1. Standards

The aim of standardization is to reduce technical and commercial differences in products, define and unify right concepts and ways of expressions and to find right products and procedures for both parties. Standardization leads to easier global trade and increase of safety and wellfare.

DIN German national standard (Deutsches Institut für Normung). DIN-numbers are still valid for products which do not have ISO- or EN-standard.

ISO International standard (International Standardization Organisation). Many DIN-standard have formed basis for ISO-standards.

DIN ISO German national version of ISO-standard where to many ISO-numbers have been taken unchanged.

EN Euroapean standard (CEN = Comité Européen de Normalisation). Valid ISO-standards have been taken to use unchanged in EN-standards as far as possible. If EN-standard differs from ISO-standard, product specification is done according to EN-standard.

DIN EN German national version of EN-standard unchanged. According to Euroapean Council's decision, member countries of Euroapean Union take EN-standards into use unchanged. Corresponding national standards are cancelled simultaneously. If EN-standard differs from ISO-standard, product specification is done according to EN-standard.

EN ISO Euroapean version of ISO-standard unchanged. EN- and ISO-numbers are identical, former procedure "ISO-number + 20 000" have not been valid since 1/95. In exception are the standards that are in the conversation procedure. Product specification is done according to ISO-standard.

DIN EN ISO German national version of EN ISO-standard unchanged.. Product specification is done according to ISO-standard.

SFS Finnish national standard. Applying of International and Euroapean standards as shown above.

In fasteners business the most commonly used in standards areDIN- and ISO-standards. DIN- and ISO-standards differences in product dimensions:

DIN	ISO	Item	Differences
1	2339	Taper pin	Usually replaceable. Lenght in DIN-standard do not include pin´s ends.
7	2338	Parallel pin	Usually replaceable. Lenght in DIN-standard do not include pin´s ends.
84	1207	Slotted cheese head screw	Differences in head dimensions
85	1580		Differences in head dimensions
94	1234	Splint pin	-
125	7089	Washer	Nominal dimensions based on thread diameter (ISO) , or on hole diameter (DIN). No dimensional differences
126	7090	Washer	Nominal dimensions based on thread diameter (ISO) , or on hole diameter (DIN). No dimensional differences
127	-	Spring washer	-
314 **315** **316** **318**	-	Wing nut	-
417	7435	Slotted grub screw with full dog point	Usually replaceable
427	2342	slotted headless screw with chamfered end	Usually replaceable
433	7092	Washer	-
434 **435** **436**	-	Square washer	-
438	7436	Countersank head rivet	No dimensional differences
439	7435	Hexagon nut	Usually replaceable
440	7094	Spring washer	No dimensional differences
444	-	Eye bolt	-
471	-	Retaining bolt	-
472	-	Retaining ring for bore	-
551	4766	Slotted grub screw with flat point	No dimensional differences
553	7434	Slotted set screw with cone point	No dimensional differences
555	4034	Hexagon nut	Differences in width across flats and in height of the nut. **Look DIN-ISO detailed comparison.**
558	4018	Hexagon screw	No dimensional differences

DIN	ISO	Item	Differences
580	3266	Lifting eye bolt	No dimensional differences.
601	4016	Hexagon bolt	
603	8677	Mushroom head square head bolt	-
906 **908** **910**	-	Pipe plug	-
912	4762	Hexagon socket head screw	No dimensional differences
914	4027	Hexagon socket set screw	No dimensional differences
916	4029	hexagon socket set screw, cup point	No dimensional differences
929	-	Hexagon weld nut	-
931	4014	Hexagon bolt	Differences in width across flats (M10, 12, 14 and 22). Usually replacaple
933	4017	Hexagon head bolt	Differences in width across flats (M10, 12, 14 and 22). Usually replacaple
934	4032	Hexagon nut	Differences in width across flats and in height of the nut (M10, 12, 14 and 22). **Look DIN-ISO detailed comparison.**
935	-	Hexagon slotted and castle nut	-
938 **939**	-	Stud	-
960	8765	Hexagon bolt, metric fine pitch thread	-
961	8676	Hexagon screw, metric fine pitch thread	-
963	2009	Slotted countersank head screw	Differences in head dimensions
964	2010	slotted raised countersank head screw	Differences in head dimensions
965	7046	Cross recessed countersank head screw	Differences in head dimensions
966	7047	Cross recessed countersank head screw	Differences in head dimensions
971	4034	Hexagon nut	-
975	-	Threaded rod	-
976	-	Threaded rod	-
980	7042	Selflocking hex. nut	-
985	10511	selflocking hex. nut	
1440	8738	Washer	Usually replaceable
1441	8738	Washer	-
1481	8752	Spring type straight pin	Chamfer in both ends: ISO D<10mm, DIN D<6mm
6325	8734	Parallel pin	-
6914	7412	HV Hexagon nut	-
6915	7414	HV hexagon nut	-
6916	7416	HV washer	-
7504	15480 15481 15482	Selfdrilling screw, hexagon head selfdrilling screw, pan head Selfdrilling screw, countersank head	-
7976	1479	Hexagon head tapping screw	Differences in head dimensions
7978	8736	Taper pin with internal thread	-
7980	-	single coil spring washer	-
7981		Cross recessed pan head tapping screw	Differences in head dimensions
7982	7050	Cross recessed countersank head tapping screw	Differences in head dimensions. Countersank head: ISO 90°, DIN 80°
7983	7051	Cross recessed raised countersank head tapping screw	Differences in head dimensions. Countersank head: ISO 90°, DIN 80°
7985	7045	Cross recessed raised countersank head screw	Differences in head dimensions.
9021	7093	Spring washer	Nominal dimensions based on thread diameter (ISO), or on hole diameter (DIN). Usually replaceable.

DIN-ISO standards detailed comparison

Across flats in hexagon head screws/nuts. (DIN 439, 557, 562, 917, 931, 933, 934, 935, 979, 980, 982, 985, 986, 1587, 6330, 6331, 6923).

	Width across flats		Nuts height min-max			
d	DIN	ISO	DIN 555	ISO 4034	DIN 934	ISO 4032 8673
M 1	2,5	-	-	0,55 - 0,8	-	-
M 1,2	3		-	-	0,75-1	-
M 1,4	3		-	-	0,95-1,2	-
M 1,6	3,2		-	-	1,05-1,3	1,05-1,3
M 2	4		-	-	1,35-1,6	1,35-1,6
M 2,5	5		-	-	1,75-2	1,75-2
M 3	5,5		-	-	2,15-2,4	2,15-2,4
M 3,5	6		-	-	2,55-2,8	2,55-2,8
M 4	7		-	-	2,9-3,2	2,9-3,2
M 5	8		3,4-4,6	4,4-5,6	3,7-4	4,4-4,7
M 6	10		4,4-5,6	4,6-6,1	4,7-5	4,9-5,2
M 7	11		-	-	5,2-5,5	-
M 8	13		5,75-7,25	6,4-7,9	6,14-6,5	6,44-6,7
M 10	17	16	7,25-8,75	8-9,5	7,64-8	8,04-8,4
M 12	19	18	9,25-10,75	10,4-12,2	9,64-10	10,37-10,8
M 14	22	21	-	12,1-13,9	10,3-11	12,1-12,8
M 16	24		12,1-13,9	14,1-15,9	12,3-13	14,1-14,8
M 18	27		-	15,1-16,9	14,3-15	15,1-15,8
M 20	30		15,1-16,9	16,9-19	14,9-16	16,9-18
M 22	32	34	17,1-18,9	18,1-20,2	16,9-18	18,1-19,4
M 24	36		17,95-20,05	20,2-22,3	17,7-19	20,2-21,5
M 27	41		20,95-23,05	22,6-24,7	20,7-22	22,5-23,8
M 30	46		22,95-25,05	24,3-26,4	22,7-24	24,3-25,6
M 33	50		24,95-27,05	27,4-29,5	24,7-26	27,4-28,7
M 36	55		27,95-30,05	28-31,5	27,4-29	29,4-31
M 39	60		29,75-32,25	31,8-34,3	29,4-31	31,8-33,4
M 42	65		32,75-35,25	32,4-34,9	32,4-34	32,4-34
M 45	70		34,75-37,25	34,4-36,9	34,4-36	34,4-36
M 48	75		36,75-39,25	36,4-38,9	36,4-38	36,4-38
M 52	80		40,75-43,25	40,4-42,9	40,4-42	40,4-42

hex nut DIN 439 - ISO 4035: no dimensional differences.

National standards in different countries:

Country	Standard
Algeria	IANOR
Argentina	IRAM
Australia	SAI
Austria	ON
Bangladesh	BSTI
Belgium	IBN
Brazil	ABNT
Bulgaria	BDS
Canada	SCC
Chile	INN
China	CSBTS
Columbia	ICONTEC
Cuba	NC
Cyprus	CYS
Czech	CSNI
Denmark	DS
Egypt	EOS
Ethiopia	QSAE
Europe	EN
Finland	SFS
France	AFNOR
Germany	DIN
Ghana	GSB
Greece	ELOT
Hungary	MSZT
India	BIS
Indonesia	BSN
International	ISO
Iran	ISIRI
Ireland	NSAI
Israel	SII
Italy	UNI
Jamaica	JBS
Japan	JISC
Kenya	KEBS

Country	Standard
Korea, Dem. P. Rep. of	CSK
Korea, Rep. of	KATS
Libya	LNCSM
Malaysia	DSM
Mexico	DGN
Mongolia	MNCSM
Marocco	SNIMA
Netherlands	NEN
New Zealand	SNZ
Nigeria	SON
Norway	NSF
Pakistan	PSI
Philippines	BPS
Poland	PKN
Portugal	IPQ
Russia	GOST
Romania	ASRO
Saudi Arabia	SASO
Singapore	PSB
South Africa	SABS
Spain	AENOR
Sri Lanka	SLSI
Sweden	SIS
Switzerland	SNV
Syria	SASMO
Tanzania	TBS
Thailand	TISI
Trinidad & Tobago	TTBS
Turkey	TSE
United Kingdom	BSI
USA	ANSI
Uzbekistan	UZGOST
Venezuela	FONDONORMA
Vietnam	TCVN
Yugoslavia	SZS

Technical delivery conditions and basic standards:

DIN (old)	ISO	DIN (new) or DIN EN	Content
DIN 267 Part 20	-	DIN EN 493	Fasteners, surface defects, nuts
DIN 267 Part 21	-	DIN EN 493	Fastener elements, surface defects, nuts
DIN ISO 225	225	DIN EN 20225	Fasteners - Bolts, screws, studs and nuts. Symbols and designations of dimensions (ISO 225: 1991)
DIN ISO 273	273	DIN EN 20273	Fasteners - Clearance holes for bolts and screws (ISO 273:1991)
DIN ISO 898 Part 1	898 1	DIN EN 20898 Part 1	Mechanical properties of fasteners (ISO 898-1: 1988)
DIN 267 Part 4	898 2	DIN ISO 898 Part 2	Mechanical properties of fasteners - Part 2: Nuts with specified proof load values (ISO 898-2: 1992)
DIN ISO 898 Part 6	898 6	DIN EN 20898 Part 6	Mechanical properties of fasteners - Part 6: Nuts with specified proof load values. Fine pitch thread (ISO 898-6: 1988)
DIN 267 Part 19	6157-1	DIN EN 26157 Part 1	Fasteners - Surface discontinuities - Part 1: Bolts, screws and studs for general requirements (ISO 6157-1: 1988)
DIN 267 Part 19	6157-3	DIN EN 26157 Part 3	Fasteners - Surface discontinuities - Part 3: Bolts, screws and studs for special requirements (ISO 6157-3: 1988)
DIN ISO 7721	7721	DIN EN 27721	Countersunk head screws - Head confirugation and gauging (ISO 7721: 1983)
DIN 267 Part 9	-	DIN ISO 4042	Fasteners - Electroplated coatings
DIN 267 Part 19	-	DIN ISO 8992	Fasteners - General requirements for bolts, screws, studs and nuts
DIN 267 Part 5	-	DIN ISO 3269	Mechanical fastening elements - acceptance inspection
DIN 267 Part 11	-	DIN ISO 3506	Stainless steel fasteners - technical delivery conditions
DIN 267 Part 12	-	DIN EN ISO 2702	Heat-treated steel tapping screw. Mechanical properties.
DIN 267 Part 18	8839	DIN EN 28839	Mechanical properties of fasteners - bolts, screws, studs and nuts made of non-ferrous metals (ISO 8839: 1986)

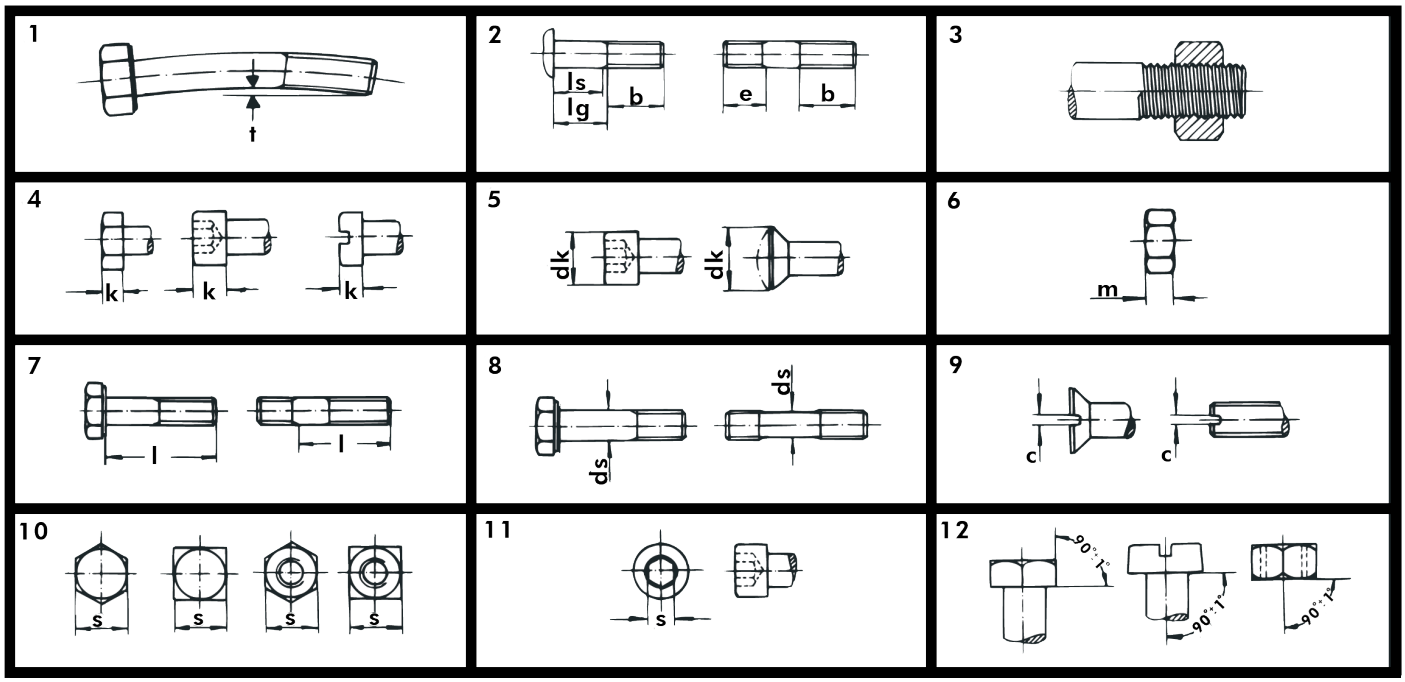
2. Tolerances

Product's dimensions are impossible to manufacture exactly right. Although products used in different machines and applications have to be accurate enough to fullfill three main requirements:

- products have to function as required
- products have to be compatible so that machine or application can be assembled
- products have to be replaceable for example maintenance work done later on

These requirements are met by using acceptable variation in dimensions in manufacturing, known also as tolerances.

Main dimensional and geometrical tolerances for fasteners are shown in the following table:



Pict	Feature		Symbol	Additional info	Size	Product class A (previously "m")	Product class B (previously "mg")	Product class C (previously "g"	NOTE!
1	Straightness		t	l = nominal length b = thread length	d ≤ 8	0,0020 l + 0,05		2 X (0,0020 b + 0,05)	
					d > 8	0,0025 l + 0,05		2 X (0,0025 b + 0,05)	
2	Thread length		b	P = pitch ls = non-threaded min length lg = non-threaded max length		0...+2P*			* tolerace +2P is valid only if ls or lg is not specified in product standard
		stud bolt	e			js16	js17	js17	
3	Thread tolerance	nut				6H		7H	
		screw				6g		8g	
4	Head height	outside drive	k		k < 10	js14	js15	js16	
					k ≥ 10			js17	
		inside drive	k		M ≤ 5	h13	-	-	
					M > 5	h14			
5	Head diameter		dk			h13*	h14	-	* in machine screws h14
6	Nut's height		m		≤ M12	h14		h17	
					> M12 ≤ M18	h15			
					> M18	h16			
7	Nominal length		l		l ≤ 150	js15*	js17	js17	* in machine screws l > 50 js16
					l > 150			2 X js17	
8	Shank diameter		ds			h13	h14	± IT15	
9	Slot width*		n		n ≤ 1	+0,06...+0,20	-	-	* depth of slots and sockets: see product standards
					1 < n ≤ 3	+0,06...+0,31			
					3 < n ≤ 6	+0,07...+0,37			
10	Width across flats	outside drive	s			s ≤ 32 → h13 s > 32 → h14	s ≤ 19 → h14 19 < s ≤ 60 → h15 60 < s ≤ 180 → h16 s > 180 → h17		
11		inside drive	s			s = 0,7 → EF8 s = 0,9 → JS9 s = 1,3 → K9 s = 1,5...2,0 → D10 (D9*) s = 2,5 → D11 (D10*) s = 3,0 → D11 s = 4,0 → E11 s = 5,0...14,0 → E12 (E11*) s > 14,0 → D12	-		* tolerance range for socket set screws
12	Angle		90°		M ≤ 39	± 1°		± 2°	
					M > 39	± 1/2°		± 1°	
					Screws acc. to DIN-standard	84, 85, 444C, 478, 479, 480, 561, 564, 609, 610, 653, 787, 835, 912, 931, 933, 938, 939, 940, 960, 961, 963, 964, 965, 966, 6912, 7380, 7513, 7516, 7971-7985, 7991	444B 609, 610 ≥ M12, 931, 933 > M24 960, 961 L>10d/>150mm	95, 96, 97, 186, 188, 261, 316, 444A, 525, 529, 558, 571, 601, 603, 604, 605, 607, 608, 6914, 7968, 7969, 7990, 11014	
					Nuts acc. to DIN-standard	439, 466, 467, 917, 934, 935, 936, 937, 979, 980, 982 ≤ M12, 985 ≤ M12, 986, 1587, 6330, 6331	439, 562, 934, 935, 936, 980 ≥ M16, 982 ≥ M16, 985 ≥ M16, 1587, 6915, 7965	314, 315, 555, 557, 935	

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Standard tolerances and tolerance fields for internal and external dimensions:

Nominal (mm)		Standard tolerances (mm)							Tolerance fields for internal dimensions (mm)											
>	≤	IT11	IT12	IT13	IT14	IT15	IT16	IT17	D12	F8	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15
	3	0,06	0,1	0,14	0,25	0,4	0,6	1	+0,12 +0,02	+0,02 +0,006	+0,006 0	+0,01 0	+0,014 0	+0,025 0	+0,04 0	+0,06 0	+0,1 0	+0,14 0	+0,25 0	+0,4 0
3	6	0,075	0,12	0,18	0,3	0,48	0,75	1,2	+0,15 +0,03	+0,028 +0,01	+0,008 0	+0,012 0	+0,018 0	+0,03 0	+0,048 0	+0,075 0	+0,12 0	+0,18 0	+0,3 0	+0,48 0
6	10	0,09	0,15	0,22	0,36	0,58	0,9	1,5	+0,19 +0,04	+0,035 +0,013	+0,009 0	+0,015 0	+0,022 0	+0,036 0	+0,058 0	+0,09 0	+0,15 0	+0,22 0	+0,36 0	+0,58 0
10	18	0,11	0,18	0,27	0,43	0,7	1,1	1,8	+0,23 +0,05	+0,043 +0,016	+0,011 0	+0,018 0	+0,027 0	+0,043 0	+0,07 0	+0,11 0	+0,18 0	+0,27 0	+0,43 0	+0,7 0
18	30	0,13	0,21	0,33	0,52	0,84	1,3	2,1	+0,275 +0,065	+0,053 +0,02	+0,013 0	+0,021 0	+0,033 0	+0,052 0	+0,084 0	+0,13 0	+0,21 0	+0,33 0	+0,52 0	+0,84 0
30	50	0,16	0,25	0,39	0,62	1	1,6	2,5	+0,33 +0,08	+0,004 +0,025	+0,016 0	+0,025 0	+0,039 0	+0,062 0	+0,1 0	+0,16 0	+0,25 0	+0,39 0	+0,62 0	+1 0
50	80	0,19	0,3	0,46	0,74	1,2	1,9	3	+0,4 +0,1	+0,076 +0,03	+0,019 0	+0,03 0	+0,046 0	+0,074 0	+0,12 0	+0,19 0	+0,3 0	+0,46 0	+0,74 0	+1,2 0
80	120	0,22	0,35	0,54	0,87	1,4	2,2	3,5	+0,47 +0,12	+0,09 +0,036	+0,022 0	+0,035 0	+0,054 0	+0,087 0	+0,14 0	+0,22 0	+0,35 0	+0,54 0	+0,87 0	+1,4 0
120	180	0,25	0,4	0,63	1	1,6	2,5	4	+0,545 +0,145	+0,106 +0,043	+0,025 0	+0,04 0	+0,063 0	+0,1 0	+0,16 0	+0,25 0	+0,4 0	+0,63 0	+1 0	+1,6 0
180	250	0,29	0,46	0,72	1,15	1,85	2,9	4,6	+0,63 +0,17	+0,122 +0,05	+0,029 0	+0,046 0	+0,072 0	+0,115 0	+0,185 0	+0,29 0	+0,46 0	+0,72 0	+1,15 0	+1,85 0
250	315	0,32	0,52	0,81	1,3	2,1	3,2	5,2	+0,71 +0,19	+0,137 +0,056	+0,032 0	+0,052 0	+0,081 0	+0,13 0	+0,21 0	+0,32 0	+0,52 0	+0,81 0	+1,3 0	+2,1 0
315	400	0,36	0,57	0,89	1,4	2,3	3,6	5,7	+0,78 +0,21	+0,151 +0,062	+0,036 0	+0,057 0	+0,089 0	+0,14 0	+0,23 0	+0,36 0	+0,57 0	+0,89 0	+1,4 0	+2,3 0
400	500	0,4	0,63	0,97	1,55	2,5	4	6,3	+0,86 +0,23	+0,165 +0,068	+0,04 0	+0,063 0	+0,097 0	+0,155 0	+0,25 0	+0,4 0	+0,63 0	+0,97 0	+1,55 0	+2,5 0

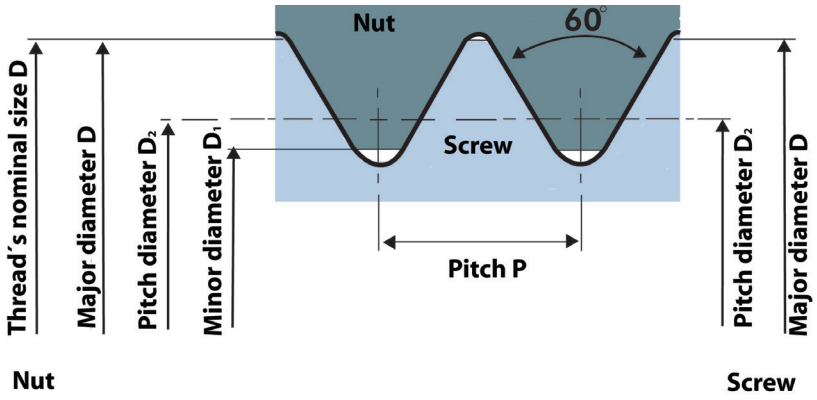
Nominal (mm)		Tolerance fields for external dimensions (mm)																
>	≤	f9	h6	h7	h8	h9	h10	h11	h12	h13	h14	h15	h16	h17	js14	js15	js16	js17	m6
	3	-0,006 -0,031	0 -0,006	0 -0,01	0 -0,014	0 -0,025	0 -0,04	0 -0,06	0 -0,1	0 -0,14	0 -0,25	0 -0,4	0 -0,6		±0,125	±0,2	±0,3		+0,008 +0,002
3	6	-0,01 -0,04	0 -0,008	0 -0,012	0 -0,018	0 -0,03	0 -0,048	0 -0,075	0 -0,12	0 -0,18	0 -0,3	0 -0,48	0 -0,75	0 -1,2	±0,15	±0,24	±0,375	±0,6	+0,012 +0,004
6	10	-0,013 -0,049	0 -0,009	0 -0,015	0 -0,022	0 -0,036	0 -0,058	0 -0,09	0 -0,15	0 -0,22	0 -0,36	0 -0,58	0 -0,9	0 -1,5	±0,18	±0,29	±0,45	±0,75	+0,015 +0,006
10	18	-0,016 -0,059	0 -0,011	0 -0,018	0 -0,027	0 -0,043	0 -0,07	0 -0,11	0 -0,18	0 -0,27	0 -0,43	0 -0,7	0 -1,1	0 -1,8	±0,215	±0,35	±0,55	±0,9	+0,018 +0,007
18	30	-0,02 -0,070	0 -0,013	0 -0,021	0 -0,033	0 -0,052	0 -0,084	0 -0,13	0 -0,21	0 -0,33	0 -0,52	0 -0,84	0 -1,3	0 -2,1	±0,26	±0,42	±0,65	±1,05	+0,021 +0,008
30	50	-0,025 -0,087	0 -0,016	0 -0,025	0 -0,039	0 -0,062	0 -0,1	0 -0,16	0 -0,25	0 -0,39	0 -0,62	0 -1	0 -1,6	0 -2,5	±0,31	±0,5	±0,8	±1,25	+0,025 +0,009
50	80	-0,03 -0,104	0 -0,019	0 -0,03	0 -0,046	0 -0,074	0 -0,12	0 -0,19	0 -0,3	0 -0,46	0 -0,74	0 -1,2	0 -1,9	0 -3	±0,37	±0,6	±0,95	±1,5	+0,03 +0,011
80	120	-0,036 -0,123	0 -0,022	0 -0,035	0 -0,054	0 -0,087	0 -0,14	0 -0,22	0 -0,35	0 -0,54	0 -0,87	0 -1,4	0 -2,2	0 -3,5	±0,435	±0,7	±1,1	±1,75	+0,035 +0,013
120	180	-0,043 -0,143	0 -0,025	0 -0,04	0 -0,063	0 -0,1	0 -0,16	0 -0,25	0 -0,4	0 -0,63	0 -1	0 -1,6	0 -2,5	0 -4	±0,5	±0,8	±1,25	±2	+0,04 +0,015
180	250	-0,05 -0,165	0 -0,029	0 -0,046	0 -0,072	0 -0,115	0 -0,185	0 -0,29	0 -0,46	0 -0,72	0 -1,15	0 -1,85	0 -2,9	0 -4,6	±0,575	±0,925	±1,45	±2,3	+0,046 +0,017
250	315	-0,056 -0,185	0 -0,032	0 -0,052	0 -0,081	0 -0,13	0 -0,21	0 -0,32	0 -0,52	0 -0,81	0 -1,3	0 -2,1	0 -3,2	0 -5,2	±0,65	±1,05	±1,6	±2,6	+0,052 +0,02
315	400	-0,062 -0,202	0 -0,036	0 -0,057	0 -0,089	0 -0,14	0 -0,23	0 -0,36	0 -0,57	0 -0,89	0 -1,4	0 -2,3	0 -3,6	0 -5,7	±0,7	±1,15	±1,8	±2,85	+0,057 +0,021
400	500	-0,068 -0,223	0 -0,04	0 -0,063	0 -0,097	0 -0,155	0 -0,25	0 -0,4	0 -0,63	0 -0,97	0 -1,55	0 -2,5	0 -4	0 -6,3	±0,775	±1,25	±2	±3,15	+0,063 +0,023

3. Threads

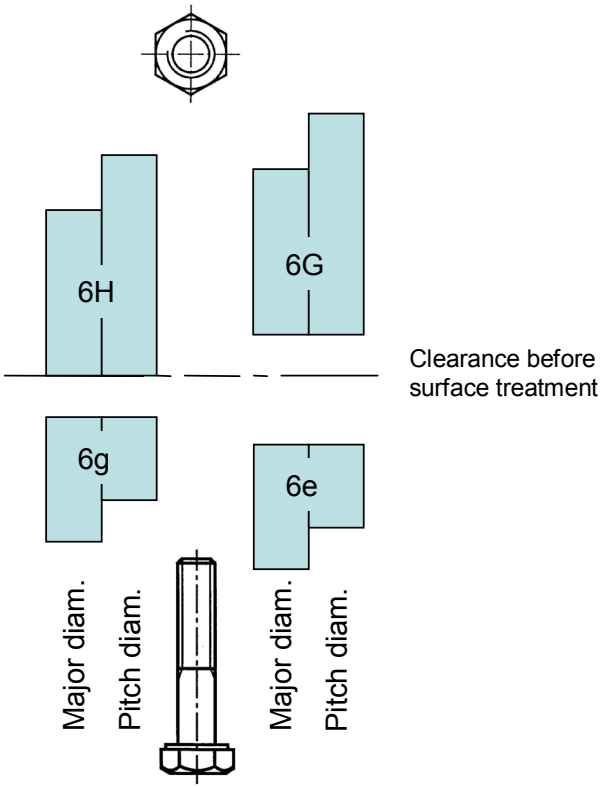
Thread dimensions and accuracy of the profile are crucial when determining:

- whether the fastener can be surface treated
- whether the parts can be jointed together without problems
- whether the thread can transmit the forces for which the components are designed

Thread's main dimensions are: nominal diameter, pitch and minor diameter:



There is different tolerance fields for screw and nut thread: screw thread dimensions are located below the nominal dimension and nut thread above. This leaves necessary clearance for surface treatment. Standard ISO 965 recommends following tolerance fields for commercial grade fasteners:



For threads M1,4 and above following tolerance fields are standard:

Screw	Nut	Surface treatment
6g	6H	plain, phosphated or electro zinc plated
6e	6G	plain (big clearance) or thick platings

Dimensions for Metric ISO-threads, screws (6g) and nuts (6H):

M	Pitch P	Screw, tolerance 6g				Nut, tolerance 6H			
		Major diameter d (mm)		Pitch diameter d2 (mm)		Pitch diameter D2 (mm)		Minor diameter D1 (mm)	
		max	min	max	min	max	min	max	min
2	0,4	1,981	1,886	1,721	1,654	1,830	1,740	1,679	1,567
2,5	0,45	2,480	2,380	2,188	2,117	2,303	2,208	2,138	2,013
3	0,5	2,980	2,874	2,655	2,580	2,775	2,675	2,599	2,459
3,5	0,6	3,479	3,354	3,089	3,004	3,222	3,110	3,010	2,850
4	0,7	3,978	3,838	3,523	3,433	3,663	3,545	3,422	3,242
5	0,8	4,976	4,826	4,456	4,361	4,605	4,480	4,334	4,134
6	1	5,974	5,794	5,324	5,212	5,500	5,350	5,153	4,917
7	1	6,974	6,794	6,324	6,212	6,500	6,350	6,153	5,917
8	1,25	7,972	7,760	7,160	7,042	7,348	7,188	6,912	6,647
10	1,5	9,968	9,732	8,994	8,862	9,206	9,026	8,676	8,376
12	1,75	11,966	11,701	10,829	10,679	11,063	10,863	10,441	10,106
14	2	13,962	13,682	12,663	12,503	12,913	12,701	12,210	11,835
16	2	15,962	15,682	14,663	14,503	14,913	14,701	14,210	13,835
18	2,5	17,958	17,623	16,334	16,164	16,600	16,376	15,744	15,294
20	2,5	19,958	19,623	18,334	18,164	18,600	18,376	17,744	17,294
22	2,5	21,958	21,623	20,334	20,164	20,600	20,376	19,744	19,294
24	3	23,952	23,577	22,003	21,803	22,316	22,051	21,252	20,752
27	3	26,952	26,577	25,003	24,803	25,316	25,051	24,252	23,752
30	3,5	29,947	29,522	27,674	27,462	28,007	27,727	26,771	26,211
33	3,5	32,947	32,522	30,674	30,462	31,007	30,727	29,771	29,211
36	4	35,940	35,465	33,342	33,118	33,702	33,402	32,270	31,670
39	4	38,940	38,465	26,342	26,118	36,702	36,402	35,270	34,670

Some common thread types are introduced in following table. The most typical thread is metric ISO-thread.

Symbol	Name	Thread type or application		Marking	Flank angle	Standard
M	Metric ISO-thread	Coarse thread	Right hand	M8 X 50	60°	ISO 724 (DIN 13-1)
M-LH		Fine thread	Left hand	M8 X 50 LH		
M		Coarse thread	Right hand	M8 X 1 X 50		ISO 724 (DIN 13-2...11)
M-LH		Fine thread	Left hand	M8 X 1 X 50 LH		
M	Metric conical male thread	Grease nipples		M20 X 1,5 cone		DIN 158-1
G	Non-sealing pipe thread	Female thread: symbol G		G 3/4"	55°	ISO 228-1
		Male thread: symbol G and product cl. A or B		G 3/4" B		
R	Self-sealing pipe thread	Conical male thread		R 1½"		DIN 2999-1 DIN 3858
Rc		Conical female thread		Rc 1½"		
Rp		Cylindrical female thread		Rp 1½"		
Tr	Metric ISO-trapezoidal thread	I.e. motion screws		Tr 50 X 8	30°	ISO 2901-4
Rd	Cylindrical round thread	I.e. fire equipment joints		Rd 20 X 3/4		DIN 405-1,2
ST	Self tapping thread	Self tapping screws		ST 3,5	60°	ISO 1478
UNC	Inch size thread (USA)	Coarse thread		3/4-10 UNC	55°	ANSI B 1.1 B.S. 1580-1.2
UNF	Inch size thread (USA)	Fine thread		3/4-16 UNF		
BSW	Inch size thread (UK)	Coarse thread		3/4-10 BSW		B.S. 84
BSF	Inch size thread (UK)	Fine thread		3/4-12 BSF		

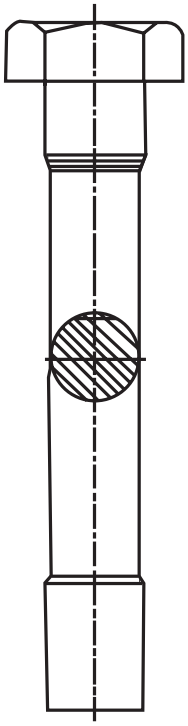
Properties for the inch sized threads:

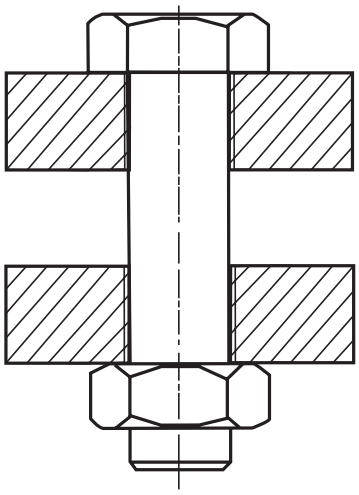
Dimension		Threads Per Inch (TPI)		
inch	mm	UNC	UNF	Whitworth
1/4"	6,3	20	28	20
5/16"	7,9	18	24	18
3/8"	9,5	16	24	16
7/16"	11,1	14	20	14
1/2"	12,7	13	20	12
5/8"	15,9	11	18	11
3/4"	19,1	10	16	10
7/8"	22,2	9	14	9
1"	25,4	8	12	8
1 1/4"	31,8	7	12	7
1 1/2"	38,1	6	12	6
1 3/4"	44,5	5	-	5
2"	50,8	4½	-	4½
2 1/4"	57,1	4½	-	4
2 1/2"	63,5	4	-	4
2 3/4"	69,9	4	-	3½
3"	76,2	4	-	3½

4. Mechanical properties

Screw's mechanical properties are presented in short in this section. Identifying these properties, it is essential to know terminology used.

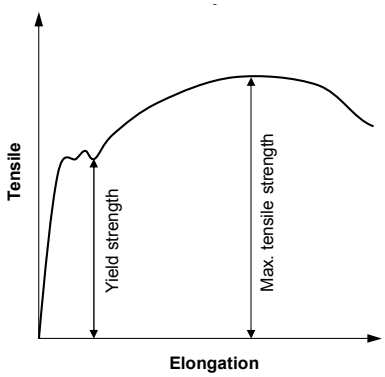
Tensile strength Rm (N/mm2)
Tensile strength of a screw is the stress in which it can break. Breaking is allowed to happen in the screw's shank or thread but not under the head. If testing is done with full-size screws, the result is always approximate. To determine tensile strength accurately, machined test rod have to be pulled. Excluding stainless steel screws (material groups A1...A5) which are always tested at full size (DIN ISO 3506).





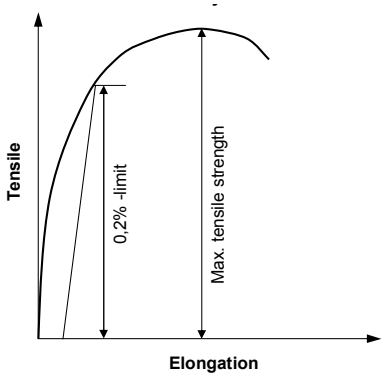
Yield strength Re (N/mm2)
Yield strength indicates the tensile strength from which elongation begins to increase. Screw starts to yield when moving between elastic and plastic reformation area of the material. Machined test rod should be used to determine also the accurate yield strength.

Tensile-elongation diagram for class 5.6 screw:



0,2% -limit Rp0,2 (N/mm2)
The yield strength of harder material is difficult to define since there is no clear point where the elongation begins. Therefore it is taken into use term 0,2% -limit, where permanent elongation of 0,2% is remained after relief. This value is used for class 8.8 and harder screws.

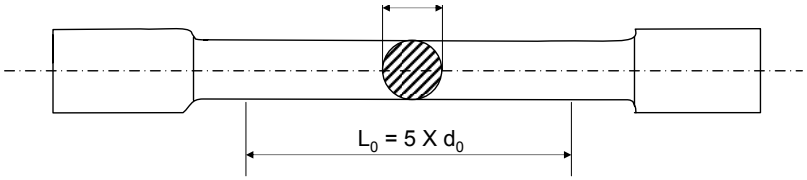
Tensile-elongation diagram for class 8.8 screw:



Breaking elongation A5 (%)
Breaking elongation indicates machined test rod's elongation in percents:

A5 = (LU-LO) / LO X 100%, where

d0 = test rod's / screw's diameter before the test
LO = defined length LO = 5 X d0
LU = length after breaking



Hardness and it's testing
In general, hardness is defined as the material's ability to resist testing equipment's penetration under surface. Three widely used systems for hardness testing are Brinell HB (ISO 6506), Vickers HV (ISO 6507) and Rockwell A, B, C (ISO 6508).

Mechanical properties for screws in class 5.6...12.9:

Mechanical property		Property class				
		5.6	8.8		10.9	12.9
			≤ M16*	> M16*		
Tensile strength Rm (N/mm2)**	Nominal	500	800		1000	1200
	min.	500	800	830	1040	1220
Yield strength Re (N/mm2)**	Nominal	300	-	-	-	-
	min.	300	-	-	-	-
0,2% -limit Rp0,2 (N/mm2)**	Nominal	-	640	640	900	1080
	min.	-	640	660	940	1100
Yield strength Re or 0,2%- limit Rp0,2 in high temperatures (N/mm2)	+ 100°C	270	590		875	1020
	+ 200°C	230	540		790	925
	+ 250°C	215	510		745	875
	+ 300°C	195	480		705	825
Breaking elongation A5 (%)**	min.	20	12		9	8
Vickers-hardness F≤ 98N (HV)**	min...max	155...220	250...320	255...335	320...380	385...435
	***	250	-	-	-	-
Brinell-hardness F = 30D2 (HB)**	min...max	147...209	238...304	242...318	304...361	366...414
	***	238	-	-	-	-
Rockwell-hardness HR**	HRB min...max	79...95	-	-	-	-
	***	99,5	-	-	-	-
	HRC min...max	-	22...32	23...34	32...39	39...44
Impact strength KV (J)**	min.	25	30	30	20	15

* For structural bolts the limit is M12
** Properties in temperature + 20°C
*** Hardness value at the end of the bolt

Following hardness comparison table is valid only for carbon steels, low alloy steels and cast steels. For high alloy or austenitic steels, there can be major differences expected.

Tensile strength N/mm2	Vickers-hardness (F≥98 N)	Brinell-hardness 1)	Rockwell-hardness		
			HRA	HRB	HRC
305	95	90,2		52,0	
320	100	95		56,2	
335	105	99,8			
350	110	105		62,3	
370	115	109			
385	120	114		66,7	
400	125	119			
415	130	124		71,2	
430	135	128			
450	140	133		75,0	
465	145	138			
480	150	143		78,7	
495	155	147			
510	160	152		81,7	
530	165	156			
545	170	162		85,0	
560	175	166			
575	180	171		87,1	
595	185	176			
610	190	181		89,5	
625	195	185			
640	200	190		91,5	
660	205	195		92,5	
675	210	199		93,5	
690	215	204		94,0	
705	220	209		95,0	
720	225	214		96,0	
740	230	219		96,7	
755	235	223			
770	240	228	60,7	98,1	20,3
785	245	233	61,2		21,3
800	250	238	61,6	99,5	22,2
820	255	242	62,0		23,1
835	260	247	62,4		24,0
850	265	252	62,7		24,8
865	270	257	63,1		25,6
880	275	261	63,5		26,4
900	280	268	63,8		27,1
915	285	271	64,2		27,8
930	290	276	64,5		28,5
950	295	280	64,8		29,2
965	300	285	65,2		29,8
995	310	295	65,8		31,0
1030	320	304	66,4		32,2
1060	330	314	67,0		33,3
1095	340	323	67,6		34,3
1125	350	333	68,1		35,5
1155	360	342	68,7		36,6
1190	370	352	69,2		37,7
1220	380	361	69,8		38,8
1255	390	371	70,3		39,8
1290	400	380	70,8		40,8
1320	410	390	71,4		41,8
1350	420	399	71,8		42,7
1385	430	409	72,3		43,6

Material categories used in fasteners:

Carbon steel	Several materials which properties as used in fasteners do not differ greatly from each other. In exception are cold resistant materials below -50°C and heat resistant materials over 300°C. Mechanical properties according to ISO 898.
Stainless steel	Several materials which properties as used in ready end products differs a lot in means of corrosion resistance, heat resistance, weldability, magnetization and hardening. Mechanical properties according to ISO 3506.
Non-iron metals, e.g. aluminium and copper	Material codes, mechanical properties, testing methods and values and markings according to standards ISO 8839 / EN 28 839.
Other metals, e.g. brass and titanium	No standards. In some cases, mechanical properties of carbon steel screws can be applied.
Plastic	No standards

Carbon steel (ISO 898)

ISO 898 covers metric bolts, screws, studs and nuts in coarse and fine threads up to size M39.

PROPERTY CLASS										
Screw	3.6	4.6	4.8	5.6	5.8	6.8	8.8	9.8	10.9	12.9
Nuts		4 04		5 05		6	8	9	10	12

Screws
Property class is defined in format A.B

A is 1/100 of tensile strength (Rm = 100 x A)
B is multiplication of tensile strength x yield strength x 10 (Re = 10 x A x B)

e.g. 8.8 = Rm = 800 MPa ja Re = 640 MPa

Nuts

ISO 898-2 defines coarse thread nuts.
ISO 898-6 defines fine thread nuts.

The symbol for property class is a number which indicates for which property class screw the nut can be jointed (first number of the screw's property class).

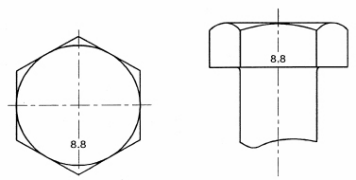
For low height nuts the property classes are 04 and 05.

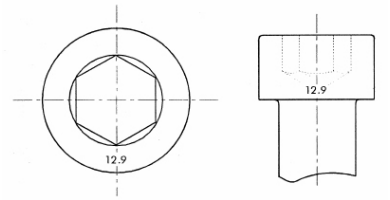
Head marks

Zinc plated / Plain

Marking according to ISO 898-1.

Hexagon head screws and nuts with thread diameter M5 and above have to be marked as shown in the picture.

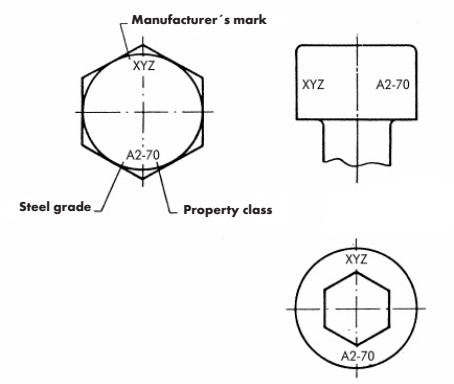




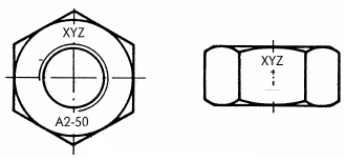
Stainless steels (A4 / A2)

Marking according to ISO 3506-1.

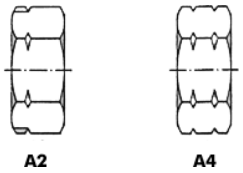
Hexagon head screws with thread diameter M5 and above have to be marked as shown in the picture. Steel grade, property class and manufacturer's mark has to be visible in the stamp.



Hexagon nut with thread diameter M5 and above have to be marked as shown in the picture. Marking can be made also to the across flats –surface..

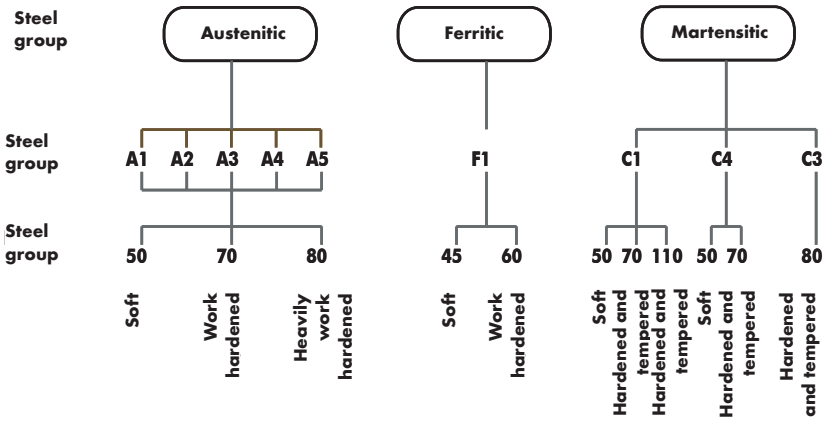


Alternative marking for A4 / A2 hexagon nuts



Stainless steels (ISO 3506)

Steel groups according to ISO 3506:



A1	Machineable grade. Limited properties for corrosion protection and weldabilty. Similar classification in AISI-standard: AISI 303. Non-magnetic, non-hardening.
A2	Most common grade of stainless steels used e.g. in chemical industry and in household devices. Rustproof, acidproof and weldable. Do not apply for non-oxidizing acids nor chlorine-rich environments e.g. to sea water. Similar classification in AISI-standard: AISI 304. Non-magnetic, non-hardening. Cold-resistant down to - 200 °C
A3	Properties as in A2. Non-magnetic, non-hardening.
A4	Most common garde of "acidproof" steels. Resistant to many acids depending of temperature, reasonable resistant in chlorine-rich environments. Good weldability. Widely used in wood-processing, food-processing and ship-building industry. Non-magnetic, non-hardening. Cold-resistant down to - 60 °C Similar classification in AISI-standard: AISI 316.
A5	Properties as in A4. Non-magnetic, non-hardening.
F1	Magnetic grade. In some cases A2 can be replaced by F1 which have good resistance to chlorine.
C1	Hardening grade. Quite good corrosion resistance when surface treated (e.g. Delta –plating). Magnetic. Similar classification in AISI-standard: AISI 410.
C3	Limited properties for corrosion protection.
C4	Limited properties for corrosion protection. Machineable.

Temperature effect on corrosion: Environment's chemical compound and temperature have a great effect on stainless steel's corrosion resistance.

Friction coefficent is high on stainless steel's surface (appr. 0,40...0,50). Therefore lubrication or waxation is needed before mounting.

Stainless steels are identified with following letter-number combination:

A2 - 70

Steel groups´s symbol
A = Austenitic steel

Steel grade´s symbol
1 = Automatic steel, sulphur surcharge
2 = Cold formed steel, chrome/nickel compound
3 = Cold formed steel, chrome/nickel compound + Ti, Nb, Ta
4 = Cold formed steel, chrome/nickel/molybdene compound
5 = Cold formed steel, chrome/nickel/molybdene compound + Ti, Nb, Ta

Property class symbol
50 = 1/10 of tensile strenght (min. 500 N/mm^2)
70 = 1/10 of tensile strenght (min. 700 N/mm^2)
80 = 1/10 of tensile strenght (min. 800/Nmm^2)

When there is no symbol for the property class, it is regarded as class 50.
In common speech, description of fasteners:
A2 = "Rustproof fastener"
A4 = "Acidproof fastener"

Chemical analysis for austenitic steel group:

	Material	Mat. nro	C ≤ %	Si ≤ %	Mn ≤ %	Cr %	Mo %	Ni %
A2	X5 Cr Ni 1810	1.4301	0,07	1,0	2,0	17,0 - 20,0	-	8,5 - 10,0
	X2 Cr Ni 1811	1.4306	0,03	1,0	2,0	17,0 - 20,0	-	10,0 - 12,5
	X8 Cr Ni 19/10	1.4303	0,07	1,0	2,0	17,0 - 20,0	-	10,5 - 12,0
A3	X6 Cr Ni Ti 1811	1.4541	0,10	1,0	2,0	17,0 - 19,0	-	9,0 - 11,5
A4	X5 Cr Ni Mo 1712	1.4401	0,07	1,0	2,0	16,5 - 18,5	2,0 - 2,5	10,5 - 13,5
	X3 Cr Ni Mo 1712	1.4404	0,03	1,0	2,0	16,5 - 18,5	2,0 - 2,5	11,0 - 14,0
A5	X6 Cr Ni Mo Ti 1712	1.4571	0,10	1,0	2,0	16,5 - 18,5	2,0 - 2,5	10,5 - 13,5

Mechanical properties for austenitic steel group:

Steel group	Steel grade	Property class	Diam. range	Screws		
				Tensile strength R_m [1] N/mm^2 min.	- 0,2% limit $R_{p\,0,2}$ [1] N/mm^2 min.	Breaking elongation A [2] mm min.
Austenitic	A1, A2, A3, A4 and A5	50	≤ M 39	500	210	0,6 d
		70	≤ M 24	700	450	0,4 d
		80	≤ M 24	800	600	0,3 d

[1] The tensile stress is calculated on the stress area (see ISO 3506-1 annex A).
[2] To be determined on actual screw length, not on prepared test piece.
d = nominal thread diameter

Mechanical properties at elevated temperatures; application at low temperatures (ISO 3506-1):

For values for lower yield stress Re and stress at 0,2 % permanent strain Rp0,2 at elevated temperatures in % of the values at room temperature.

Steel grade	Re and Rp0,2 (%) in temperature			
	+ 100 °C	+ 200 °C	+ 300 °C	+ 400 °C
A2, A4	85%	80%	75%	70%
C1	95%	90%	80%	65%
C3	90%	85%	80%	60%

Note! This applies to property classes 70 and 80 only.

For application of stainless steel bolts, screws and studs at low temperatures:

Steel grade	Lower limits of operational temperature at continuous operation	
A2	- 200 °C	
A4	Bolts and screws 1)	- 60 °C
	Studs	- 200 °C
1) In connection with the alloying element Mo the stability of the austenite is reduced and the transition temperature is shifted to higher values if a high degree of deformation during manufacturing of the fastener is applied.		

Arguments for using austenitic (A1, A2 ja A4) fasteners:

Advantage	Potential problem
Bright surface, nice appearance	Poor quality impression of the end product due to screws in rust.
Safety	Corrosion in fasteners reduces their strength and operational features.
No rust marks	Red rust can colour e.g. plastics and textiles. Stainless stell fastener is easy to clean and it is hygienic.
No health risks	If you cut yourself into a rusty part it can lead to blood poisoning. Zinc plated fasteners must be kept out of touch with food stuff and out of reach of children (licking).
Austenitic chrome-nickel steels are almost completely non-magnetical	Use of magnetic fasteners in e.g. sensitive measuring devices can lead into faulty readings.
High temperature resistance	In above 80°C temperatures, zinc plating's chromating will destroy which leads to dramatical drop in corrosion resistance.
Easy maintenance	Screws and nuts in rust are difficult to open. This requires extra effort and time. To disassemble the joint, rusty fasteners often have to be broken. This may cause damage also to the clamped parts.

Screws and nuts from heat and cold resistant materials (DIN 267-13):

Temperature °C	Material	Symbol	Material No.
Up to+350 °C	C 35 N	Y	1.0501
	Cq 35	YQ	1.1172
	Ck 35	YK	1.1181
Up to+400 °C	24 CrMo 5	G	1.7258
Up to +540 °C	21 CrMoV 57	GA	1.7709
Up to +540 °C	40 CrMoV 47	GB	1.7711
Up to +580 °C	X 22 CrMoV	V	1.4923
Up to +580 °C	X 19 CrMoVNbN	VW	1.4913
Up to +650 °C	X 8 CrNiMoBNv 16 16	S	1.4986
Up to +700 °C	X 5 NiCrTi 26 15	SD	1.4980
Up to +700 °C	NiCr 20 TiAl	SB	2.4952
-65 °C	26 CrMo 4	KA	1.7219
-140 °C	12 Ni 19	KB	1.5680
-253 °C	X 12 CrNi 18 9	KC	1.6900
-253 °C	X 10 CrNiTi 18 10	KD	1.6903
-196 °C	X 5 CrNi 18 9	A2	1.4301
	X 5 CrNi 19 11		1.4303
	X 10 CrNiTi 18 9		1.4541
-60 °C	X 10 CrNiMo Ti 18 10	A4	1.4571
	X 5 CrNiMo 18 10		1.4401

5. Quality and testing

All fasteners properties are defined in DIN-, ISO- or EN-standards as follows:

Product standard (e.g. DIN 931 / ISO 4014):
Includes information about product's form, version, tolerance (product grade A, B, C), strength or material and nominal dimensions. Product standards always refers to valid basic standards.

Basic standard (e.g. DIN 13, ISO 898/4759/3269):
Includes general information for example of threads, tolerances, surface treatments, mechanical properties and testing.

Fasteners according to standards fullfill the demands for "normal use" (ISO 3269/8992). For more demanding special applications, extra testing or other requirements must be defined before ordering by the customer.

Basic standards require testing programs and processes with which manufacturers guarantees their quality inspecting random samples. In addtion to these tests Ferrometal Oy performs continual quality control of in-coming goods.

Economical mass production for standard fasteners is not possible without nonconforming items. ISO 3269 introduces acceptable quality level (AQL) which is a statistical procedure for quality definition. AQL gives quality level in a sampling plan corresponding to a high probability of acceptance. From the results the whole manufacturing lot's quality can be determined. AQL –value depends of:

- product: screw, nut, washer, bolt, pin, rivet
- product (tolerance) class: A, B or C
- main characteristic: AQL-value = 1,5...1,0
- secondary characteristic: AQL-value = 4,0...2,5
- mechanical characteristic: AQL-value = 1,5...0,65

Main characteristic includes all the main properties for the functioning of the product, like: head / slot / socket, thread etc. Secondary characteristic may include slight deviations in dimensions or forms not affecting to the product's function or suitability.

AQL-values for threaded fasteners according to dimensional characteristics:

Dimensional characteristics	Product group					
	1	2	3	4	5	6
	Bolts, screws and studs in product class A and B	Bolts, screws and studs in product class C	Nuts in product class A and B	Nuts in product class C	Self-tapping screws and wood screws	All thread-forming screws not covered in group 5, self-drilling and chipboard screws
	AQL					
Width across flats	1	1,5	1	1,5	1,5	1
Width across corners	1	1,5	1	1,5	1,5	1
Nut height	-	-	1	1,5	-	-
Width of slot	1	-	-	-	1,5	1
Depth of slot	1	-	-	-	1,5	1
Recess penetration	1	-	-	-	1,5	1
Socket, GO gauge	1	-	-	-	-	-
Socket, NOT GO gauge	1	-	-	-	-	-
Configuration under head	1	-	-	-	-	1
Thread, GO gauge	1	1,5	1	1,5	-	1
Thread, NOT GO gauge	1	1,5	1	1,5	-	1
Major diameter	-	-	-	-	2,5	1
Geometric tolerances	1	1,5	1	1,5	2,5	1
All others	1,5	2,5	1,5	2,5	2,5	1,5
Nonconforming fasteners	2,5	4	2,5	4	4	2,5

Characteristics		AQL	Reference standard
Mechanical characteristics and surface integrity	Non-destructive tests [a]	0,65	ISO 898 [c] ISO 2320 ISO 2702 ISO 3056 [c] ISO 6157 [c] ISO 7085 ISO 8839 etc.
	Destructive tests	1,5	
Chemical composition		1,5	
Metallurgical characteristics		1,5	
Functional (performance) characteristics		1,5	
Coating		1,5	ISO 4042 ISO 10683
Others [b]		1,5	

[a] If non-permitted surface discontinuities (for example, quench cracks) are found during surface discontinuity inspection (non-destructive test), regardless of their size, the inspection lot shall be rejected.

[b] Other characteristics may be required according to applicable specifications

[c] See the applicable parts of these standards

In the acceptance inspection it is taken into account the size of production lot. (defined by the manufacturer), suitable LQ10 –value and the sample size. Example of sampling plan where acceptance number Ac can be read:

Ac	AQL				
	0,65	1,0	1,5	2,5	4,0
	n (pcs) LQ_{10} (%)				
0	**8** 25	**5** 37	**3** 54	-	-
1	**50** 7,6	**32** 12	**20** 18	**13** 27	**8** 42
2	**125** 4,3	**80** 6,5	**50** 10	**32** 17	**20** 25
3	**200** 3,3	**125** 5,4	**100** 6,6	**50** 13	**32** 20
4	**315** 2,6	**200** 3,9	**125** 6,2	**80** 9,6	**50** 15
5	**400** 2,4	**250** 3,7	**160** 5,8	**100** 9,3	-
6	-	**315** 3,4	**200** 5,2	**125** 8,4	**80** 13
7	-	**400** 3,0	**250** 4,7	**160** 7,3	**100** 11,5
8	-	-	**315** 4,2	**200** 6,6	**125** 10
10	-	-	**400** 3,9	**250** 6,0	**160** 9,5
12	-	-	-	**315** 5,6	**200** 8,8
14	-	-	-	**400** 5,0	**250** 8,0
18	-	-	-	-	**315** 7,8
22	-	-	-	-	**400** 7,3

Ac = Acceptance number. It is the maximum number of nonconformities of the same characteristic in any given sample which, when exceeded, causes the lot to be rejected.

n = Sample size, number of fasteners in a sample

LQ10 = Limiting quality. Quality level in a sampling plan corresponding to a low probability of acceptance. LQ10 is the percentage of fastemers that do not conform in respect of product characteristic, having one chance in ten of being accepted under the sampling plan; often referred to as the consumer's risk.

Zero nonconformity deliveries always require additional testing and they must be agreed prior to ordering. otherwise ISO 3269 is applied.

Material certificates, Pressure Equipment Directive.

Additional tests can be carried out accordance to the special request of the customer. Results of these tests are documentated into a certificate which is delivered to the customer.

For certain fastener groups, Ferrometal Oy has available the most commonly used Inspection certificate 3.1B. Our catalogue prices do not include certficate expenses.

EN 10204	Designation	Inspection	Test results	Validated by
2.1	Declaration of compliance	No determination of test results	No results	The manufacturer
2.2	Test report	Indication of results of non-specific insopection	Chemical analysis	
3.1	Inspection certificate	The test unit and the tests to be carried out are defined by the product specification, the official regulation and/or the order	Chemical analysis and mechanical properties	The manufacturer
3.2	Inspection certificate			The inspector authorized by the manufacturer and the purchaser or by the official regulations

NOTE! None of these certificates is capable to fullfill the requirements set by the **Pressure Equipment Directive** (PED; EN 13445, EN 12962, EN 12953, EN 13488). Ask for more information about the PED requirements from Ferrometal Oy sales.

6. Surface treatments and corrosion

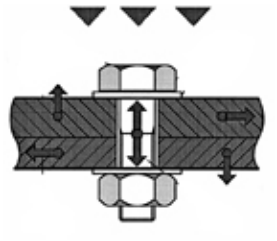
Corrosion in screw joints

Corrosion resistance for all steels base on two factors – either to their natural nobleness in electrochemical series or to their ability to produce corrosion protective layer to their surface (e.g. aluminium or stainless steels).

Stainless steels include at least 16% of chromium (Cr) and they are resistant against oxidizing environments. With higher amount of chromium and with other components like nickel (Ni), molybdene (Mo), titanium (Ti) or niobium (Nb) the corrosion resistance can be improved. These components have an effect also the steels mechanical properties.

Fasteners in austenitic steel group are not usually magnetic. Magnetization can be achieved through cold forming. This do not affect on corrosion resistance.

Main factors for corrosion generation:



1. Surface corrosion
2. Stress corrosion
3. Hole corrosion
4. Intergranular corrosion
5. Evosive corrosion
6. Salvanic corrosion
7. Mechanical causes

1. Surface corrosion

Surface corrosion means steady and slowly proceeding corrosion in the surface. It is common type of corrosion for plain metal surfaces and zinc plated fasteners. This corrosion type can be avoided by a careful material selection, see later on "A4 / A2 chemical resistance".

Local corrosion, point corrosion exists as surface corrosion with addition of local hole and crack formation. Point corrosion starts from uneven surfaces and it exists typically in fasteners which corrosion protection is produced by passive film or zinc plating / painting.

Local corrosion erosion occurs in stainless steels fasteners when they are in contact with chlorine or borium rich environment. Swimming pool areas for example.

Austenitic steels, like A2 and A4, are more local corrosion resistant than ferritic chrome steels..

2. Stress corrosion

This type of corrosion occurs generally on parts in industrial environments which are exposed to strong mechanical loads of tensile and bending. Residual stress generated e.g. from welding can also lead to stress corrosion.

Austenitic steels in a chlorine rich atmosphere are especially sensitive to stress corrosion.
Temperatures over 50 °C makes them even more sensitive.

4. Intergranular corrosion

This type of corrosion is essentially joined into high temperature, e.g. from welding or heat treatment. Corrosion causing substances are formated into grain boundary of the steel and it will rust along the grain boundaries.

A4 / A2 steels are also sensible to this corrosion type, when it is called sensitization of stainless steels. Austenitic steel is sensitized in temperature 550...800 °C. Chromium carbide forms at the intergranular boundaries, depleting the grain edges of chromium, impairing their corrosion resistance.

5. Erosive corrosion

Erosive corrosion exists because of the movement of solution which is in touch with the material. The corrosion protection of the surface is worn because of the solution flow, for example in pipe curves.

This is not typical corrosion type in screw joints.

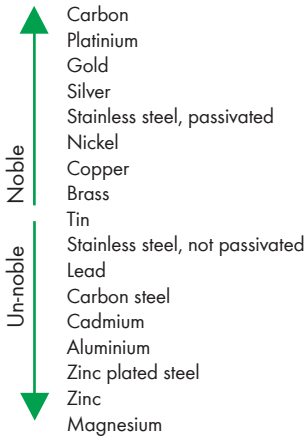
6. Galvanic corrosion

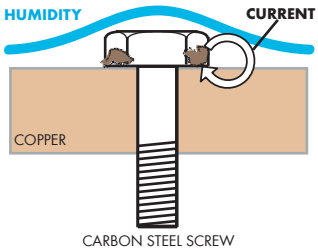
Galvanic corrosion, also known as contact corrosion, occurs when two parts of different composition are in metallic contact. As humidity acts like electrolyte, the lower grade element in the electrochemical series will corrode.

This typical corrosion type also in the screw joints where exists potential difference between metals and humidity acting as electrolyte.

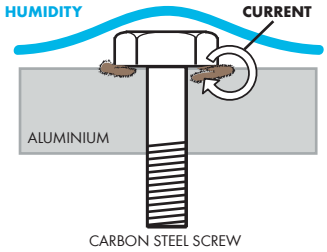
Electrochemical series for metals
There exists potential difference between different metals. The more far away the metals are from each other in the attached electrochemical series, the larger is the potential difference and risk for corrosion.

Chemical tension of metals

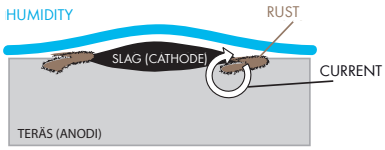




In this screw joint carbon steel screw acts as cathode and copper material as anode, the screw will rust because it is lower in the electrochemical series.



Carbon steel screw acts again as cathode in this screw joint. Aluminium material acts as anode and it will rust due to it's position in the series.



Slag or impurity in the same material leads into the corrosion of the base material. Humidity acts as electrolyte.

Galvanic corrosion will activate when:

1. Air humidity exceeds 60%
2. Impurity in the air: lot of metallic particles
3. Metals with big potential difference in the same screw joint
4. Wrong ratio of surface area for anode & cathode

How to prevent corrosion?

1. Disable galvanic pair.
   - protect structures from humidity (remove the electrolyte)
   - insulate different metals from each other with e.g. surface treatments
   - insulate metals from the electrolyte

2. Avoid using metals with big potential difference.

3. Arrange good ventilation for the structure and screw joint.

4. Choose screws from more noble potential than the structure. Strucutre with less noble potential should have larger surface area than the screw.

5. Choose adequate surface treatment.

6. Arrange temperature as low as possible.

7. Choose the right fasteners: avoid zinc plated fasteners with low corrosion resistance.

NOTE! Stainless fasteners in class A4 are not sufficient in chlorium-rich environments such as swimming pool areas. Ask for suitable application from Ferrometal Oy sales.

A4 / A2 Chemical resistance

Recistance grade	Evaluation	Weight loss g/m²h
A	Fully resistant	< 0,1
B	Practically resistant	0,1 - 1,0
C	Low resistance	1,0 - 10
D	No resistance	> 10

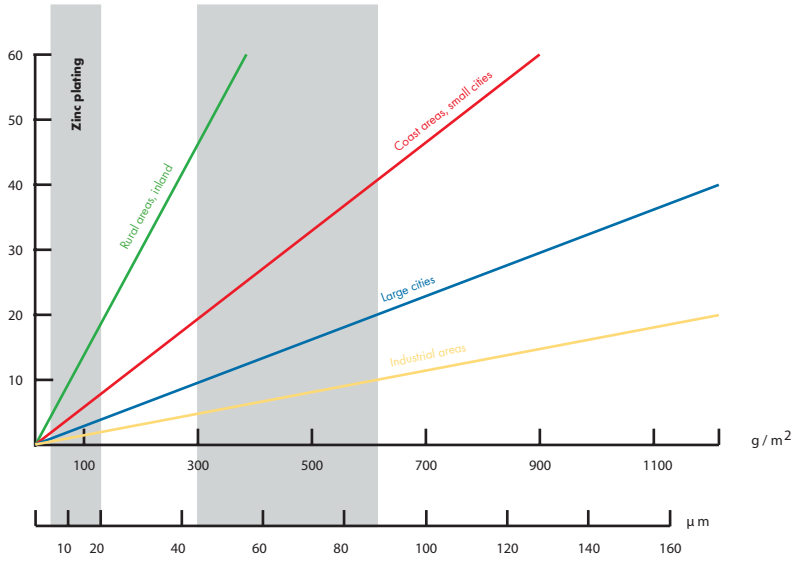
Corrosive agent	Concentration	Temperature °C	Resistance grade	
			A2	A4
Ammonia	all	20 boiling	A A	A A
Acetone	all	all	A	A
Petrol	-	all	A	A
Benzol	-	all	A	A
Benzoic acid	all	all	A	A
Mercury	-	< 50	A	A
Mercury nitrate	-	all	A	A
Vinegar acid	10%	20 boiling	A A	A A
Ethyl alcohol	all	20	A	A
Ethyl ether	-	all	A	A
Pheno	pure	boiling	B	A
Phosphoric acid	10% 50% 80% conc.	boiling 20 boiling 20 boiling 20 boiling	A A C B D B D	A A B A C A D
Glycerine	concentrated	all	A	A
Fruit	-	-	A	A
Fruit juice	-	all	A	A
Carbon dioxide	-	-	A	A
Lime	-	-	A	A
Developer (photography)	-	20	A	A
Chlorine	dry gas humid gas	20 all	A D	A D
Chloroform	all	all	A	A
Copper acetate	-	all	A	A
Copper nitrate	-	-	A	A
Copper sulphate	-	-	A	A
Magnesium sulphate	ca. 26 %	all	A	A
Milk acid	1,5 % 10 %	all 20 boiling	A A C	A A A
Sea water	-	20	A	A
Methyl alcohol	all	all	A	A
Formic acid	10%	20 boiling	A B	A A
Sodium hydroxide	20 % 50 %	20 boiling 120	A B C	A B C
Sodium carbonate	-	all	A	A
Sodium nitrate	-	all	A	A
Beer	-	all	A	A

Corrosive agent	Concentration	Temperature °C	Resistance grade	
			A2	A4
Oxalic acid	10 % 50 %	20 boiling boiling	B C D	A C C
Tannic acid	all	all	A	A
Petroleum	-	all	A	A
Fat acid		150 180 200-235	A B C	A A A
Sulphuric dioxide	-	100-500 900	C D	A C
Sulphuric acid	2,5 % 5 % 10% 60 %	< 70 boiling 20 > 70 20 70 all	B C B B C C D	A C A B B C D
Sulphurous acid	Watery solution	20	A	A
Salicylic acid	-	20	A	A
Citric acid	< 10 % 50 %	all 20 boiling	A A C	A A B
Lemon juice	-	20	A	A
Sugar solution	-	all	A	A
Hydrochloric acid	0,2 % 2 % < 10 %	20 50 20 50 20	B C D D D	B B D D D
Cyanide	-	20	A	A
Industrial air	-	-	A	A
Tar	-	hot	A	A
Nitric acid	< 40 % 50 % 90 %	all 20 boiling 20 boiling	A A B A C	A A B A C
Blood	-	20	A	A
Wine	-	20 and hot	A	A
Wine acid	< 10 % > 10 % < 50 % 75 %	20 boiling 20 boiling boiling	A B A C C	A A A C C
Oils (mineral)	-	all	A	A

Meaning of the zinc layer thickness

Zinc electroplating produces significantly thinner layer than hot dip galvanizing. Zinc plated fastener is applies only to use in dry indoor air. For outdoor use zinc plating is not suitable.

Hot dip galvanizing layer is almost evenly thick in the fastener surface, just opposite as in the zinc plating.



Values in the chart are approximate

Hydrogen embrittlement

Both electro zinc plating and hot dip galvanizing (acid pickling phase before coating) processes can weaken dramatically and randomly fastener's mechanical properties. In these processes, hydrogen is dissolved into the metal and it will lead into hydrogen embrittlement. This causes inner cracks in the metal and formation of pores.

Fasteners above class 8.8 are not recommended to be electro zinc plated nor hot dip galvanized due to the risk of hydrogen embrittlement. Heat treatment after metal coating process will reduce the risk, but however it is not guaranteed that hydrogen embrittlement will be completely removed.

If total surety is needed, alternative types of corrosion protection should be selected: anorganic zinc coatings (Delta, Ruspert, Dacromet etc.), mechanical galvanization or a change to stainless steel fasteners.

Environment's corrosion effect

Fastener's and structure's tendency for corrosion can be determined by classification of the environment's stress.

ISO 12944-2 Classification	SFS 4596 Classification	Corrosion effect	Typical environments
	M0	No stress	
C1	M1	Very light stress	Dry, heated interiors.
C2	M2	Light stress	Heated interiors, danger of condensation. Rural areas, low pollution.
C3	M3	Moderate stress	Urban areas. Interiors with high humidity.
C4	M3	Moderate stress	Industrial and coastal environments, chemical processing plants, swimming pool areas.
C5-1	M4	Heavy stress	Industrial environments with aggressive atmosphere.
C5-2	M4	Heavy stress	Offshore atmosphere.

Other commonly used surface treatments

Surface treatment	Explanation	Max. Temperature
Ruspert	Disc coating with high values of zinc and aluminium can be manufactured in different colors. Depending on the layer thickness, 500h or 1000h resistance in the salt spray test.	-
Hot Dip Galvanizing	Dipping in a zinc bath with temperature between 440...470 °C. Layer thickness is min. 40µm. Finish is dull and rough, color change is possible after a certain time. Gives very good corrosion protection. Applicable only for threads M8 and above. Threads need to be under or overcutted to ensure proper fitting.	250 °C
Phosphating	Only light corrosion protection. With oiled surface gives better resistance against rust. Good base layer for painting. Finish appearance from grey to grey/black.	70 °C
Dacromet	Good coating with high content of zinc (silver grey color) for parts with high tensile strength, $R_m \geq 1000$ N / mm^2 or hardness ≥ HV 300. Can be applied to threads M4 and above. No risk for hydrogen embrittelement.	300 °C
Mechanical plating	Chemical-mechanical coating process. Degreased items are put together with crystall ball mix and zinc powder into a plating drum. Crystall balls act as bearers of the zinc powder flakes and adheres them onto the item's surface through cold welding.	-

Delta -microsurface

Delta-Tone is an inorganic basecoat which is based on zinc and aluminium lamella. Delta-Tone is conducting and it formates a cathodic corrosion protection.

Delta-Seal is an organic topcpat which can be used together with Delta-tone basecoat which improves the corrosion protection even more. Delta-Seal surface is hard and very low-frictioned. It is suitable for food applications and it do not include chrome 6, lead, cadmium or other heavy metals.

Applications by: Dip-spin, dip-drain, spraying, spin coating. Surface treatment can be done in one or multiple layers; final film thickness between 4...20 µm. After application follows heat treatment, typically 20 minutes in 200 °C.

Heat resistance +250 °C.

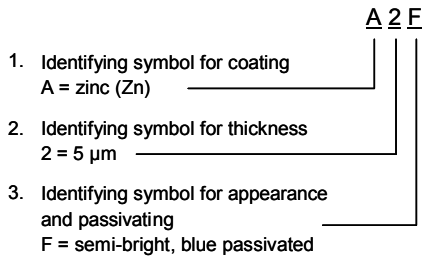
Excellent **corrosion protection** reached – 800 hours salt spray test according to DIN 50021 and minimum of 10 rounds in Kesternich test according to DIN 50018.

Ferrometal Oy delivers fasteners also with Delta –plating.
Ask for more from Ferrometal Oy sales.

	Delta-Tone	Delta-Seal	Delta-Tone+ Delta-Seal	Electro zinc plating	Hot Dip Galvanizing
Cathodic protection	yes	No	yes	yes	yes
Electric protection	Conducting	Insulating	Insulating	Conducting	Conducting
Risk of hydrogen embrittlement	no	no	no	yes	yes
Chrome 6	no	no	no	yes [1)]	yes
Friction coefficient 0,08...0,14	yes	yes	yes	no	no
Re-mountable	yes/no	yes	yes	yes/no	yes
Acid and base proof	no	yes	yes	no	no
Black color	no	yes	yes	yes	no
Silver color	yes	yes	yes	yes	yes
Yellow color	no	no	no	yes	no
Other colors	no	yes	yes	no	no

Markings of electroplated coatings

Standard ISO 4042 defines the symbols for markings of electroplated coatings for fasteners:



1. Coating material		
A	=	Zinc (Zn)
B	=	Cadmium (Cd)
C	=	Copper (Cu)
D	=	Brass (CuZn)
E	=	Nickel (Ni)
F	=	Nickel-chrome (NiCr)
G	=	Copper-nickel (CuNi)
H	=	Copper-nickel-chrome (CuNiCr)
J	=	Tin (Sn)

2. Coating thickness		
1	=	3 µm
2	=	5 µm
3	=	8 µm
9	=	10 µm
4	=	12 µm
5	=	15 µm
6	=	20 µm
7	=	25 µm
8	=	30 µm

3. Appearance (passivating / chromating)			
A	=	dull	no color
B			blue
C			yellow
D			olive
E	=	semi-bright	no color
F			blue
G			yellow
H			olive
J	=	bright	no color
K			blue
L			yellow
M			olive
R	=	dull	black
S		semi-bright	
T		bright	

Hot dip galvanized coatings

Fasteners to be hot dip galvanized (ISO 10684) should be threaded to special dimensions. Since hot dip galvanizing coating thickness is always above 40 µm, zinc layer needs enough clearance to fit after coating into normal commercial grade tolerance 6g / 6H.

In practice, this can be done with two methods:
1) Screws are undersized into tolerance class 6az before hot dip galvanizing. After coating they will fit to nuts with tolerance class 6H (normal commercial grade) and they are convertible with screws in tolerance class 6g.

2) Screws with normal tolerance class 6g are hot dip galvanized and they become oversized. Since they do not fit to normal 6H nuts, nuts have to be oversized into tolerance class 6AZ or 6AX after hot dip galvanizing. Nuts and other female threaded parts have to be tapped always after coating.

Ferrometal stocks screws manufactured according to method 1) (so called ISO-fittting).

NOTE!
M8 and M10 undersized screws and oversized nuts mechanical properties are slightly lower than specified in ISO 898-1 and ISO 898-2. Tensile strengths and proof loads for M8 and M10 can be found in ISO 10684 annex A.

Diameters M12 and above must be according to ISO 898-1 and ISO 898-2.

Most common short names in Ferrometal Oy for surface treatments:

plain	ST
electro zinc plated	ZN
yellow passivated	ZNC
hot dip galvanized	HOT
phosphated	FOS

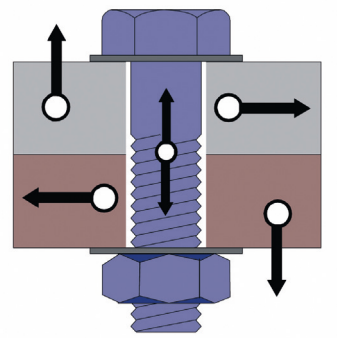
Color codes for threaded rods according to DIN 975/ 976:

Material	Color	RAL-code
Class 4.8	no color	-
Class 5.6	brown	RAL 8015
Class 5.8	blue	RAL 5010
Class 8.8	yellow	RAL 1023
Class 10.9	white	RAL 1013
Class 12.9	black	RAL 9017
A2-70	green	RAL 6024
A4-70	red	RAL 3000

7. Screw joints

Screw joint is the most common dismountable joint in machine building since it is easy to mount and dismount, reliable when used right and it can be used in many environments. Moreover, standard fasteners are relatively inexpensive items.

One of screw joint's drawbacks is reliability because of difficult control of tightening torque. Screws also have discontinuity points where stresses are high. In most screw joints, loading forces are tensile force parallel to screw's axle and shear force perpendicular to that.



In tapping and fitting screws shear force can affect straight into the screw which generates shear stress. Demanding screw joints are designed so that friction force caused by axial force will transfer shear force from item to another. This way, the only shear force left in the screw shank is the torque shear stress possibly left from tightening of the nut.

Screw's tensile strength is the most important feature in durability of the joint. When the screw is loaded statically, it can break in following ways:
- screw will break when tensile strength exceeds it's breaking strength
- screw's thread breaks
- nut's thread breaks

When the threads of screw and nut are strong enough to transfer the axial force from screw to nut, the screw is the one which have to fail. It should break from the thread or from the shank, but never from the head.

Thread's manufacturing method have a great effect on screw's fatigue strength. In practical, there is two different ways for thread manufacturing: cutting or rolling. Standard screws are usually threaded by rolling in cold. Very big diameters and small production batches can be made also in hot rolling. Cold rolled threads have better fatigue strength than cutted ones because of thread's smoothening and plastic deformation.

Right pretensioning is crucial in order to achieve a reliable screw joint. It has to be adequate, but not too big. The more specific pretensioning can be made, the lighter and inexpensive the joint can be designed. On the other hand, the pretensioning methods are more expensive when the accuracy grows.

Insufficient pretensioning leads to:
- detaching of jointing surfaces under axial loads
- growth of the screw's tensile amplitude
- fatigue of the screw
- nut loosening under vibration
- sliding of the joint because of the shearing forces

Too big pretensioning leads to:
- static overloading of the screw under load
- screw loosening under load due to plastic elongation
- breaking of the screw already in the tightening

Screw joint must retain proper pretensioning through it's planned lifetime. Following events can cause the joint to loose it's tightness:
- screw breaks
- thread shears
- nut unscrews
- joint parts sets

Prestressing forces and tightening torques
Recognition of friction coefficient μ is very important to be able to determine right tightening torque. There can be considerate differences in tightening torques, depending on the surfaces, lubricants, tightening methods and the deviations of all above. **Therefore it is highly recommended to carry out practical tests to determine the right tightening torque in the application in question. Following tables for hex head screws DIN 931 – DIN 933 and hex socket head screws DIN 912 are only approximate!**

carbon steel screws

M-thread std pitch	Friction coefficient μ	Max. Prestressing force (kN)				Max. Tightening torque (Nm) (90% utilisation of 0,2%-limit)			
		5.6	8.8	10.9	12.9	5.6	8.8	10.9	12.9
M4	0,10	2,10	4,5	6,7	7,8	1,21	2,6	3,9	4,5
	0,12	2,04	4,4	6,5	7,6	1,37	3,0	4,6	5,1
	0,14	1,98	4,3	6,3	7,4	1,51	3,3	4,8	5,6
M5	0,10	3,43	7,4	10,8	12,7	2,4	5,2	7,6	8,9
	0,12	3,33	7,2	10,6	12,4	2,7	5,9	8,6	10,0
	0,14	3,23	7,0	10,3	12,0	3,0	6,5	9,5	11,2
M6	0,10	4,84	10,4	15,3	17,9	4,1	9,0	13,2	15,4
	0,12	4,71	10,2	14,9	17,5	4,7	10,1	14,9	17,4
	0,14	4,57	9,9	14,5	17,0	5,2	11,3	16,5	19,3
M8	0,10	8,8	19,1	28,0	32,8	10,0	21,6	31,8	37,2
	0,12	8,6	18,6	27,3	32,0	11,3	24,6	36,1	42,2
	0,14	8,3	18,1	26,6	31,1	12,6	27,3	40,1	46,9
M10	0,10	14,1	30,3	44,5	52,1	20	43	63	73
	0,12	13,7	29,6	43,4	50,8	23	48	71	83
	0,14	13,3	28,8	42,2	49,4	25	54	79	93
M12	0,10	20,5	44,1	64,8	75,9	34	73	108	126
	0,12	20	43,0	63,2	74,0	39	84	123	144
	0,14	19,4	41,9	61,5	72,0	43	93	137	160
M14	0,10	28,2	60,6	88,9	104,1	55	117	172	201
	0,12	27,4	59,1	86,7	101,5	62	133	195	229
	0,14	26,7	57,5	84,4	98,9	69	148	218	255
M16	0,10	38,6	82,9	121,7	142,4	84	180	264	309
	0,12	37,6	80,9	118,8	139,0	96	206	302	354
	0,14	36,6	78,8	115,7	135,4	107	230	338	395
M18	0,10	47,1	104	149	174	117	259	369	432
	0,12	45,8	102	145	170	133	295	421	492
	0,14	44,6	99	141	165	148	329	469	549
M20	0,10	60,3	134	190	223	164	363	517	605
	0,12	58,8	130	186	217	187	415	592	692
	0,14	57,2	127	181	212	209	464	661	773
M22	0,10	75,2	166	237	277	220	495	704	824
	0,12	73,4	162	231	271	252	567	807	945
	0,14	71,4	158	225	264	282	634	904	1057
M24	0,10	86,9	192	274	320	282	625	890	1041
	0,12	84,7	188	267	313	322	714	1017	1190
	0,14	82,4	183	260	305	359	798	1136	1329
M27	0,10	114	252	359	420	414	915	1304	1526
	0,12	111,2	246	351	410	474	1050	1496	1750
	0,14	108,3	240	342	400	530	1176	1674	1959
M30	0,10	138,7	307	437	511	563	1246	1775	2077
	0,12	135,3	300	427	499	644	1420	2033	2380
	0,14	131,7	292	416	487	719	1597	2274	2662
M33	0,10	172,5	381	543	635	760	1679	2392	2799
	0,12	168,4	373	531	621	871	1928	2747	3214
	0,14	164	363	517	605	975	2161	3078	3601
M36	0,10	202,7	448	638	747	979	2164	3082	3607
	0,12	197,8	438	623	729	1121	2482	3535	4136
	0,14	192,6	427	608	711	1253	2778	3957	4631
M39	0,10	243,1	537	765	895	1264	2791	3975	4652
	0,12	237,4	525	748	875	1450	3208	4569	5346
	0,14	231,3	512	729	853	1624	3597	5123	5994

Austenitic (stainless) screws:

M-thread std pitch	Friction coefficient μ	Max. Prestressing force (kN)		Max. Tightening torque (Nm) (90% utilisation of 0,2%-limit)	
		A2-70 A4-70	A4-80	A2-70 A4-70	A4-80
M4	**0,10**	2,97	3,96	1,7	2,3
	0,20	2,40	3,20	2,6	3,5
	0,30	1,94	2,59	3,0	4,1
M5	**0,10**	4,85	6,47	3,4	4,6
	0,20	3,93	5,24	5,1	6,9
	0,30	3,19	4,25	6,1	8,0
M6	**0,10**	6,85	9,13	5,9	8,0
	0,20	5,54	7,39	8,8	11,8
	0,30	4,49	5,98	10,4	13,9
M8	**0,10**	12,60	16,70	14,5	19,3
	0,20	10,20	13,60	21,4	28,7
	0,30	8,85	11,00	25,5	33,9
M10	**0,10**	20	26,6	30	39,4
	0,20	16,2	21,7	44	58
	0,30	13,1	17,5	51	69
M12	**0,10**	29,1	38,8	50	67
	0,20	23,7	31,6	74	100
	0,30	19,2	25,6	88	117
M14	**0,10**	40	53,3	79	106
	0,20	32,6	43,4	119	159
	0,30	26,4	35,2	141	188
M16	**0,10**	55	73,3	121	161
	0,20	44,9	59,8	183	245
	0,30	36,4	48,6	218	291
M18	**0,10**	69	92	174	232
	0,20	56,2	74,9	260	346
	0,30	45,5	60,7	308	411
M20	**0,10**	88,6	118,1	224	325
	0,20	72,4	96,5	370	494
	0,30	58,7	78,3	439	586
M22	**0,10**	107	143	318	424
	0,20	88	118	488	650
	0,30	72	96	582	776
M24	**0,10**	142	165	400	534
	0,20	101	135	608	810
	0,30	83	110	724	966

For lengths up to 8X thread diameter. Strength requirements for diameters above M24 must be agreed between the buyer and the manufacturer.

Approximate values for friction coefficients of different materials, surfaces and lubricants:

Range of friction coefficient	Typical example	
	Material or surface	Lubricant
0,04...0,10 0,08...0,16	metallic, bright-polished phosphated galvanic coatings: Zn, Zn/Fe, Zn/Ni zinc laminated coatings	solid lubricants: MoS2, graphite, PTFE, PA, PE, PI in lubricating lacquers or pastes wax dispersions
	metallic, bright-polished phosphated galvanic coatings: Zn, Zn/Fe, Zn/Ni zinc laminated coatings aluminium and manganese alloys	solid lubricants: MoS_2, graphite, PTFE, PA, PE, PI in lubricating lacquers or pastes wax dispersions, greases oils as delivered condition
	hot dip galvanized	MoS_2, graphite wax dispersions
	organic coatings	with integrated lubricant wax dispersions
0,14...0,24	austenitic steel	solid lubricants or waxes pastes
	austenitic steel	wax dispersions pastes
	metallic, bright-polished phosphated	as delivered condition (light oiled)
0,20...0,35	galvanic coatings: Zn, Zn/Fe, Zn/Ni zinc laminated coatings	none
	austenitic steel	oil
	galvanic coatings: Zn, Zn/Fe hot dip galvanized	none
≥ 0,30	galvanic coatings: Zn/Fe, Zn/Ni austenitic steel aluminium and manganese alloys	none

Tightening factor aA allows errors in tightening methods and it is considerated when designing the screw joint. The greater the factor is, the bigger the screw must be selected.

Tightening factor a_A	Deviation	Tightening method
1	± 5% ...12%	Yield point or rotation angle controlled tightening, power-assisted or manual
1,2...1,6	± 9% ...23%	Hydraulic tightening
1,4...1,8	± 17% ...28%	Torque-controlled tightening or precision tool with torque measurement
1,7...2,5	± 26% ...43%	Torque-controlled tightening using a torque wrench
2,5...4,0	± 43% ...60%	Impulse-controlled tightening, impact wrench

Example:
From above tables, search maximum tightening torque and the corresponding maximum prestressing force for hex head screw DIN 931 8.8 ZN M16X80. Joint is assembled with torque measuring precision tool and without lubricants.

1) The screw is electro zinc plated and no lubricant is used.
⇨ **Friction coefficient is 0,14...0,24. Lower value 0,14 is chosen.**

2) From the carbon steel screw table, search M16 / 0,14 / 8.8
⇨ **Maximum tightening torque is 230 Nm.**

3) From the same table, search maximum prestressing force.
⇨ **230 Nm results max. prestressing force 78,8 kN.**

4) Prestressing force is corrected with the tightening factor aA.
⇨ **Minimum expected prestressing force is 78,8 kN / 1,6 = 49,25 kN.**

Friction grip (HV) fasteners

Changeover to EN –product standards in structural fasteners

Changeover

DIN 6914	EN 14399-4
DIN 6915	EN 14399-4
DIN 6916	EN 14399-6

Washers according to DIN 6917 and DIN 6918 remain as they are defined in DIN –standards.

In joints where DIN –standardized products are specified EN products can be used since they are technically equivalent or better. This is not the case vice versa.

Ordering information

DIN

Hexagon screw DIN 6914 10.9 HOT M20X80
Hexagon nut DIN 6915 10 HOT M20
Washer DIN 6916 HOT M20 (21.0)

EN

Hexagon screw / nut assembly EN 14399-4 HV 10.9/10 HOT M16X70
Washer EN 14399-6 HOT M20 (21.0)

Deadlines for product standards

Untill September 2007, German national standards DIN 6914, DIN 6915 and DIN 6916 existed side by side with European standards EN 14399-4 and -6. After that only products according to EN with CE –marking are allowed to be produced. HV –sets on stock according to DIN 6914 / 6915 / 6916 are allowed to be supplied and used without any limitation in time.

Properties

HV (Hoch Vorgespannt) is the term used for steel construction joints with high tensile screws. Special requirements are set to these screws, washers and nuts since they have to establish a safe and tested joint. They can be used only for constructions with mainly static load, such as halls, platforms and framework constructions.

The surface treatment in HV –fasteners are usually hot dip galvanizing. Zinc layer thickness is even up to 50...70 µm. This gives sufficient corrosion protection also in the most aggressive atmospheres. Together with known surface properties and defined friction coefficient of nuts treated by MoS2, proper tightening values can be determined. HV –fasteners are also available in plain finish.

Screw and nut set EN 14399-4 and washer EN 14399-6 form a complete set which should be delivered from the same manufacturer. **Ferrometal Oy stocks a wide range of HV-sets produced by our high quality partner Peiner Umformtechnik GmbH.**

Specified preloads and tightening torques for 4 tightening methods for property class 10.9 HV –assemblies:

1	2	3	4	5	6	7	8
Screw diameter	Required preload F_V in the screw	Torque control method		Air driven impact wrench method	Turn of the nut method	Combined method	
		Tightening torque M_A to achieve the specified preload F_V		Set preloading force F_{V5} [2] to achieve the specified preload F_V	Pretightening torque M_{VA6} [2]	Pretightening torque M_{VA78}	
		Surface treatment and lubrication					
		Hot Dip Galvanized and lubricated [1]	As manufactured and slightly oiled	As in column 3 or 4 [2]	As in column 3 or 4 [2]	Hot Dip Galvanized and lubricated [1]	As manufactured and slightly oiled
	k	Nm		kN	Nm	Nm	
M12	50	100	120	60	10	75	90
M16	100	250	350	110	50	190	260
M20	160	450	600	175	50	340	450
M22	190	650	900	210	100	490	680
~~**M24**~~	~~220~~	~~800~~	~~1100~~	~~240~~	~~100~~	~~600~~	825
M27	290	1250	1650	320	200	940	1240
M30	350	1650	2200	390	200	1240	1650
M36	510	2800	3800	560	200	2100	2850

1) Nuts lubricated with MoS2 or equivalent lubricant
2) Independent from the lubrication on the thread and on the faces of the nut and bolt

When assembling, install a washer under each screw head and nut. Make sure that the washer's chamfer points outwards, this way the washer can absorb the transition radius between the shaft and the head. Screw the nut by hands before tightening it to the right torque.

Torque control method
To achieve the specified preload FV according to column 2 in above table, a torque MA shown in columns 3 & 4 (dependant on the surface treatment and lubrication of the threads), shall be applied with measurable tightening tools. This method allows a stepwise tightening when the joint has many screws. By this method, it is possible to continue with preloading and so to inspect the screws. Moreover, second round of tightening can be applied after couple of days to assure that the specified preload is achieved.

Air driven impact wrench method
This method uses an air driven impact wrench for tightening of the nut. The wrench shall be set according to the column 5 to a preload FV5, which is 10% higher than for the torque control method.

Turn of the nut method
Following condition should be fullfilled and checked before using this tightening method: all parts have to be flat and in good firm contact with each other. Tightening is done in two steps: first apply a pretorque MVA6 according to column 6 by using some of the methods described above. In the second step, an additional rotation of nut shall be applied. The required additional rotation angle must be determined via appropiate testing procedure on the original assembly. One option is to measure the elongation of the screw under full preload.

Combined method
Apply the pretensioning torque according to column no. 7 or 8 depending on the surface treatment. Second step is to apply additional angle of nut rotation δ according to the table below.

Required additional angle of rotation δ and value of rotation V for the combined tightening method

1	2	3
Clamping length L_K [1] of the HV-set	Additional angle of rotation δ	Value of rotation V
$L_K < 2d$	45°	1/8 turn
$2d \le L_K < 6d$	60°	1/6 turn
$6d \le L_K < 10d$	90°	1/4 turn
$10d < L_K$	No recommendation	No recommendation

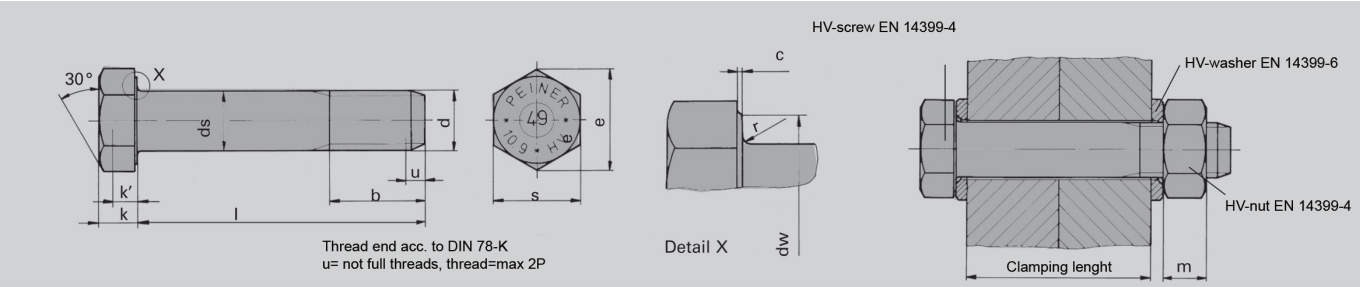
1) LK = lK + 2h
lK = clamping length according to EN 14399-4
h = washer thickness according to EN 14399-6

Inspection of the specified screw preload

1	2	3
Additional angle of rotation	Conclusion	Further actions
< 30°	Preload force is sufficient	None
30°...60°	Preload force is barely sufficient	Leave the inspected assembly but inspect two more screws in the same connection
> 60°	Preload force is not sufficient	Replace the inspected screw by a new one [1] and inspect two more screws in the same connection

1) In case of statically loaded bearing type connection with HV- or HV fit screws without axial forces, the inspected screws may remain in the construction.

Main dimensions for HV-fasteners



	M12	M16	M20	M22	M24	M27	M30	M36
d_s	12	16	20	22	24	27	30	36
b_1	21	26	31	32	34	37	40	48
b_2	23	28	33	34	37	39	42	50
c	0,6-0,2	0,6-0,2	0,8-0,4	0,8-0,4	0,8-0,4	0,8-0,4	0,8-0,4	0,8-0,4
d_w (min)	20	25	30	34	39	43,5	47,5	57
e (min)	23,91	29,56	35,03	39,55	45,20	50,85	55,37	66,44
k	8	10	13	14	15	17	19	23
k' (min)	5,28	6,47	8,47	9,17	9,87	11,27	12,56	15,36
m	10	13	16	18	20	22	24	29
r (min)	1,2	1,2	1,5	1,5	1,5	2	2	2
s	22	27	32	36	41	46	50	60

b_1 for lengths above the red line, b_2 for lengths under the red line

Nominal length	Clamping length							
	M12	M16	M20	M22	M24	M27	M30	M36
30	6 - 10							
35	11 - 15	5 - 9						
40	16 - 20	10 - 14	5 - 9					
45	21 - 23	15 - 19	10 - 14					
50	24 - 28	20 - 24	15 - 19	14 - 18	12 - 16			
55	29 - 33	25 - 29	20 - 24	19 - 23	17 - 21			
60	34 - 38	30 - 34	25 - 29	24 - 28	22 - 26	18 - 22		
65	39 - 43	35 - 39	30 - 34	29 - 33	27 - 31	23 - 27		
70	44 - 48	40 - 44	35 - 39	34 - 38	32 - 36	28 - 32	24 - 28	
75	49 - 53	45 - 47	40 - 44	39 - 43	37 - 41	33 - 37	29 - 33	
80	54 - 58	48 - 52	45 - 49	44 - 48	42 - 46	38 - 42	34 - 38	
85	59 - 63	53 - 57	50 - 54	49 - 53	47 - 51	43 - 47	39 - 43	31 - 35
90	64 - 68	58 - 62	55 - 57	54 - 56	52 - 53	48 - 52	44 - 48	36 - 40
95	69 - 73	63 - 67	58 - 62	57 - 61	54 - 58	53 - 57	49 - 53	41 - 45
100	74 - 78	68 - 72	63 - 67	62 - 66	59 - 63	58 - 60	54 - 56	46 - 48
105		73 - 77	68 - 72	67 - 71	64 - 68	61 - 65	57 - 61	49 - 53
110	84 - 88	78 - 82	73 - 77	72 - 76	69 - 73	66 - 70	62 - 66	54 - 58
115		83 - 87	78 - 82	77 - 81	74 - 78	71 - 75	67 - 71	59 - 63
120	94 - 98	88 - 92	83 - 87	82 - 86	79 - 83	76 - 80	72 - 76	64 - 68
125		93 - 97	88 - 92	87 - 91	84 - 88	81 - 85	77 - 81	69 - 73
130		98 - 102	93 - 97	92 - 96	89 - 93	86 - 90	82 - 86	74 - 78
135			98 - 102	97 - 101	94 - 98	91 - 95	87 - 91	79 - 83
140		108 - 112	103 - 107	102 - 106	99 - 103	96 -100	92 - 96	84 - 88
145			108 - 112	107 - 111	104 - 108	101- 105	97 - 101	89 - 93
150		118 - 122	113 - 117	112 - 116	109 - 113	106 - 110	102 - 106	94 - 98
155			118 - 122	117 - 121	114 - 118	111 - 115	107 - 111	99 - 103
160		128 - 132	123 - 127	122 - 127	119 - 123	116 - 120	112 - 116	104 - 108
165			128 - 132	128 - 131	124 - 128	121 - 125	117 - 121	109 - 113
170		138 - 142	133 - 137	132 - 136	129 - 133	126 - 130	122 - 126	114 - 118
175			138 - 142		134 - 138	131 - 135	127 - 131	119 - 123
180		148 - 152	143 - 147	142 - 146	139 - 143	136 - 140	132 - 136	124 - 128
185					144 - 148	141 - 145	137 - 141	129 - 133
190		158 - 162	153 - 157	152 - 156	149 - 153	146 - 150	142 - 146	134 - 138
195					154 - 158	151 - 155	147 - 151	139 - 143
200		168 - 172	163 - 167	162 - 166	159 - 163	156 - 160	152 - 156	144 - 148
210		178 - 182	173 - 177	172 - 176	169 - 173	166 - 170	162 - 166	154 - 158
220		188 - 192	183 - 187	182 - 186	179 -183	176 - 180	172 - 176	164 - 168
230			193 - 197	192 - 196	189 - 193	186 - 190	182 - 186	174 - 178
240			203 - 207	202 - 206	199 - 203	196 - 200	192 - 196	184 - 188
250			213 - 217	212 - 216	209 - 213	206 - 210	202 - 206	194 - 198
260			223 - 227	222 - 226	219 - 223	216 - 220	212 - 216	204 - 208

Standard clamping lengths

Further clamping lengths

Securing screw joint can be done with different products and methods:

1. Mechanical components, such as locking wires, locking washers, spring or tooth washers, flanged / serrated screws or nuts.
2. Locking nuts (Nyloc-nuts). Heat resistance up to 120°C / 170°C. Recommended to be replaced after five unscrewing.
3. Thread forming screws. Because of high friction and small tolerance, they do not loose easily.
4. Special products, like Nordlock –locking washers or thread locking glues.

When designing a screw joint, galvanic corrosion (contact corrosion) must be taken into account. It occurs when jointing elements have a electrochemical potential difference and huidity acts as a electrolyte. In order to avoid galvanic corrosion, suitable and not suitable materials and surfaces are presented in table below.

Structure material / Fastener material	A2 / A4	Aluminium	Copper	Brass	Steel, black passivated	Steel, yellow passivated	Steel, zinc plated	Steel, plain
A2 / A4	+++	+++	++	++	++	++	++	++
Aluminium	++	+++	++	++	+	+	+	+
Copper	+	+	+++	++	+	+	+	+
Brass	+	+	++	+++	+	+	+	+
Steel, black passivated	-	-	-	-	+++	++	++	+
Steel, yellow passivated	–	–	–	–	+	+++	++	+
Steel, zinc plated	–	–	–	–	+	+	+++	+
Steel, plain	–	–	–	–	–	–	–	+++

+++ = recommended combination

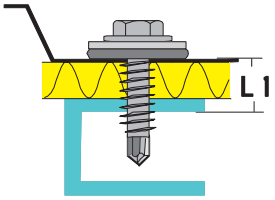
--- = not recommended combination

8. Self drilling screw

DESIGN AND INSTALLATION INSTRUCTIONS

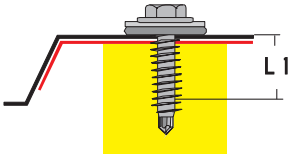
Useful lengths L1 and L2: Installing to steel basematerials

L1 is the maximum overall thickness of materials to be fixed
L2 is the length of the unthreaded part of the screw
L1 and L2 can be found from the technical information tables
The first two threads cut the spiral to the steel, and might therefore be reshaped.
They are not considered to be included to the useful length measures.



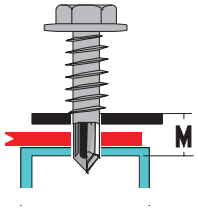
Useful lengths L1 and L2: Installing to wooden basematerial

L1 selection criteria:
Either the installation depth to wooden basematerial must be minimum 23 mm or L1=thickness of the wooden material



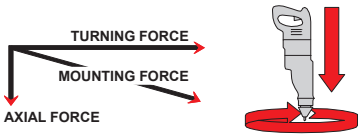
Effective drilling thickness M

Drilpoint must penetrate the material before it starts the threading.
This is why the recommended maximum thickness should not be exceeded.
Possible empty space between materials is as well considered as part of the effective drilling thickness M. If going under recommended minimum thickness, joint-strength and sealing capacity will decrease.



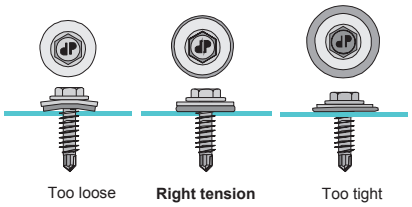
Installation

It is recommended to use electrical screw driver with torque release or depth gauge.
Axial force need is 10-20 kp.



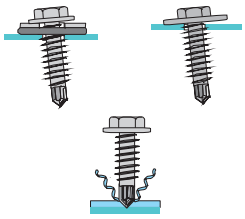
Rotation speeds for screws (unloaded)
Diameters 3,5-4,8 mm 1700-2500 rpm
Diameters 5,5-6,3 mm 1200-1800 rpm

Right tension – EPDM-insulation shown approx 1 mm under washer



Screws must set in to the basematerial within 90 degree angle. When there will be small deflections with installation angle in practise, the best joint-strength and sealing capacity will be achieved with a detachable washer.

PIAS/PIASTA drillpoints drill down easier in a right angle, than a self drilling screw with a spoonlike drillpoint.



Headmarking

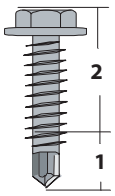
Headmarking enables screw type identification after installation

Electro zinc plated carbon steel

A2 stainless steel Piasta

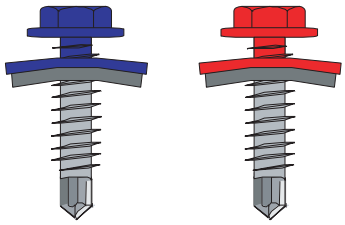
Piasta; genuine A2-stainless steel

The corrosion resistance of a A2-stainless steel is remarkably good, but it is impossible to harden it. The drillpoint and the first two cutting threads of a Piasta screw, 1) are hardened carbon steel.
The head and the rod, which submit to load and corrosion, 2) are A2-stainless steel. The whole Piasta screw has Ruspert-cover to protect from corrosion and to reduce friction when installing.



Painted screws

Standard colours are RR- and RAL-shades.
Paint thickness is minimum 40 µm.
Screws with washers, the washer is also painted from the top and sides. The paint surface tolerates installation and normal stress of usage.

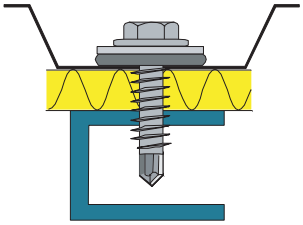


Corrosion resistance

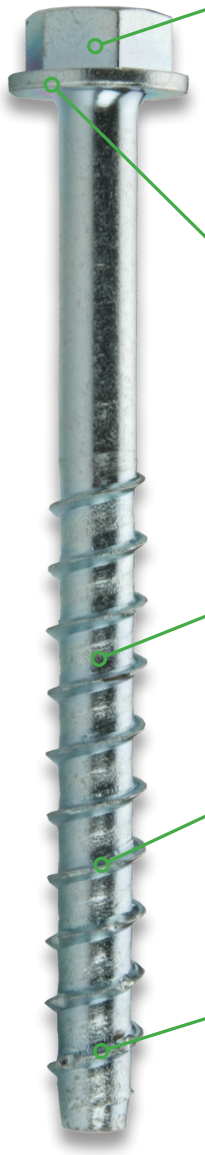
In additional to the environment conditions, things that effect the development of corrosion:

Microclimate, which can differ from the general surrounding climate. The ventilation of structures, which effects the microclimate

Galvanic corrosion eats the less electronegative metal in the pair.
The potential difference and mass index between metals, effects the corrode-speed. The mass of a screw is always only a friction of the mass of the whole structure. To secure a long life time, screw should always be more noble metal than the structure's metal is.



9. Fixcon concrete screw



Easy to install

Hexagon head together with Torx drive gives flexibility and makes installation easier. Screw's dimensions are stamped into the head where from they can be easily checked even after installation.

Number of tools needed for the installation process is less as the same wrench size is used in both 7,5 mm and 10 mm screws.

Flange head makes it even more easier

Hexagon head together with flange do not require separate washer to be used. Flange also protects fixture's surface from scratching when the screw is tightened and gives extra grip as socket tool can be pushed against it.

High class material

Through suitable material selection and controlled heat treatment, FIXCON Concrete screw gains strength that does not fail under toughest loads.

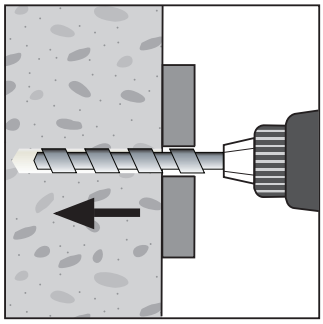
Optimum thread design

Thread design has been developed to give exceptional performance for pull-out values yet retaining easiness of installation.

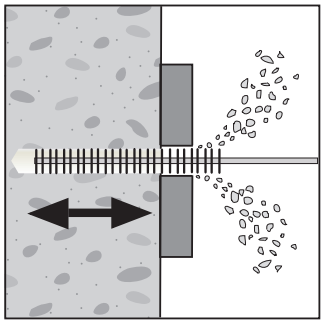
Cutting edge technology

Hardened and toothed screw tip cuts tight and firm thread groove into the concrete. Even when passing by an ironbound.

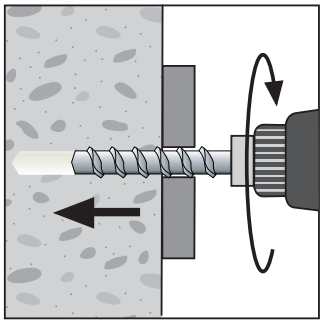
Installation



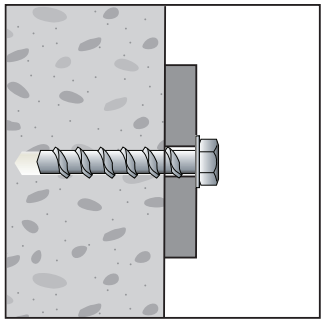
1. Drill a hole with right diameter and depth into the base material.



2. Clean the hole carefully.

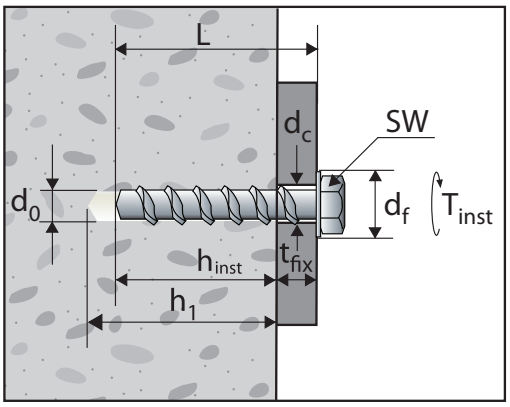


3. Drive the FIXCON concrete screw firmly in without impact motion.
   Do not exceed the maximum tightening torque.



4. Installation is ready.

Size	Drilling		Installation		Anchor				
	d_0	h_1 (min)	h_{inst} (min)	T_{inst} (max)	L	t_{fix} (max)	SW	d_f	d_c
6X35	5	50	30	12 Nm	35	5	SW 8 TX25	10,5	9
6X50		65			50	20			
6X80		95			80	50			
6X50 c-sunk.		65			50	20			
6X100 c-sunk.		115			100	70			
7,5X40	6	55	30	20 Nm	40	10	SW 13 TX40	16,5	9
7,5X50		65			50	20			
7,5X60		75			60	30			
7,5X80		95			80	50			
7,5X100		115			100	70			
7,5X120		135			120	90			
10X60	8	80	40	40 Nm	60	20	SW 13 TX40	17,5	12
10X80		100			80	40			
10X100		120			100	60			
10X120		140			120	80			



d_0	Drill hole diameter
h_1	Drill hole depth
h_{inst}	Min. installation depth
T_{inst}	Installation torque
L	Screw anchor length
t_{fix}	Fixture thickness
SW	Drive size
d_f	Flange diameter
d_c	Fixture's clearance hole

	Anchor size [dXL]	Installation depth h_{inst} [mm]	Average load F_{max} [kN]	Characteristic load F_k [kN]	Permitted load F_{sall} [kN]
Tension load	7,5X50	30	7,3	4,5	1,4
	7,5X100	45	15,0	10,1	3,1
	10X60	40	12,7	8,9	2,7
	10X120	60	23,6	18,2	5,6
Shear load	7,5X50	45	14,9	13,3	4,1
	7,5X100	55	15,2	9,8	3,0
	10X60	45	27,7	21,4	6,6
	10X120	65	27,9	22,4	6,9

The values informed are based on tests carried out by Tampere University of Technology. The concrete of nominal strength K30 was used as a base material. Characteristic load Fk is defined according to SFS EN 1990 appendix D. Permitted load Fsall have been defined with total safety factor of 3,22 which consist of partial safety factor of 2,3 for the concrete material and partial safety factor of 1,4 for the load type (½ constant and ½ changing load).

Whenever the fixing parameters are changed from the informed test arrangements, the permitted load must be defined accordingly.

10. SB structural bolting assembly

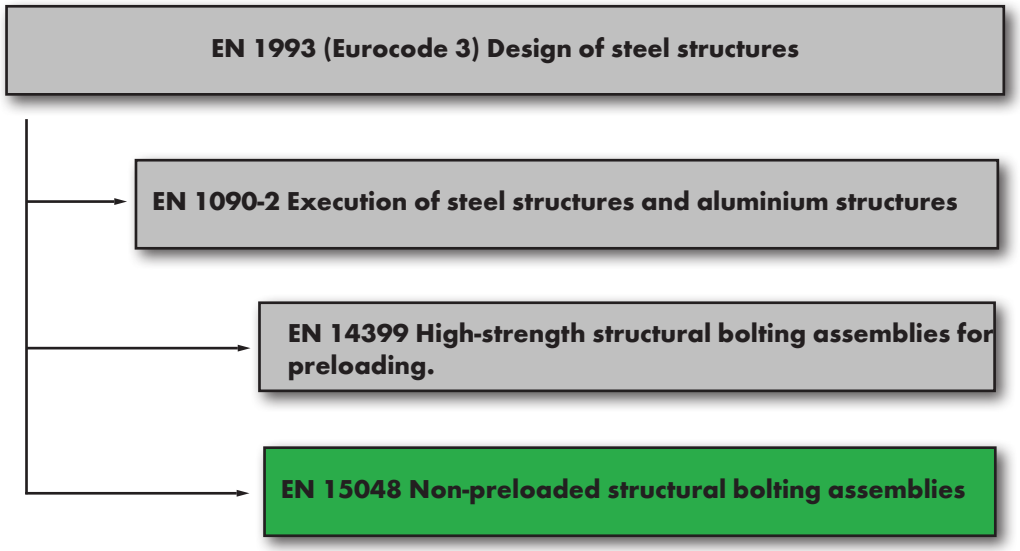
General about Eurocode 3

EN 1993 (Eurocode 3:n) brings changes also to the fasteners used in steel structure building. Fasteners used have to be according to European product standards. Hot Dip Galvanization shall be done according to EN 10684. If special fasteners are used their technical properties and required tests have to be displayed.

Standard fasteners in steel structure building engineered according to EN 1993 and executed according to EN 1090-2 can be divided into two categories in the future:

- Preloaded friction grip joints where bolting assemblies EN 14399 are required to be used. These items have been available in the markets al ready for few years and they are also belonging to Ferrometal's delivery program. These assemblies are also known as HV –sets in spoken language.

- For non-preloaded joints, a new standard EN 15048 is introduced. These bolting assemblies are currently hard to source in the markets. Ferrometal will be the first Finnish fastener distributor to ramp up an extensive stock range in the spring 2011.



General about 15048-1

Majority of the screw joints in steel structures bears only static shear forces or just mounts the elements in place. In these kind of joints pre-loading does not give any advantage in technical or in economical means.

So far non-preloaded joints have been manufactured with DIN 931 or DIN 79990 hexagon head screws and DIN 934 hexagon nuts. Approvals have been national approvals from the steel structure associations and inspection reports EN 10204 3.1 from the fastener manufacturers.

In the non-preloaded joints of steel structures executed acc. to EN 1090-2, the bolting assemblies must be according to the new standard EN 15048-1. In these joints HV or TCB assemblies (please see description later on) acc. to EN 14399 can be used.

Bolting assembly means screw, nut and washer(s) if such are needed.

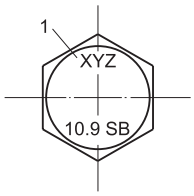
EN 15048-1 requirements

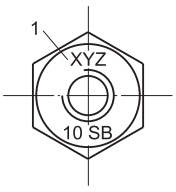
EN 15048-1 is not a product standard. It defines the technical requirements for the fasteners in this assembly:

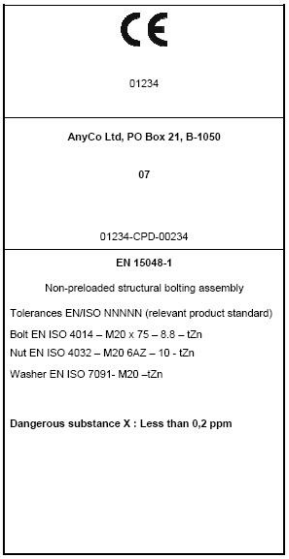
- Recognised property classes: 4.6, 4.8, 5.6, 5.8, 6.8, 8.8 and 10.9. Of which 8.8 will be the class for the stock range.
- Stainless steels A2 and A4, possible property classes are 50, 70 and 80.
- Fastener diameters M12... M36.

Bolting assembly must be supplied by one and the same CE –certified manufacturer.
Products must be CE –marked although marking just in the packing is sufficient.
Enclosed is an example of a CE –marking attached into the box. Manufacturer's production batch identification number shall be marked since full traceability is mandatory.

In addition to the familiar property class and manufacturer's identification marking, every single screw and nut have to be marked "SB" which comes from the words Structural Bolting. Enclosed is an example of the head marks in SB sets.







The usage of SB –sets

According to the requirements of EN 15048, the components of the bolting assembly must conform to European product standards. In practical, the assemblies that Ferrometal stocks consists of hexagon head screws EN ISO 4014 and hexagon nuts EN ISO 4032.

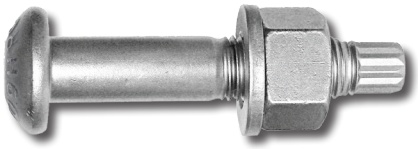
Dimensional differences to the previously used DIN 931 screws and DIN 934 nuts are: Across flats size in M12 screws and nuts, the nut height in all sizes from M12 to M36.

The screw length must be chosen so that after tightening the screw's tip must penetrate minimum one full thread out of the nut's bearing face. On the other hand, between nut's bearing face and the thread run out there must be also minimum of one full thread before the screw's shank starts. Nuts are required to be installed so that the stampings can be inspected afterwards. Washers are not required to be used in these joints excluding single lap joints with only one screw or with single row of screws.

Since SB screw assemblies are not intended to be preloaded, from standards cannot be found any instructions for the tightening torque that shall be applied into the screw joint. However, the structures have to be fastened tightly together. The only referral to this matter is can be found from EN 1090-2 where from direct citation is: "Every bolting assembly must be brought into at least tight tension. This can be achieved when the assembler uses regular size wrench without any extensions or when the impacting torque wrench starts to hammer."

Overtightening must be avoided, especially in case of diameter M12 and in short screws.

11. TCB – Tension Control Bolts: lowest cost method for pre-loaded joints



TCB complies to the latest norms of steel structure engineering

TCB is a fastening solution according to the Eurocode system for pre-loaded high friction grip joints (EN 14399-10). TCBs complies to the requirements of property class 10.9 / 10 and the minimum values of preload defined in EN 1090-2 are achieved. This means that they are interchangeable with other fastening systems.

$F_{p,C}$ values [kN]

Property class	Screw diameter (mm)							
	12	16	20	22	24	27	30	36
8.8	47	88	137	170	198	257	314	458
10.9	59	110	172	212	247	321	393	572

Here are few examples of the many applications for TCB system:

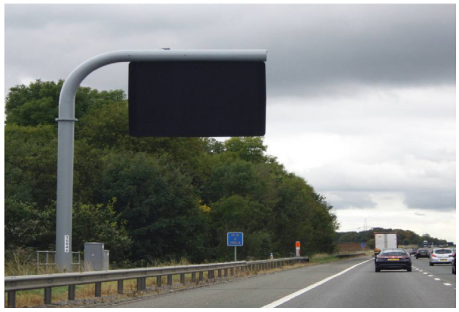
Bridges

Stadiums

Railway structures

Steel structures

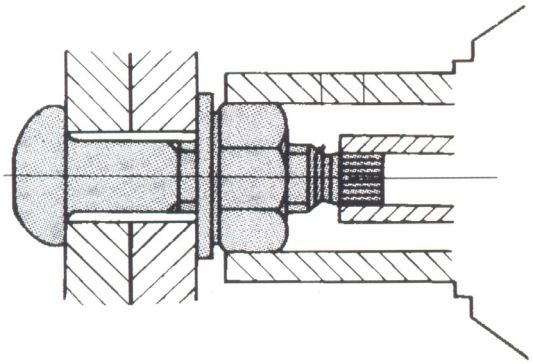
Rivet replacements



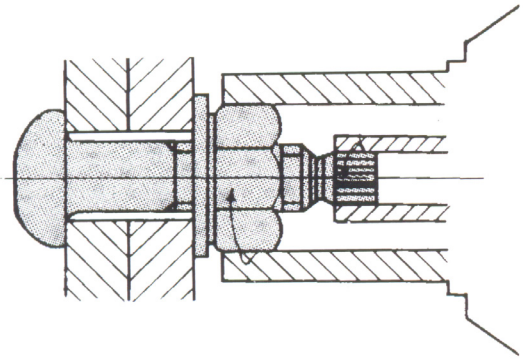
Highway gantries

TCBs can be used also in joints where only shearing forces exists. In these cases the undeniable advantage is the speed of installation achieved by the use of TCB system.

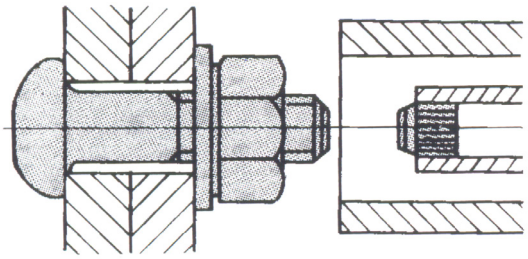
Advanced technology in installing and tightening



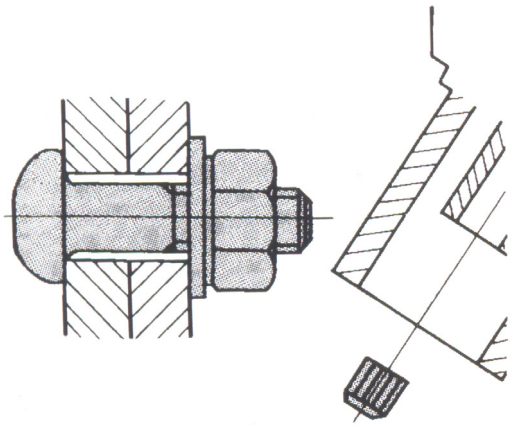
1. Slide the inner socket over the bolt spline and the outer socket over the nut.



2. Switch the wrench on. The outer socket will rotate and tighten the nut untill the bolt reaches the required tension. After this the outer socket will stop rotating and the inner socket will rotate in the opposite direction and shear the spline off.



3. When the spline has sheared off pull back on the wrench until the outer socket is no longer engaging the nut. The installation is ready and in right tension.



4. The bolt spline is retained by the wrench and can be discarded by engaging the small trigger on the wrench handle.

TCB is extremely quick, easy and safe to install. One man can install and tighten the joint. Visual inspection can be easily done to check whether the joint has been manufactured or not.

With one shear wrench several dimensions can be installed just by changing the socket of a right size.

For limited space installation there are available sophisticated tools to complete the job. With non impacting electrical shear wrenches there is no risk for hand-arm vibration syndrome.

With TCBs, consistent tension is achieved in the joint which do not loosen with vibration. No additional locking elements are needed.

There is no risk of bolt relaxation since no torsional shear is induced during tightening

Nominal thread size		Add to grip lenght => bolt lenght	
mm	inch	mm	inch
M12	-	20	-
M16	5/8″	25	1″
M20	3/4″	30	1 1/4″
M22	7/8″	35	1 1/4″
M24	1″	40	1 1/2″
M27	1 1/8″	45	1 3/4″
M30	1 1/4″	50	2″

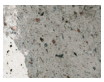
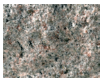
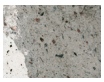
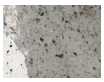
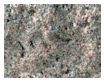
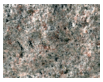
Determination of bolt length is done from the enclosed table.

High performance yet environment friendly Greenkote coating

Greenkote is a new innovative diffusion coating developed for the corrosion protection of TCBs. The process is a thermochemical surface modification and can be used for various metals, alloys, sintered ferrous-based materials, grey iron and cast iron.

- ✓ Totally environment friendly.
- ✓ Salt spray resistance up to 1200 hours.
- ✓ No risk of hydrogen embrittlement.
- ✓ Long-term corrosion protection up to 400 °C.
- ✓ Coating thickness uniformity +/- 5 microns.
- ✓ Excellent preparation for painting.
- ✓ Greenkote does not include forbidden chrome VI or chrome III particles.

12. SORMAT
TRUSTED FIXINGS SINCE 1970

	Concrete	Solid brick	Hollow brick	Natural stone	Aerated concrete	Light grovel	Plasterboard
S-KA							
Multi-Monti							
LA, LAH							
MTA							
PFG							
Voima-ankkuri B/S							
MSA							
PKN							
CONFIX							
KRH							
NAT, NAT L							
SUP, SUF							
LYT							
KBT							
KBTM							
KEM KEMLA							
ITH							

	Concrete	Solid brick	Hollow brick	Natural stone	Aerated concrete	Light grovel	Plasterboard
KLA 							
OLA 							
MOLA 							
YLT 							

CONCRETE
The most common building material. Concrete is mainly used in industrial building because of it's high strength. In housebuilding typical concrete structures are foundations, supporting structures, midsoles and stair elements. All expanding anchors as well as chemical anchors are suitable for use in concrete. Restrictions of use are spacings and edge distances.

SOLID BRICK
A very common building material. Brick is used mainly in small house building. In industrial building brick is mainly used as material of separating structures. All expanding anchors are suitable for using in brick. Restrictions of use are spacings, edge distances and sizes of fixings

HOLLOW BRICK
A very common building material. Hollow brick is mainly used as material for separating structures, and in constructions where some kind of thermal isolation is required. Suitable anchors for hollow brick are Nylon plugs made with long expanding zone as well as injection resins used with a sleeve. Restrictions of use are same as in solid brick.

NATURAL STONE
Main use in buidings is in covering surfaces like facades and fl oors. Most expanding anchors as well as chemical anchors are suitable for use in natural stone. Restrictions of use are spacings and edge distances. Because of brittleness, stone cracks easily.

AERATED CONCRETE
A rather common building material in all building because of it's light weight and fl exibility in use. Aerated concrete is used mostly in separating structures, but also in supporting structures. Suitable anchors for aerated concrete are Nylon plugs with long expansion zone and those, specially designes for this material, like KBT. Chemical fi xings can be used with resticions (special shape of the hole).

LIGHT GRAVEL
A common building material in small house building. It is mainly used in foundations and supporting structures. Suitable anchors for this material are Nylon plugs with long expanding zone. Chemical fi xings can be used with resticions (special shape of the hole).

PLASTERBOARD
A very common building material in all building. Main use of this material is in surface structures. Suitable fi xings are hollow wall and cavity anchors.

MATTERS TO BE OBSERVED WHEN INSTALLING AN ANCHOR

1. Enough strength in the base material (concrete >C20/25). Base material's strength has a remarkable infl uence in the capacity of an anchor.
2. Right size of the hole. Anchors do not fi t in too small holes and they do not work properly, or at all in too big holes.
3. Embedment depth according to instructions. Embedment depth has a remarkable influence in the capacity of an anchor.

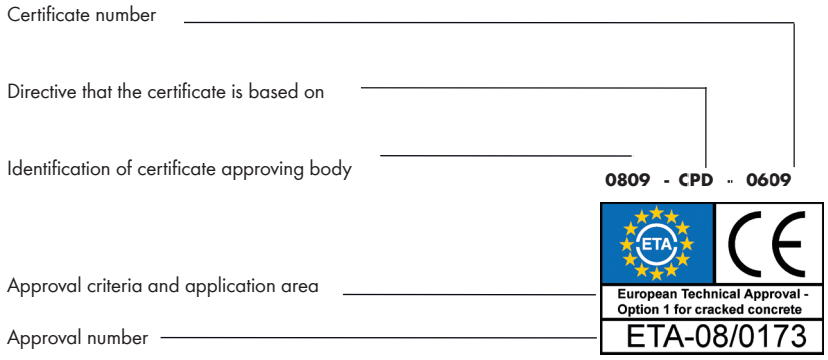
CE-MARKING AND ETA APPROVAL

WE HAVE THEM!

Sormat products have several national and international approvals of which the most important is the certifi ed proof of conformity, CE-certificate, based on the European Technical Approval ETA.

A right to use CE marking requires a European Technical Approval, ETA. Opposite to the CE marking, the ETA is not well known, not even among professionals. One of the reasons is, that the ETA for metallic anchors consists of 12 alternative options. Each option consists of different amount of tests to be performed to the product. In option 1, a lot of different properties of the product is tested, as in option 12 just a few properties will be tested. This all means that a product in option 1 has got much more official data of its properties than the one in option 12. However, amount of data does not make a product better, it only provides a possibility to study somewhat versatile applications.

According to the Quality Policy of Sormat, the products must fulfil customer needs, as well as self evident needs like the needs of authorities. This is why we take care that the essential products in our range will have a CE marking. When choosing a Sormat product, as a retailer or as an end user, You can be sure about conformity, safety, and suitability of the product also in most demanding applications.



Sormat chemical solutions

Sormat offers a wide range of chemical anchoring solutions for the building and construction industry. These resin-based systems can be used to fix a wide variety of components and fixtures directly to different base materials. Each system has been designed to meet the high performance standards of the construction industry and is manufactured within the internationally recognized ISO 9001:2000 Quality System.

Sormat comprehensive chemical anchoring solutions consists of two different kind of anchoring methods and a large variety of accessories. Sormat ITH resins are 2-componet, solid plastic cartridge based, fast curing injection resins systems for chemical fastenings and Sormat
KEM/KEMLA are factory premeasured and sealed glass capsule anchors.

In general chemical anchoring solutions have additional benefits in applications which require egg. small edge distances and anchor spacing, dynamic load values and flexibility related to different base material variatons.

Determing the right anchoring method

The functioning of all types of chemical anchors is based on the adhesion of the resin to the wall of the bore hole and the threaded rod/rebar. It is of the utmost importance to comprehend the difference between the various Sormat anchoring solutions (see next pages) available and other factors related to the installation. When determining the right anchoring solution understanding of the application requirements is necessary, for example:

LOAD REQUIREMENTS
- dynamic
- static
- design, etc

BASE MATERIAL
- hard concrete (C50/60)
- soft concrete (C20/25)
- cracked concrete
- masonry

INSTALLATION DIMENSIONS
- anchor spacing
- edge distances
- embedment depth

APPLICATION- AND ENVIRONMENTAL CRITERIA
- corrosion resistance
- fire resistance requirements
- earthquakes
- extreme weather conditions
- anchoring in wet or damp holes

Product	Recommended tension load KG	Concrete	Solid brick	Hollow brick	Natural stone	Aerated concrete
	Performance M16 stud concrete C20/25					
 ITH 150 P	 1980	++	+++	+++	++	+++
 ITH 300 P	 1980	++	+++	+++	++	+++
 ITH 380 P	 1980	++	+++	+++	++	++
 ITH 300 EA	 2030	+++	+	+	+++	-
 ITH 380 EA	 2030	+++	+	+	+++	-
 ITH 380	 2480	+++	+	+	+++	-
 ITH 380 W	 2030	+++	+	+	+++	-
ITH 400 EPOX	 3880	+++	-	-	+++	-
KEM	 1500	+++	-	-	+++	-
KEM VE	 2220	+++	-	-	+++	-
KEMLA	 1190	+++	-	-	+++	-

+ mild suitability ++ average suitability +++ high suitability -not suitable

Product	Base material temperature		Dispencing tool				possible applications			Other features		
	+25 °C - -6 °C- -5 °C -18 °C	+25 °C +5 °C	silicone dispencer	IPU 380	IPU 400	no dispencer	rebar	under water	heat resistance up to 120 °C	ETA-approved	styrene free	shelf life (months)
ITH 150 P	■		■								■	18
ITH 300 P	■		■								■	18
ITH 380 P	■			■							■	18
ITH 300 EA	■		■				■	■	■		■	18
ITH 380 EA	■			■			■	■	■		■	18
ITH 380	■			■			■	■	■	■	■	18
ITH 380 W		■		■			■				■	18
ITH 400 EPOX		■			■		■	■	■		■	18
KEM	■					■		■				36
KEM VE	■					■		■		■		36
KEMLA	■					■	■					12

■ Suitable for mentioned application or conditions

Introducing the Sormat MULTI-MONTI®

Sormat Multi-Monti® is an innovative anchorage system for fixation in concrete and brick. The Sormat Multi-Monti® Screw-In-Anchor will be screwed directly into a pre-drilled hole. The holding principle is based on the multiple chisels in the tip of the screw anchor that cut in to the concrete.

The formclosed anchorage is free of expansion forces and can be loaded immediately. No defi ned torque is required for a safe connection. Sormat Multi-Monti® can be used for anchoring in concrete and other solid wall materials such as sand lime brick,
solid-brick, clinker, and even in hollow concrete slabs.

New features, new advantages!

Sormat MULTI-MONTI® in a truly innovative product for fi xation into concrete and brick. Its advantages range from ETA approved quality to easy installation and secure fixing. Here are listed some of these features and be

FIRST SCREW ANCHOR WITH ETA APPROVAL
- **high quality and safety quarantee**
- **the product can be used with complete safety even in critical installation conditions (approved for cracked and non-cracked**

INSTALLATION WITHOUT ANY PRESCRIBED TIGHTENING TORQUES
- **installation errors are effectively ruled out, which is an additional safety factor**
- **the ability to work without a torque wrench**

FASTENING WHICH IS FREE OF EXPANSION PRESSURE
- **the ability to work close to the edge of the base material**
- **small spacing and edge distances**

THE SCREW IN ANCHORS IS SET WITHOUT A PLUG
- **quick and easy to install**
- **reduced installation time**

CHISELD TIP DESIGN
- **the thread starts immediately without breakout of the concrete surface**

STAINLESS STEEL
- **suited to use in tunnel applications – wide range of applications possible**

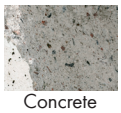
REMOVABLE AND REUSABLE
- **the anchor can be completely removed if needed**
- **the anchor can be reused two times, which saves temporary fastening costs**

NO PROTRUDING THREADS
- **neat head finish**

IMMEDIATE LOADING
- **no waste of time, the anchor will bear loads immediately**

Suitable base materials

The Sormat MULTI-MONTI® is approved for installations in cracked and non-cracked concrete and is suitable for use with many other building materials as well.


Concrete


Natural stone


Solid brick


Sand lime brick


Hollow concrete slabs

Applications

There are many different versions of Sormat MULTI-MONTI® Screw-In-Anchor available. Be it external or internal use, or structures subject to obligatory fireproofing: Sormat MULTI-MONTI® covers most areas of use. Here is a selection of the most common applications


Fastening of fences, railings / handrails


Seating installation


Racking / shelving

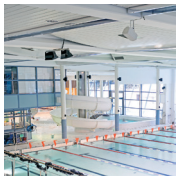

Beams and structures etc.

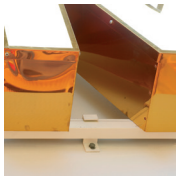

Protection barriers


Scaffolding


Suited for use in tunnel construction (fire prevention plates)


Baseplates


Suspended ceilings


Other applications such as illuminated signs concrete formwork and temporary fastenings

13. Rivets

Riveting is very reliable and widely used technique for fastening materials together permanently.
For best results following instructions should be observed:

Joint strength
Determine the shearing and tensile strengths that are required for the joint. They are fullfilled by using adequate number of rivets with right sizes and materials

Workpiece materials
When joining materials with different thickness or strengths the stronger material must be on the blind side of the joint. For example when fastening plastic and steel together the plastic piece should be under the rivet head and the steel on the blind side.

Rivet diameter
In heavy load applications the rivet diameter should be at least equal to the thickest sheet thickness but not more than 3X the sheet under the rivet head.

Rivet length
Recommended length is the same as thickness of the workpiece materials (S) added by the rivet diameter (d). L = S + d

Grip range S (min-max)
The maximum thickness of the jointing workpieces when the hole diamater is according to the given values. The possible gap between the sheets must be included in the grip range calculation.

Hole diameter
Drilled or punched holes must be free of burrs in order to achieve reliable joint. In many cases the rivet fixes well into a hole which is maximum 0,1 mm bigger than the rivet's nominal diameter.

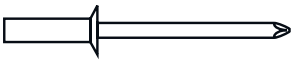
Edge distance
Rivet hole distance from an edge should be at least 2X rivet diameter but not more than 24X.

Rivet distance
In high strength joints the distance between rivets should not be more than 3X rivet diameter.

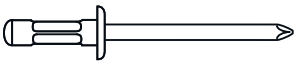
Rivet material
The right rivet material is typically chosen to achieve the required strength in the joint. If the chosen rivet material differs from the workpiece material it is important to notice the risk of galvanic corrosion.

Blind rivet types and use

Open type rivet
Vast range of blind rivets with different materials and head types.
Offers economical solution for applications which are not under heavy loads.



Closed type rivet
Blind rivets for applications in which water or pressure tightness is required or where mandrel loosening is not allowed.

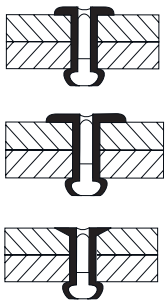


Multi-grip rivet
This rivet is suitable for joints with wider grip range than conventional rivets.
Good choice also for riveting irregular holes.

Grooved rivet
Designed for soft and fibrous materials like wood and plastic.
Material fibres penetrates into the grooves when the joint is manufactured.

Peel type rivet
Rivet is ideal for fibre glass, plastic, rubber, wood and laminate joints.
Applicable also for joints with oversize holes or misaligned work pieces.

Head types

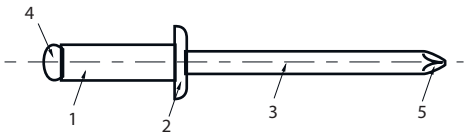


Dome head
Typical head type which can be used in majority of the applications.

Large flange
For applications where soft, thin or brittle material is fixed into a solid base.
Large flange enables bigger hole under the head.

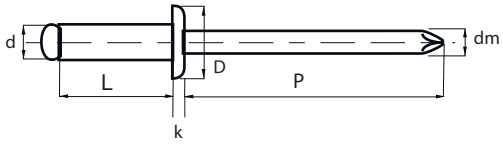
Countersunk
To be used when flush surface is needed.

Blind rivet parts



1 Body
2 Head
3 Mandrel
4 Mandrel tip
5 Mandrel beveled tip

Dimensions



d Nominal diameter
with + / - tolerance

L Body length
with + / - tolerance

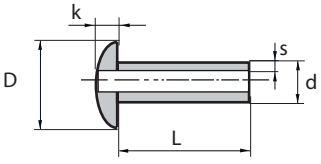
D Head diameter
with + / - tolerance

k Head height
with + / - tolerance

P Mandrel length

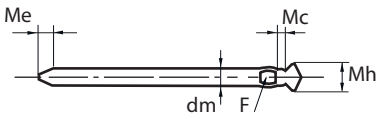
dm Mandrel nominal diameter
Helps to choose right nosepiece for the rivet tool.
Nosepiece is crucial factor in succeeded jointing.

Rivet body



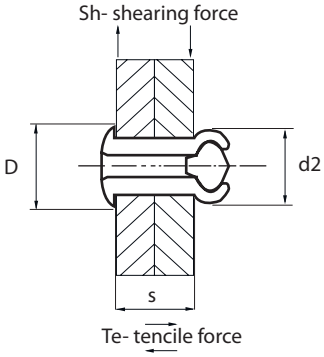
d Nominal diameter
L Length
D Head diameter
k Head height
s Body material thickness

Mandrel



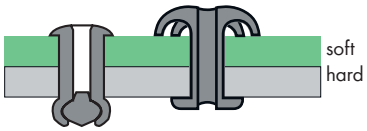
Mh Mandrel tip diameter
Ml Mandrel length
F Body locking into the mandrel
dm Mandrel diameter
Me Mandrel beveled tip
Mc Mandrel breaking zone

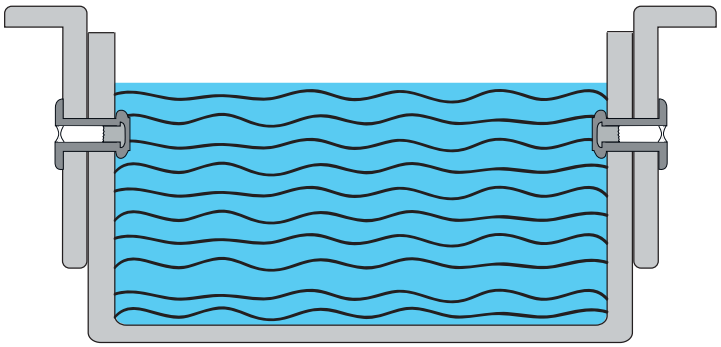
Finished rivet

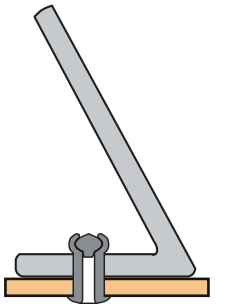


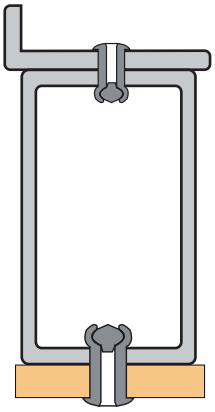
d2 Expansed rivet body
D Head diameter
S Grip range
Sh Shearing force
Te Tensile force
Shear and tensile strength defines the rivet properrties
Actual strength is dependable of the joint materials and their thickness
Unit for shear and tensile force is Newton (1 kg ≈ 10N)

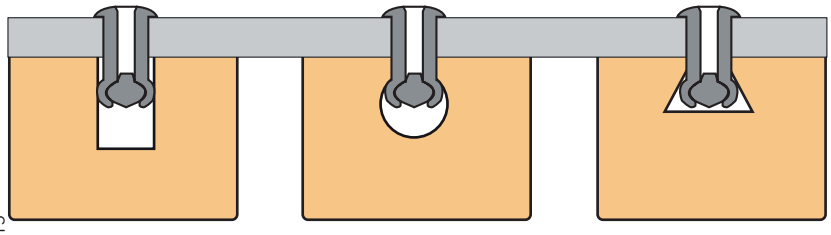
Application examples

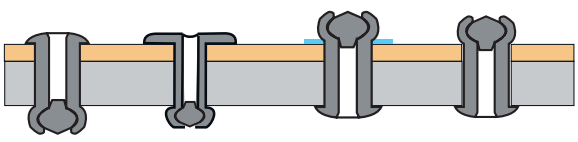


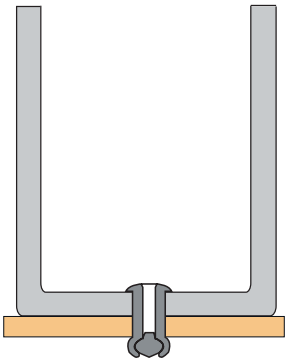








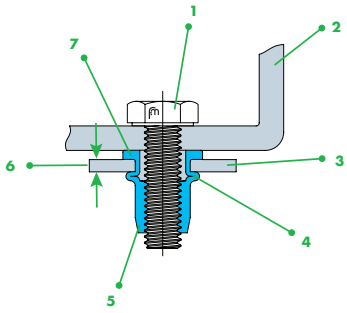




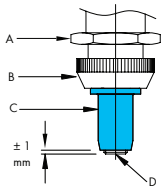
Rivet nuts

FM blind rivet nut is an excellent solution for sheet metals where high load bearing capacity is required. Installation can be done blind (one sided) in applications where there is no or little access at the rear e.g. beams, pipes, profiles... FM blind rivet nut portfolio covers a wide range of items for different materials, sizes and grip ranges. Thread sizes from M3 to M12 and materials steel, A2, A4,
aluminium and brass, zinc plating Cr6 free.

Examples of different industrial applications: automotive, aviation, shipbuilding, railroads, electronics, lightning, household furniture, household electronics, buildings etc...

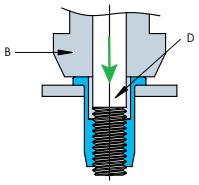


Designation
1 Fastening screw
2 Element to be fastened
3 One or several sheet(s) to be fastened
4 Deformation zone
5 Chamfer guides the rivet nut into the hole
6 Sheet thickness
7 Rivet nut head

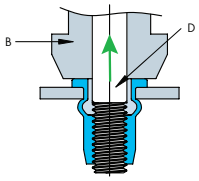


Installation

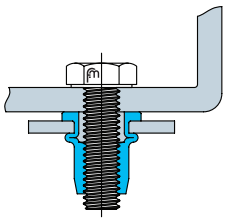
A Locking nut
B Anvil
C Blind rivet nut
D Mandrel



Screw the FM blind rivet nut on the mandrel so that the mandrel protrudes about 1 mm out of the rivet nut. Push the rivet nut into the hole of the workpiece.



The setting tool will pull the FM blind rivet nut in place by
creating the deformation chamber on the underside of the workpiece.
Unscrew the mandrel from the rivet nut.



Fix the fastening element with applicable screw.

Application examples