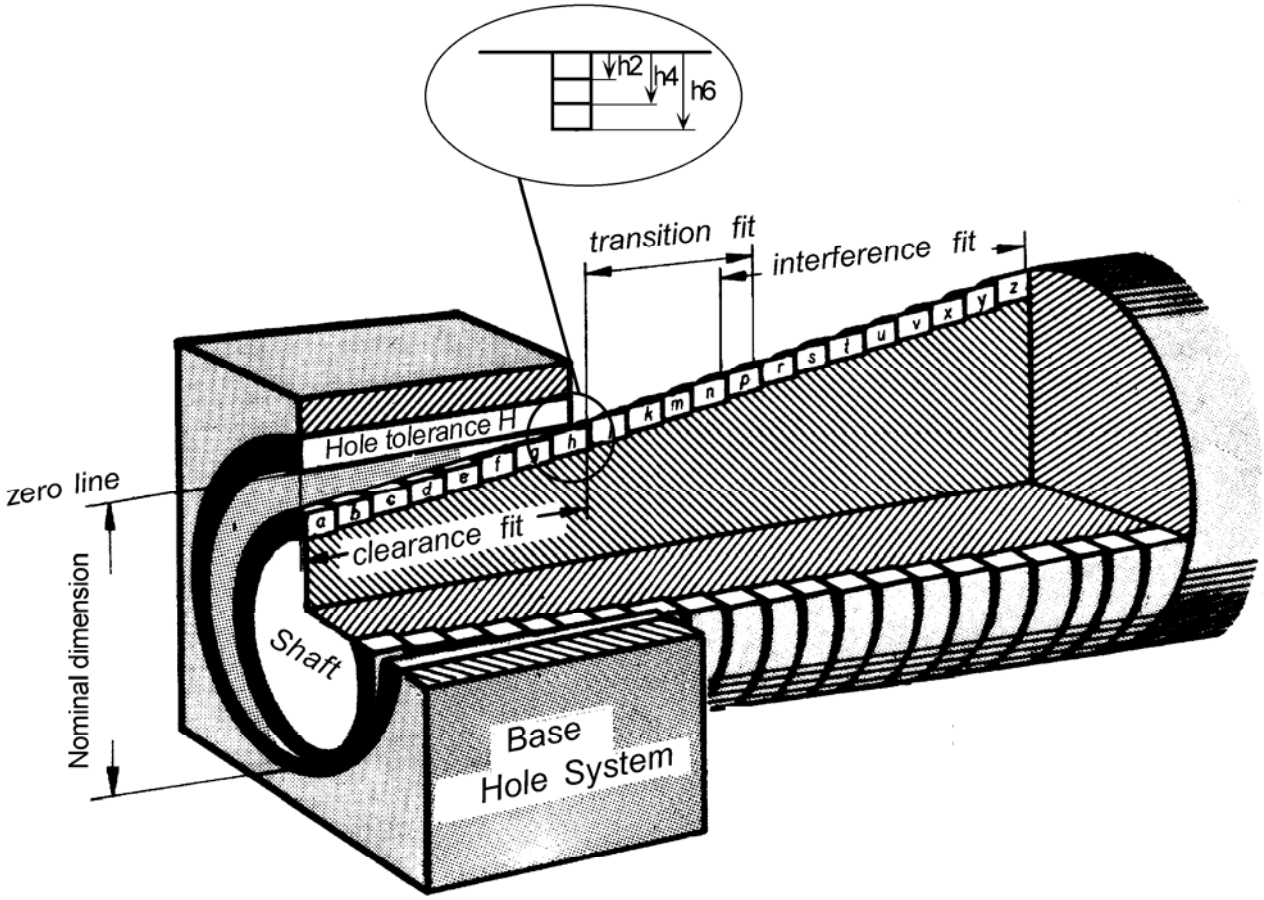
shown: 10 H7 = oversized hole

Shaft diameter 10

Shown: 10 h6 = undersized shaft

10 m6 = oversized shaft

Tolerance zone



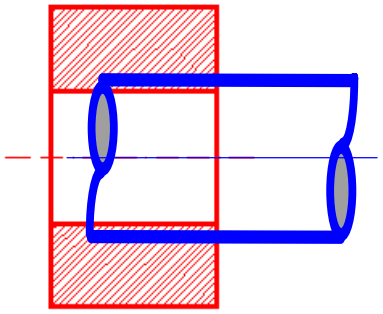
Showing position and extent of tolerance

TOLERANCES

Combination shank / hole Example: diameter 10 mm

H7 / s6
snug fit

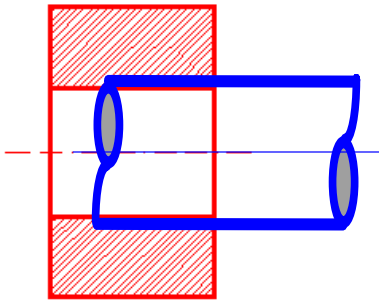
10.015
10.000



10.032
10.023

H7 / m6
drive fit

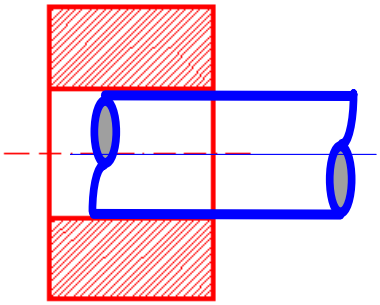
10.015
10.000



10.011
10.002

H7 / h6
sliding fit

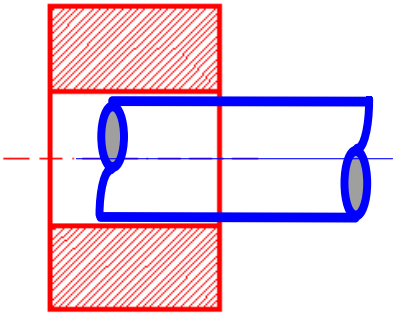
10.015
10.000



10.000
9.991

H7 / d9
loose
running fit

10.015
10.000



9.024
9.060

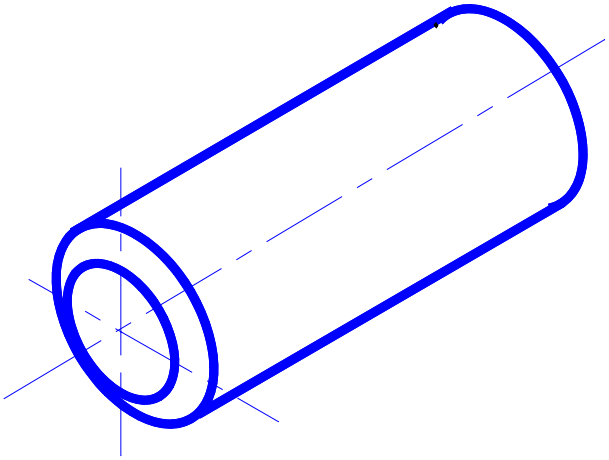
ISO TOLERANCES

ISO tolerance chart excerpts:

Nominal size		Tolerance zones			
over	to	h6	h8	m6	H7
0	1	0 - 0.006	0 - 0.040	+ 0.002 + 0.008	+ 0.010 0
1	3	0 - 0.006	0 - 0.040	+ 0.002 + 0.008	+ 0.010 0
3	6	0 - 0.008	0 - 0.048	+ 0.004 + 0.012	+ 0.012 0

EXAMPLE:

Metric dowel pin metric shaft



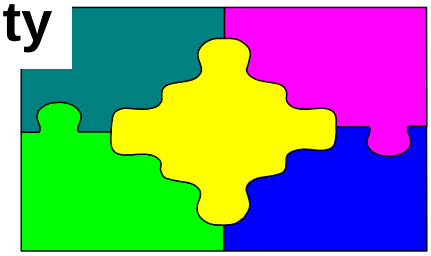
Size: 5 x 12 tolerance m6

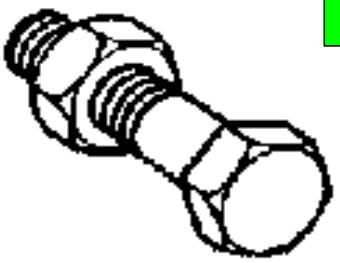
Designation: ∅ 5 m6 x 12

Tolerance: (millimeters) = 0.004 = min. = 5.004
= 0.012 = max. = 5.012

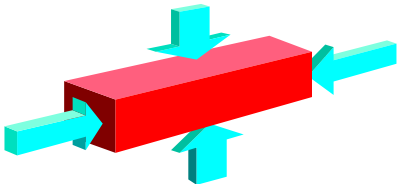
Interchangeability & Availability

Interchangeability





Availability



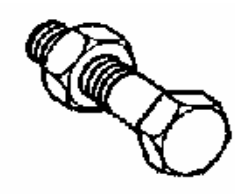
worldWide

Property of Bossard
UHBM 1/98

a must

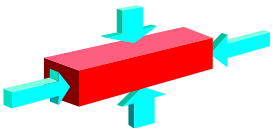
BOSSARD

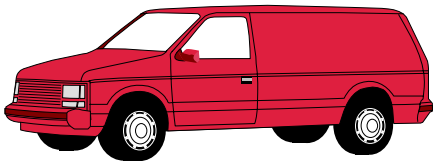
Availability - Just in time

Fasteners 

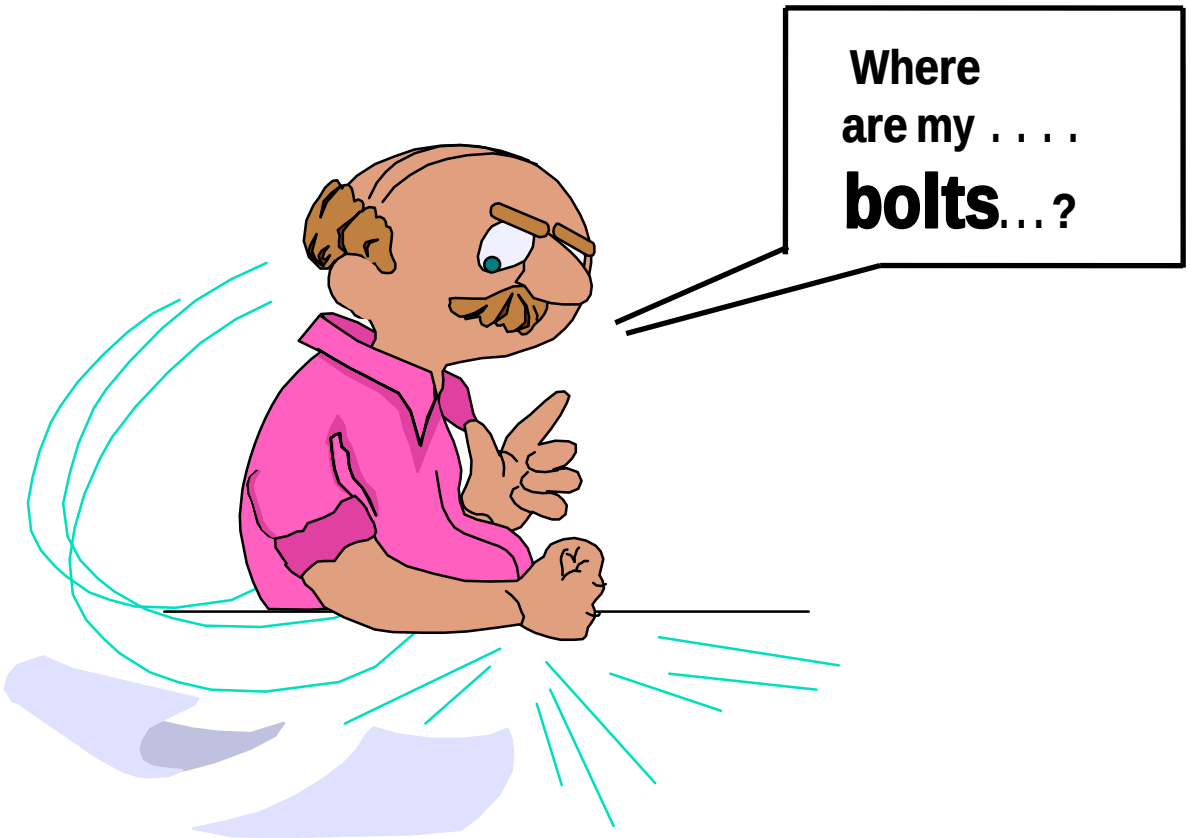
made to " well known "

worldWide recognized standards

- are more readily  **available**

- give greater assurance for " Just in time " deliveries 

and cause less ????????



Metric Standards and Standard Organizations

International Organization for Standardization

Deutsches Institut fuer Normung (German Institute for Standards)

American National Standards Institute

American Society for Testing & Materials

European Committee for Standards

BOSSARD

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

- **ISO IS** WORLD STANDARD
- ORIGINALLY PUBLISHED RECOMMENDATION ONLY
- NATIONAL STANDARDS INCORPORATED RECOMMENDATIONS
- SINCE MID 70'S - **ISO STANDARDS PUBLISHED**
- MATERIAL & MECH. PROPERTIES ARE INCLUDED IN NATIONAL STANDARDS. (SAME)
- THREAD DIMENSIONS ALL ACC. **ISO**
- FASTENERS TO **ISO PRODUCT STANDARDS** (DIMENSIONAL REQUIREMENTS) NOT YET **ALL** READILY AVAILABLE.

BOSSARD

DEUTSCHES INSTITUT FUER NORMUNG (GERMAN INSTITUTE FOR STANDARDS)

- **DIN STANDARDS** RECOGNIZED & ACCEPTED WORLDWIDE
- USED IN INDUSTRY WORLDWIDE
- MANY **DIN STANDARDS** CONVERTED TO **ISO STANDARDS**
- STILL MANY METRIC FASTENERS & MACHINE COMPONENTS AVAILABLE **PER DIN STANDARDS ONLY**

BOSSARD

AMERICAN NATIONAL STANDARDS INSTITUTE

- **ANSI STANDARDS** ALMOST IN AGREEMENT WITH **ISO**
- **ANSI STANDARD** NOT YET RECOGNIZED WORLDWIDE
- WHEN SPECIFYING **ANSI**, LIST **ISO** AND **DIN** AS PERMISSIBLE ALTERNATIVES

AMERICAN SOCIETY FOR TESTING & MATERIALS

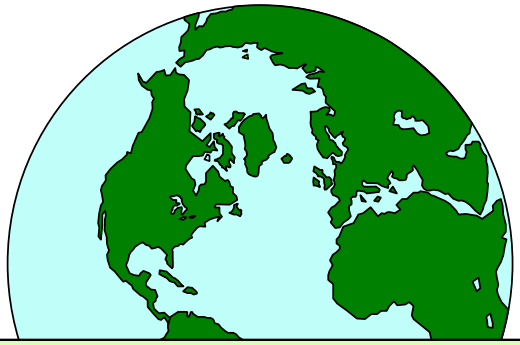
- MECHANICAL PROPERTIES ALMOST IN AGREEMENT WITH **ISO**
- WHEN SPECIFYING **ASTM**, LIST **ISO** AND **DIN** AS PERMISSIBLE ALTERNATIVES

EUROPEAN COMMITTEE FOR STANDARDS

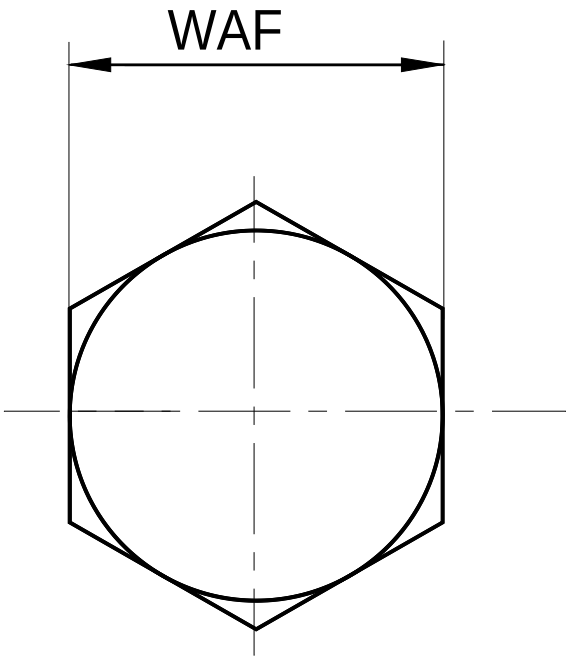
- CEN will publish EN standards (European Norm).
- EN standards based on existing ISO Standard.
- The ISO mechanical standards agree with EN standards.
- After the introduction of EN-standards, **European National standards** to be phased out.

FUNCTIONAL

INTERCHANGEABILITY



Worldwide



DIFFERENT WAF

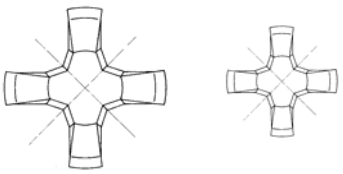
Standard ↓	Size M10	M12	M14
ISO & ANSI	16	18	21
DIN	17	19	22

Smaller heads (WAF) per ISO & ANSI standards cause some what higher strains on clamped material.

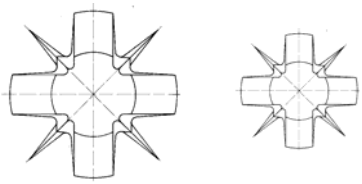
Difference in WAF may cause *problems* in the assembly if screws are mixed.

MACHINE SCREWS WITH CROSS RECESSES

Difference in Drive **sizes**



Philips drive



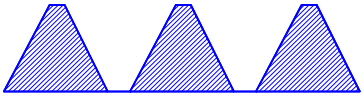
Pozidriv

Size / Standard	M2	M2.5	M 3	M3.5	M 4	M 5
ISO	0	1		2		
DIN	1			2		
ANSI	0	1		2		
JIS	1		2			

Difference if drive sizes could possible cause problems in the assembly.

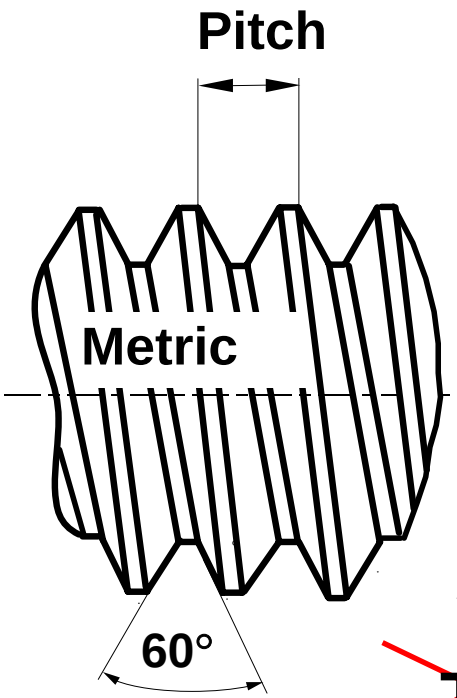
METRIC THREAD

Metric thread falls between inch coarse / inch fine thread



Inch coarse

Inch fine



P = Pitch

Flank angle = 60°

Pitch instead of threads per inch

~~TPI~~

Metric coarse thread = Standard thread

M10 **M** = metric thread **10** = nom. diameter

Metric fine thread = special

M10 x 1 **M** = metric thread 10 = diameter **1** = Pitch

Indicate pitch only for metric fine thread

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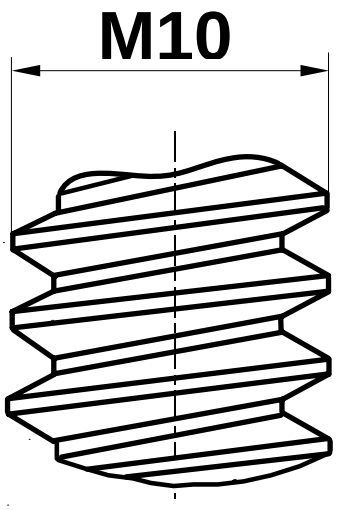
PREFERRED METRIC THREAD SIZES & LENGTHS

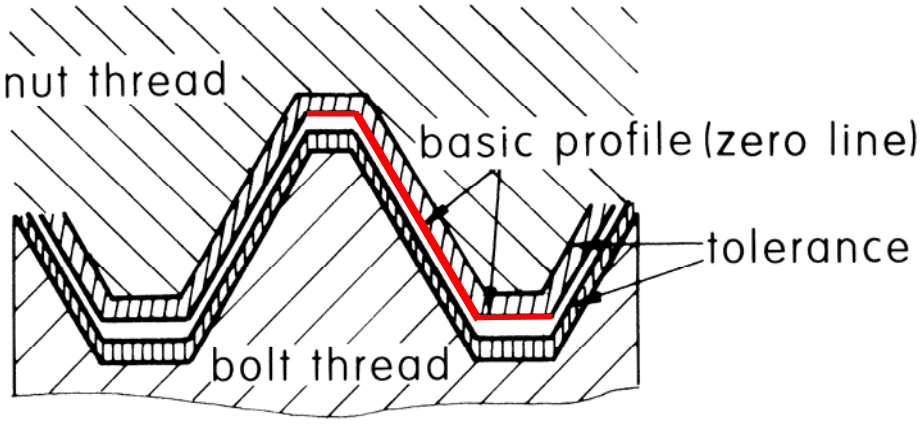


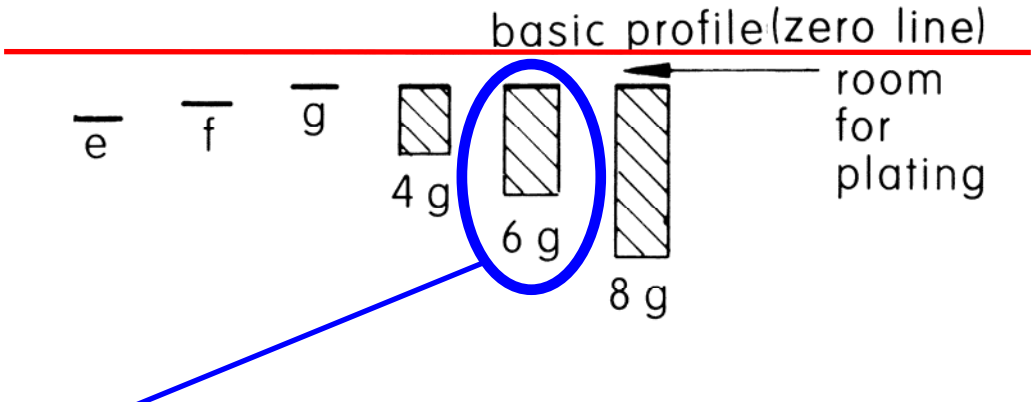
Preference classes (Pref. Diam.)			Pitch	
1	2	3	Coarse (standard)	Fine
M3			0.5	
	M3.5		0.6	
M4			0.7	
M5			0.8	
M6			1	
		M7	1	
M8			1.25	1
		M9	1.25	
M10			1.5	1.25 (1)
		M11	1.5	
M12			1.75	1.25(1.5)
M14	M14		2	1.5
M16			2	1.5
	M18		2.5	1.5
M20			2.5	1.5

Preferred Length		
Nominal Length (mm)		Increment of:
>	≤	
	6	1 mm
6	20	2 mm
20	50 (75)	5 mm
50	160	10 mm
160	300	20 mm
300		40 mm

METRIC THREAD TOLERANCES

Thread tolerance for metric external thread

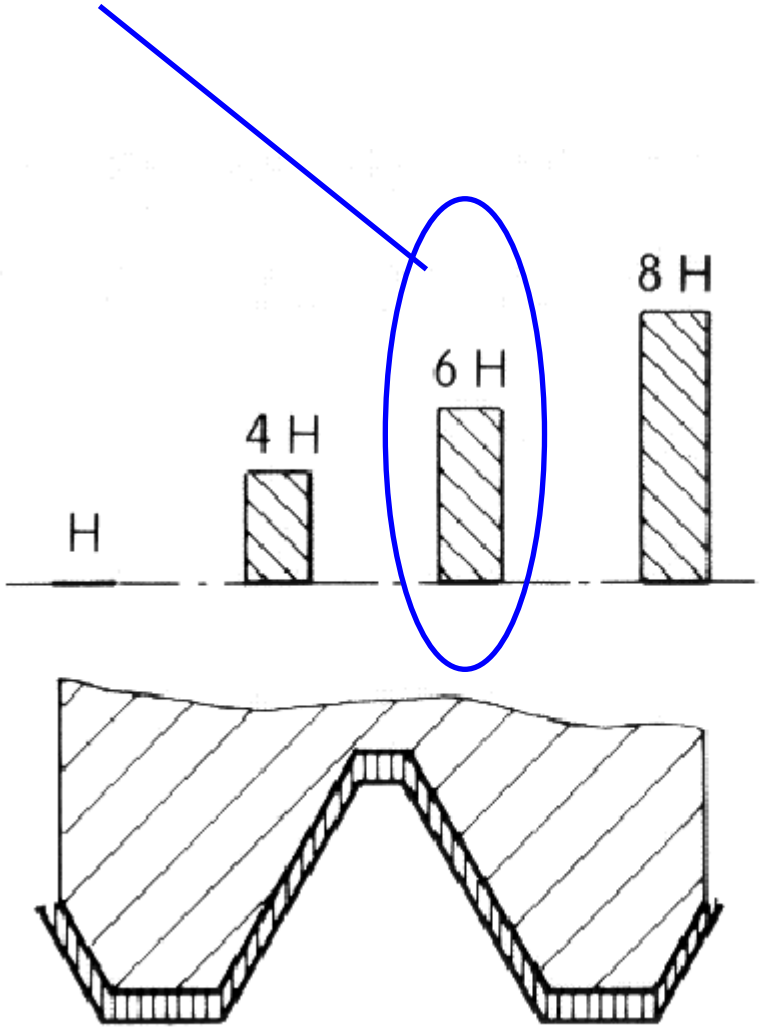




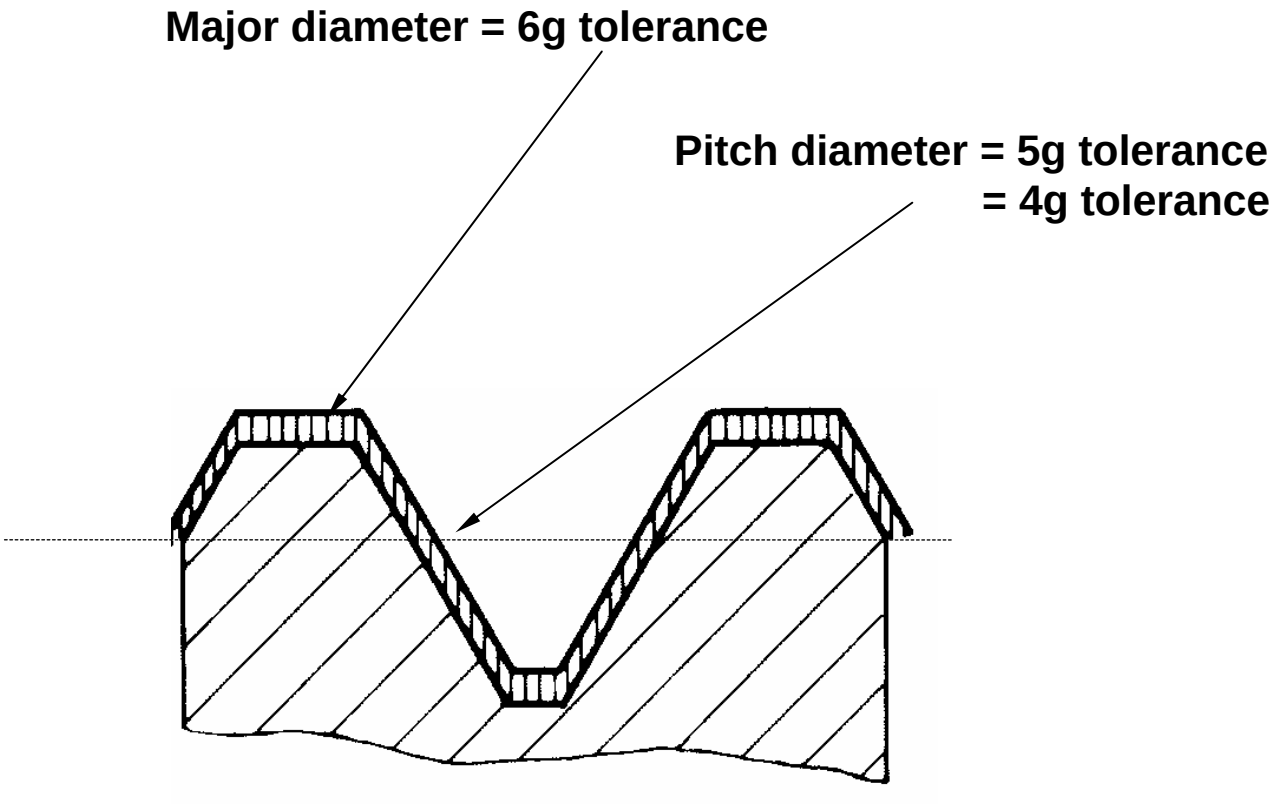
Standard bolt thread tolerance, comparable to inch thread tolerance 2A

Thread tolerance for metric internal thread

Standard Nut thread tolerance, comparable to inch thread tolerance 2B

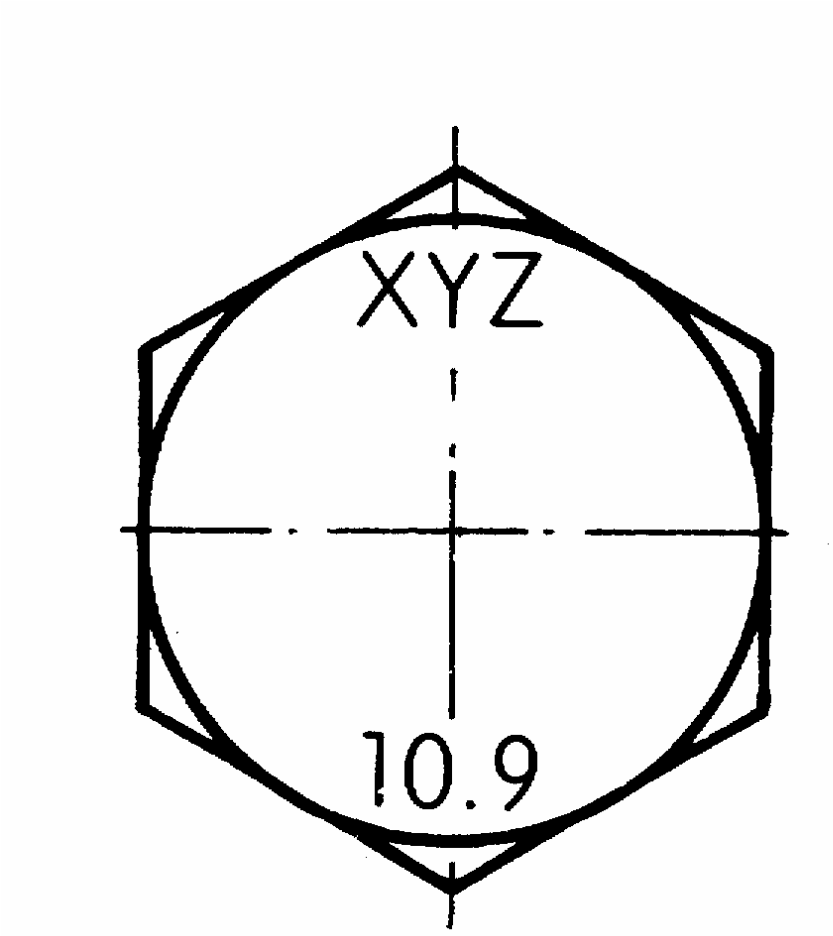


Thread tolerance 5g6g (4g6g)



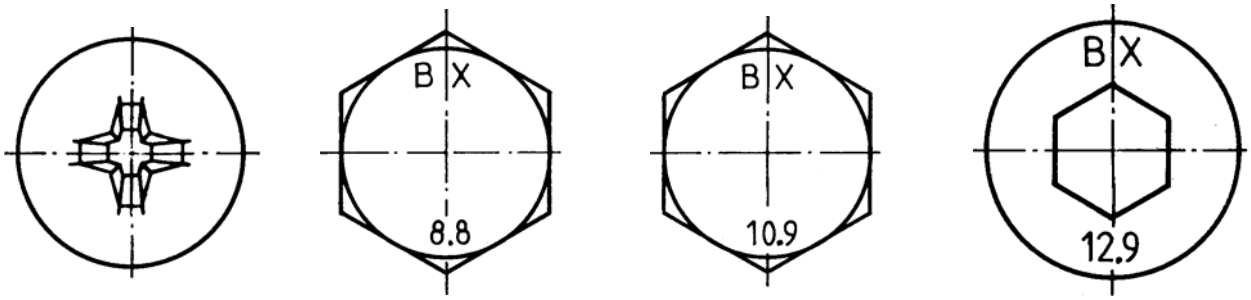
METRIC FASTENERS

Identifying metric bolts



8.8	10.9	12.9

Metric Mechanical Property Classes



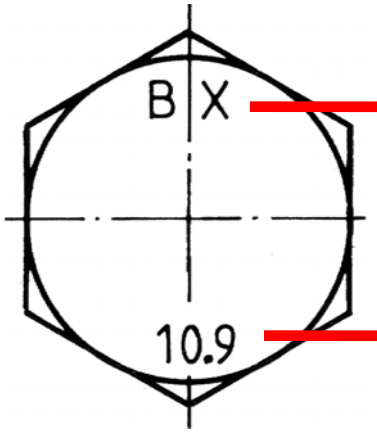
Class	Ref.	Min. Yield Str. MPa	Min. Tensile Str. MPa	Factor	Min. Yield Str. psi	Min. Tensile Str. psi
4.8		340	420	145	49300	60900
5.8	Gr. 2	420	520	145	60900	75400
8.8 ≤ M16 > M16	Gr. 5	 640 660	 800 830	 145 145	 92800 95700	 116000 120350
9.8	over Gr. 5	720	900	145	104400	130500
10.9	Gr. 8	940	1040	145	136300	150800
12.9	ref. ASTM A 574	1100	1220	145	159500	176900

METRIC FASTENERS

Interpretation of metric property class markings

Marking:

BOLTS/ SCREWS



Manufacturer's ID

Property class marking

10 x 100 = 1000 N/mm2 (MPa)

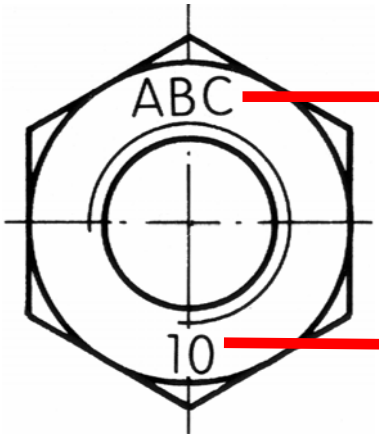
= tensile strength (nominal)

10 x 0.9 x 100 = 900 N/mm2 (MPa)

= yield strength (nominal)

Factor to convert to psi = 145

NUTS



Manufacturer's ID

Property class marking

10 x 100 = 1000 N/mm2 (MPa)
= proof stress

Property class of nut always equal or higher the property class of bolt

Metric Stainless Steel Fasteners

Stainless steels for Metric fasteners are grouped into 3 material groups:

- **Austenitic**
- **Ferritic**
- **Martensitic**

98% of Metric Fasteners are made from austenitic stainless steels.

Austenitic group:

Divided into 3 sub-groups:

A2

A4

A1

Austenitic group

= 17 - 19% Chromium

8 - 13% Nickel

Nicknamed: " 18 / 8 "

Offers good corrosion resistance

AISI 304 / 321 meet requirement of A2

= 16 - 18.5% Chromium

10 - 14% Nickel

2 - 3% Molybdenum

Offers high corrosion resistance
2 - 3% molybdenum alleviates risk of pitting

AISI 316 meets requirement of A4

A1 = A2 with added sulfur = free machineable

Definitions per ISO and DIN

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Stainless steel property class

Mechanical property indicated by numbers

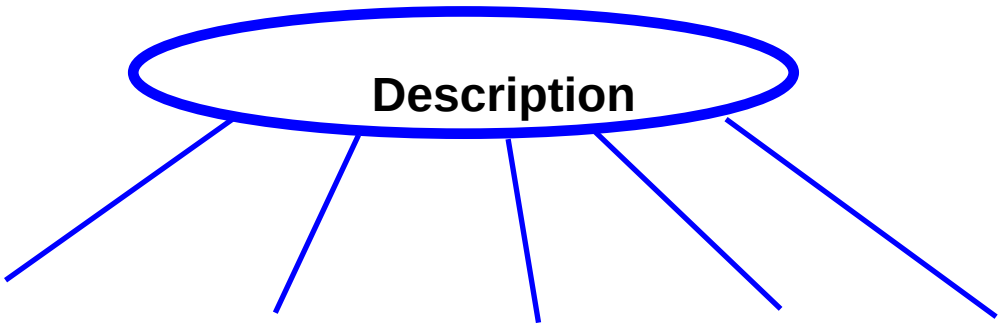
A2- 50 A4- 50 → **- when machined**
- larger sizes, generally above M20
- and/or length above 8 x d

A2-70 A4-70 → **readily available**

A2- 80 A4- 80 → **special**

A2 - 70 → **10% of tensile strength in MPa (N/mm^2)**

PROPER METRIC FASTENER DESCRIPTION



Item | Standard | Property cl. (Material) | Finish | Size

Hex cap screw - DIN 933 - 8.8 - zinc pl. - M8x20

or or or

ISO 4017 A2-70 black

or

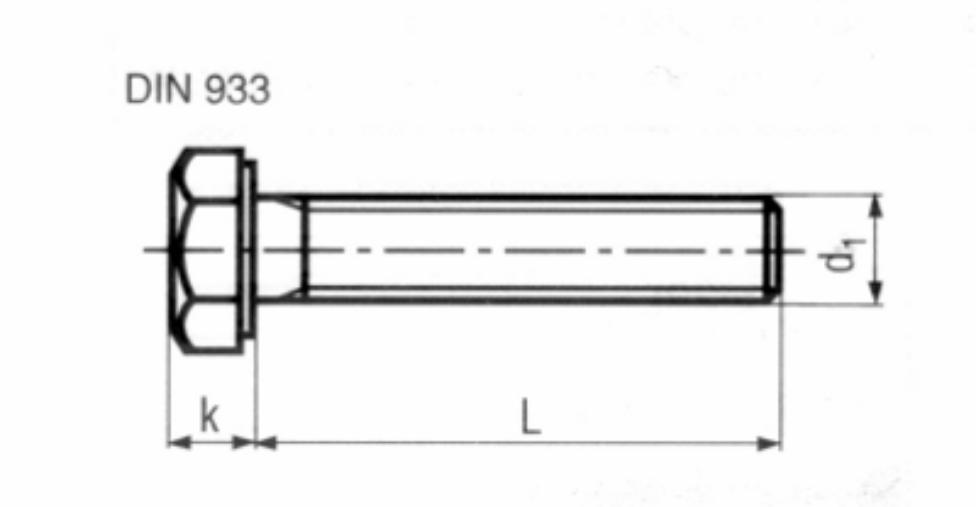
ANSI B18.2.3.1M

Or use

BN numbers

Example:

BN number 54 = Hex cap screw DIN 933 property class 8.8 black



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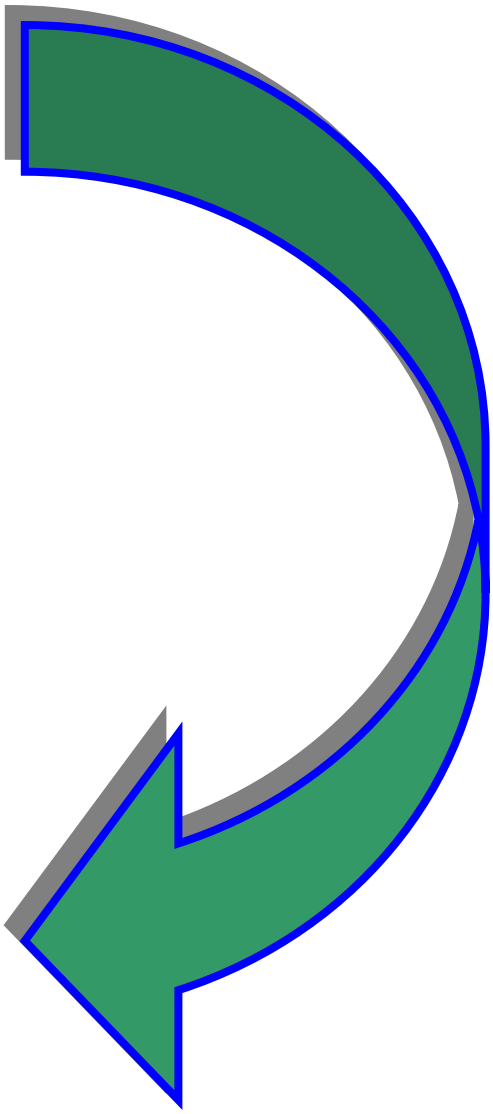
Think Global



Think Metric