Nuts And Bolt Spec. for all frame connections

a. Metric fastener size designation.

i. **Metric fastener size designation nomenclature**. As fully explained in ISO 965-1, Sect. 5, metric fastener size designations always begin with capital M or MJ followed by fastener nominal diameter and thread pitch, both in units of millimeters (mm), separated by the symbol "x", as follows. M10 x 1.5-6g-S means metric fastener thread profile M, fastener nominal size (nominal major diameter) 10 mm, thread pitch 1.5 mm, *external* thread tolerance class 6g, and thread engagement length group S ("short"). If referring to *internal* thread tolerance, "g" would be capitalized. A fit between threaded parts is indicated by internal thread tolerance class followed by external thread tolerance class separated by a slash; e.g., M10 x 1.5-6H/6g.

ii. **Default metric fastener thread pitch and engagement length**. If metric thread pitch designation (e.g., " x 1.5") is omitted, it specifies coarse pitch threads. For example, M10 or M10-6g, by default, specifies M10 x 1.5. The standard metric fastener thread series for general purpose threaded components is the M thread profile and the coarse pitch thread series. If thread engagement length group designation (e.g., "-S") is omitted, it specifies thread engagement length group N meaning "normal."

iii. **Default metric fastener thread tolerance class**. If thread tolerance class designation (e.g., "-6g") is omitted (e.g., M10 x 1.5), it specifies "medium" thread tolerance, which is 6H/6g. The 6H/6g fit is the standard ISO tolerance class for general use.

iv. **Equivalent imperial thread tolerance classes**. Imperial internal and external thread tolerance class 2B/2A is essentially equivalent to ISO thread tolerance class and fit 6H/6g. Imperial tolerance class

3A is approximately equivalent to ISO tolerance class 4g6g, though class fit 3B/3A is approximately equivalent to ISO class fit 4H5H/4h6h. For full details, see ISO 965-1, Sects. 5.2, 7, and 12.

v. **Metric fastener thread profile compatibility**. Metric fastener thread profile M is the normal, commercially-available thread profile. Thread profile MJ designates the *external* thread has an increased root radius (shallower root relative to external M thread profile), thereby having higher fatigue strength (due to reduced stress concentrations), but requires the truncated crest height of the MJ internal thread to prevent interference at the external MJ thread root (just as the UNJ external thread profile requires the UNJ internal thread). However, M external threads are compatible with M *and* MJ internal threads (just as UN and UNR external threads are compatible with UN *and* UNJ internal threads).

b. **ISO metric fastener material strength property classes (grades)**. As given in ISO 898-1, ISO metric fastener material property classes (grades) should be used. For example, fastener material ISO property class 5.8 means nominal (minimum) tensile ultimate strength 500 MPa and nominal (minimum) tensile yield strength 0.8 times tensile ultimate strength or 0.8(500) = 400 MPa. (In a few cases, the actual tensile ultimate strength may be approximately 20 MPa higher than nominal tensile ultimate strength indicated via the nominal property class code. Consult Table 10, below, for exact values.) Many anchor bolts (L, J, and U bolts, and threaded rod) are made from low carbon steel grades, such as ISO classes 4.6, 4.8, and 5.8.

c. **Preferred diameters**. Preferred nominal diameters for bolts and threaded rod are as listed below. The fourth series listed below should be limited to unusual requirements when none of the preceding series can be used. Reference individual standards prior to specification. Sizes M5 to M45 are commonly used in construction.

Nuts And Bolt Spec. for all frame connections

a. First choice:	a. M2 2.5 3 4 5 6 8 10 12 16 20 24 30 36 42
a. Second choice:	a. M3.5 14 18 22 27 33 39 45
a. Third choice:	a. M15 17 25 40
a. Avoid:	a. M7 9 11 26 28 32 35 38

u. Bolt versus screw definition. The correct definition of bolt and screw is as follows. Bolts are headed fasteners having external threads that meet an exacting, uniform bolt thread specification (such as M, MJ, UN, UNR, and UNJ) such that they can accept a nontapered nut. Screws are headed, externally-threaded fasteners that do not meet the above definition of bolts. For full discussion of misdefinitions and corresponding confusion regarding these two words, see details.

d. Handy conversion factors. Imperial conversion factors, verified accurate to the decimal places shown via multiple, independent, credible sources, are 25.4 mm/inch (exact), 4.4482216152605 N/lbf, 6.89475729318 MPa/ksi, 47.880259 Pa/psf, 112.98483 (N mm)/(in lbf), 157.08746 (N/m^3)/pcf, 16.0184634 (kg/m^3)/(lbm/ft^3), 27679.9047 (kg/m^3)/(lbm/in^3), 9.80665 (m/s^2)/gravity (exact). Rounding these conversion factors to a few less decimal places, we have 4.448222 N/lbf, 6.89476 MPa/ksi, 47.8803 Pa/psf, 113.0 (N mm)/(in lbf), 157.087 (N/m^3)/pcf, 16.01846 (kg/m^3)/(lbm/ft^3), 27679.9 (kg/m^3)/(lbm/in^3).

e. Metric system (SI). The abbreviation for the metric system is SI, the International System of Units (from the French, *Systeme International d'Unites*). It evolved from the original French metric system and is currently being used virtually worldwide. Long the language universally used in science and among

technically adept individuals, SI has also become the dominant language of international commerce and trade. All new USA standards (ASTM, ANSI, SAE, IEEE, ASME, etc.) are now written in metric, as the lead engineers in these organizations recognize the importance of trying to get the USA on track with technically advanced countries, in an effort to regain lost USA competitiveness in a global economy, as there is essentially no global market for the archaic, oddball, incompatible product dimensions USA arbitrarily comes up with, while they forfeit industries and jobs to third-world countries who have no problem understanding something so simple and fulfilling the need efficiently. IEEE was intelligent enough to recognize this decades ago. Japan also was intelligent enough to recognize simple matters such as this long ago. This small country, defeated in WWII only 60 years ago, has since captured a large portion of the global economy due to their intelligent progress, and consequently has become a major global financier, while USA has become a world-class debtor to the tune of trillions due to inefficient business practices, low educational level, slackerism, and inability to solve or understand even simple problems such as metric conversion.

8. Fastener Data. Tables 9 and 10 provide much of the data available for different metric fasteners. Table 9 comes verbatim from Ref. 1, including what appear to be a few typos, marked "[sic]," below. Table 10, on the other hand, has been verified accurate per ISO 898-1 and ASTM F 568M.

Table 9

FASTENER DATA

Nuts And Bolt Spec. for all frame connections

Basic Product	Product Type and Head Style	Available Size Range	For thread and dimension details refer to:	For mechanical property details refer to Table 10 or:
Metric Bolts	hex	M5-M100	ANSI/ASME B18.2.3.5M	ASTM F568M ASTM F486M ASTM F738M
	heavy hex	M12-M36	ANSI/ASME B18.2.3.6M	
	round head short square neck (carriage)	M8-M20	ANSI/ASME B18.5.2.1M	
	round head square neck (carriage)	M5-M24	ANSI/ASME B18.5.2.2M	
	bent	M5 and larger	IFI 528 [sic]	
	heavy hex structural	M12-M36	ANSI/ASME B18.2.3.7M	ASTM A325M ASTM A490M
	hex transmission tower	M16-M24	IFI 541 [sic]	IFI 541 [sic]

Nuts And Bolt Spec. for all frame connections

Metric Screws	hex cap	M5-M100	ANSI/ASME B18.2.3.1M	ASTM F568M ASTM F468M ASTM F738M
	formed hex	M5-M24	ANSI/ASME B18.2.3.2M	
	heavy hex	M12-M36	ANSI/ASME B18.2.3.3M	
	hex flange	M5-M16	ANSI/ASME B18.2.3.4M	
	heavy hex flange	M10-M20	ANSI/ASME B18.2.3.9M	
	hex lag	M5-M24	ANSI/ASME B18.2.3.8M	see note 3 [sic]
Metric Studs	double end	M5-M100	IFI 528 [sic]	ASTM F568M ASTM F468M ASTM F736M
	continuous thread	M5-M100		
Metric Locking Screws	prevailing torque, non-metallic insert	M1.6-M36	see note 3 [sic]	IFI 524
	chemical coated	M6-M20	see note 3 [sic]	IFI 525

Nuts And Bolt Spec. for all frame connections

Metric Socket Screws	socket head cap	M1.6-M48	ANSI/ASME B18.3.1M	ASTM A574M ASTM F837M
	socket head shoulder	M6.5-M25	ANSI/ASME B18.3.3M	ASTM F835M ASTM A574M ASTM F879M
	socket button head cap	M3-M16	ANSI/ASME B18.3.4M	
	socket countersunk head cap	M3-M20	ANSI/ASME B18.3.5M	
	socket set	M1.6-M24	ANSI/ASME B18.3.6M	ANSI/ASME B18.3.6M ASTM F912M ASTM F880M
Metric Nuts	hex, style 1	M1.6-M36	ANSI/ASME B18.2.4.1M	ASTM A563M ASTM F467M ASTM F836M ASTM A194M
	hex, style 2	M3-M36	ANSI/ASME B18.2.4.2M	
	slotted hex	M5-M36	ANSI/ASME B18.2.4.3M	

Nuts And Bolt Spec. for all frame connections

	hex flange	M5-M20	ANSI/ASME B18.2.4.4M	
	hex jam	M5-M36	ANSI/ASME B18.2.4.5M	
	heavy hex	M12-M100	ANSI/ASME B18.2.4.6M	
Metric Prevailing-Torque Nuts	hex, steel	M3-M36	ANSI/ASME B18.16.3M	ANSI/ASME B18.16.1M ANSI/ASME B18.16.2M
	hex flange, steel	M6-M20		

Notes for Table 10.

a. When only the ISO property class number is shown in Table 10, below, the class is standard in both ISO 898-1 and ASTM documents. Properties specified in each are identical except for minor exceptions. Where differences exist, the ASTM F 568M values are given.

b. To compute the tensile proof load, tensile yield strength, or tensile ultimate strength in kilonewtons (kN) for a bolt, screw, or stud, multiply the stress value (MPa) in Table 10 by the tensile stress area (mm^2) of the product's screw thread as given in Table 9 or Standard Metric Bolt Shank Dimensions, then divide this result by 1000.

c. In general, identification markings are located on the top of the head and preferably are raised.

d. Class 5.8 products are available in lengths 150 mm and less.

e. Caution is advised when considering the use of property class 12.9 products. The capabilities of the fastener manufacturer, as well as the anticipated service environment, should be carefully considered. Some environments may cause stress corrosion cracking of nonplated, as well as electroplated, products.

Table 10

MECHANICAL REQUIREMENTS FOR CARBON STEEL EXTERNALLY-THREADED METRIC FASTENERS

Property Class Designation	Nominal Size of Product	Material and Treatment	Mechanical Requirements						Property Class Ident. Marking
			Proof Load Stress, MPa	Tensile Yield Strength, MPa, Min.	Tensile Ultimate Strength, MPa, Min.	Prod. Hardness, Rockwell			
						Surface, Max.	Core		
							Min.	Max.	
4.6	M5-M100	low or medium carbon steel	225	240	400	--	B67	B95	4.6

Nuts And Bolt Spec. for all frame connections

4.8	M1.6-M16	low or medium carbon steel, fully or partially annealed	310	340	420	--	B7 1	B9 5	4.8
5.8	M5-M24	low or medium carbon steel, cold worked	380	420	520	--	B8 2	B9 5	5.8
8.8	M16-M72	medium carbon steel, quenched and tempered	600	660	830	30N5 6	C2 3	C3 4	8.8
A325M Type 1	M16-M36								A325M 8S
8.8	M16-M36	low carbon boron steel, quenched and tempered	600	660	830	30N5 6	C2 3	C3 4	8.8
A325M Type 2									A325M 8S
A325M Type 3	M16-M36	atmospheric corrosion resistant steel, quenched and tempered	600	660	830	30N5 6	C2 3	C3 4	A325M 8S3

Nuts And Bolt Spec. for all frame connections

9.8	M1.6-M16	medium carbon steel, quenched and tempered	650	720	900	30N58	C27	C36	9.8
9.8	M1.6-M16	low carbon boron steel, quenched and tempered	650	720	900	30N58	C27	C36	9.8
10.9	M5-M20	medium carbon steel, quenched and tempered	830	940	1040	30N59	C33	C39	10.9
10.9	M5-M100	medium carbon alloy steel, quenched and tempered	830	940	1040	30N59	C33	C39	10.9
A490M Type 1	M12-M36								A490M 10S
10.9	M5-M36	low carbon boron steel, quenched and tempered	830	940	1040	30N59	C33	C39	10.9
A490M Type 2	M12-M36								A490M 10S

Nuts And Bolt Spec. for all frame connections

A490M Type 3	M12-M36	atmospheric corrosion resistant steel, quenched and tempered	830	940	1040	30N59	C33	C39	A490M 10S3
12.9	M1.6-M100	alloy steel, quenched and tempered	970	1100	1220	30N63	C38	C44	12.9