STANDARD

ISO : –
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STAINLESS STEEL

Guidelines for assembling

Pre-loads and tightening torques

		Assembly pre-load F_M in kN								Tightening torque M_A in Nm							
Friction coëfficient		0,1	0,12	0,14	0,16	0,18	0,20	0,30	0,40	0,1	0,12	0,14	0,16	0,18	0,20	0,30	0,40
Nom. size	Class																
	50	1,38	1,33	1,27	1,22	1,17	1,12	0,90	0,74	0,8	0,9	1,0	1,1	1,2	1,3	1,5	1,6
M4	70	2,97	2,85	2,73	2,62	2,50	2,40	1,94	1,60	1,7	2,0	2,2	2,3	2,5	2,6	3,0	3,3
	80	3,97	3,80	3,64	3,49	3,34	3,20	2,59	2,13	2,3	2,6	2,9	3,1	3,3	3,5	4,1	4,4
	50	2,26	2,18	2,09	2,00	1,92	1,83	1,49	1,22	1,6	1,8	2,0	2,1	2,2	2,4	2,8	3,2
M5	70	4,85	4,66	4,47	4,29	4,11	3,93	3,19	2,62	3,4	3,8	4,2	4,6	4,9	5,1	6,1	6,6
	80	6,47	6,22	5,96	5,72	5,48	5,24	4,25	3,50	4,6	5,1	5,6	6,1	6,5	6,9	8,0	8,8
	50	3,20	3,07	2,94	2,82	2,70	2,59	2,09	1,73	2,8	3,1	3,5	3,7	4,0	4,1	4,8	5,3
M6	70	6,85	6,57	6,31	6,05	5,79	5,54	4,49	3,70	5,9	6,7	7,4	7,9	8,4	8,8	10,4	11,3
	80	9,13	8,77	8,41	8,06	7,72	7,39	5,98	4,93	8,0	9,1	9,9	10,5	11,2	11,8	13,9	15,0
	50	5,86	5,63	5,40	5,18	4,96	4,75	3,85	3,17	6,8	7,6	8,4	9,0	9,6	10,1	11,9	12,9
M8	70	12,6	12,1	11,6	11,1	10,6	10,2	8,25	6,80	14,5	16,3	17,8	19,3	20,4	21,5	25,5	27,6
	80	16,7	16,1	15,4	14,8	14,2	13,6	11,0	9,1	19,3	21,7	23,8	25,7	27,3	28,7	33,9	36,8
	50	9,32	8,96	8,60	8,27	7,91	7,58	6,14	5,05	13,7	15,4	16,7	18,1	19,3	20,3	24,0	26,2
M10	70	20,0	19,2	18,4	17,7	16,9	16,2	13,1	10,8	30	33	36	39	41	44	51	56
	80	26,6	25,6	24,6	23,6	22,6	21,7	17,5	14,4	39,4	44	47,8	51,6	55,3	58	69	75
	50	13,6	13,1	12,6	12,0	11,6	11,1	9,00	7,38	23,3	26,0	28,9	30,8	32,8	34,8	41,0	44,6
M12	70	29,1	28,1	26,9	25,8	24,8	23,7	19,2	15,8	50	56	62	66	70	74	88	96
	80	38,8	37,4	35,9	34,4	33,0	31,6	25,6	21,1	67	74	82	88	94	100	117	128
	50	18,7	17,9	17,3	16,5	15,8	15,2	12,3	10,1	37,1	41,7	45,6	49	52	56	66	71
M14	70	40,6	38,5	37,0	35,4	34,0	32,6	26,4	21,7	79	89	98	105	112	119	141	152
	80	53,3	51,3	49,3	47,3	45,3	43,3	35,2	29,0	106	119	131	140	150	159	188	204
	50	25,7	24,7	23,8	22,8	21,9	20,9	17,0	14,0	56	63	70	75	81	86	102	110
M16	70	55,0	52,9	50,9	48,9	46,8	44,9	36,4	30,0	121	136	150	162	173	183	218	237
	80	73,3	70,6	67,9	65,2	62,4	59,8	48,6	40,0	161	181	198	217	231	245	291	316
	50	32,2	31,0	29,8	28,5	27,3	26,2	21,2	17,5	81	91	100	108	115	122	144	156
M18	70	69,0	66,4	63,8	61,2	58,6	56,2	45,5	37,5	174	196	213	232	246	260	308	334
	80	92,0	88,5	85,0	81,6	78,1	74,9	60,7	50,1	232	261	285	310	329	346	411	447
	50	41,3	39,8	38,3	36,7	35,2	33,8	27,4	22,6	114	128	142	153	164	173	205	223
M20	70	88,6	85,4	82,0	78,7	75,4	72,4	58,7	48,1	244	274	303	328	351	370	439	479
	80	118	114	109	105	101	96,5	78,3	64,6	325	366	404	438	467	494	586	639
	50	51,6	49,8	47,9	46,0	44,1	42,3	34,3	28,3	154	174	191	208	222	234	279	303
M22	70	61,5	59,3	57,0	54,7	52,5	50,3	40,9	33,7	182	206	227	247	263	279	332	361
	80	148	142	137	131	126	121	98,2	80,9	437	494	545	593	613	670	797	866
	50	59,6	57,4	55,1	52,9	50,7	48,6	39,4	32,6	197	222	243	264	282	298	354	385
M24	70	70,9	68,3	65,6	63,0	60,4	57,9	47,0	38,8	234	264	290	314	336	355	421	458
	80	170	170	157	151	145	139	113	93,1	561	634	696	754	806	852	1010	1099
M27	50	75,6	72,9	70,1	67,3	64,5	61,9	50,2	41,5	275	311	344	377	399	421	503	548
	70	90,0	86,8	83,4	80,1	76,9	73,7	59,8	49,4	328	371	410	444	475	502	599	652
M30	50	91,9	88,6	85,2	81,7	78,4	75,2	61,0	50,3	374	423	467	506	540	571	680	740
	70	104	105	101	97,3	93,3	89,5	72,6	59,9	445	503	556	602	643	680	809	881
M33	50	114	110	106	102	98	94	76	63	506	573	634	688	763	779	929	1013
M36	50	135	130	125	120	115	110	89	74	651	737	814	882	944	998	1189	1296
M39	50	162	156	150	144	138	133	108	89	842	955	1057	1147	1228	1300	1553	1694

These values apply to austenitic stainless steel hexagon bolts and hexagon nuts.
The torques are theoretically calculated values depending on the friction coëfficient chosen and based on a pre-load, utilizing 90% of the minimum 0,2% proof stress during assembly.
This table shall only be used as a guideline. No liability can result from its use.

STANDARD

ISO : 8839
EN : 28839
DIN : 267 Part 18 (W)

COPPER AND COPPER ALLOYS

BRASS AND KUPRODUR

1. Scope and field of application

These specifications apply to mechanical fasteners (mainly bolts, screws and nuts) made from copper and copper alloys with screw thread diameters up to and including 39 mm, with metric (ISO) thread, self tapping and woodscrew thread as indicated in section 10.
Other fasteners, e.g. rivets, may have deviating properties.

The most applied copper alloy is brass, with its most interesting features being: a high electrical conductivity of 15.10^6 S/m and a non-magnetizability of $3 \div 10 \,.\, 10^{-6}\ cm^3 \,.\, g^{-1}$
Therefore brass fasteners are very popular in the electrotechnical industry for switch boxes, transformers, radio and television, antennas, domestic appliances, etc.
Because of its rather respectable corrosion resistance (see the corrosion table elsewhere in this section) this material is also very often used in furniture making and metal work, shipbuilding, the pump and sanitary industry, watchmaking, and the optical and medical equipment industry.
Also the choice can be made by the decorative colour, which can be even further improved by chrome or nickel plating.

2. Materials

For mechanical fasteners a choice can be made out of 7 material types.

Identification symbol	Material symbol		Werkstoff-nummer	Chemical composition in %									according to			Common designations
	new	old		Cu	Zn	Al	Fe	Ni	Pb	Sn	Mn	Si	DIN	ISO	unified numbering system (U.S.A.)	
1) CU 1	Cu-ETPorCu-FRHC	E-Cu	2.0060	≥ 99,90	–	–	–	–	–	–	–	–	1787	1337	C 11000	copper
2) CU 2	Cu Zn 37	Ms63	2.0321	62,0-64,0	rem.	–	–	–	–	–	–	–	17660	426/1	C27400	brass (cold-formed)
3) CU 3	Cu Zn39 Pb3	Ms58	2.0401	57,2-59,0	rem.	–	–	–	2,5-3,5	–	–	–	17660	426/2	C38500	brass (turned)
CU 4	Cu Sn6	Sn Bz6	2.1020	rest	–	–	–	–	–	5,5 7,0	–	–	17662	427	C51900	tin bronze
4) CU 5	Cu Ni1Si	–	2.0853	rest	–	–	–	1,0-1,6	–	–	–	0,4 0,7	17666	1187	–	kuprodur
3) CU6	Cu Zn40 Mn1 Pb	Ms 58 Pb	2.0580	57,0-59,0	rem.	–	–	–	1,0-2,0	–	0,4-1,8		17660	–	C67130	brass (turned)
CU7	Cu Al10 Ni5 Fe4	Cu Al10 Ni	2.0966	rest	–	8,5-11,0	2,0-5,0	4,0 6,0	–	–	–	–	17665	428	C63000	aluminium bronze

1) electrical specific conductivity in mild condition ≥ 57 . 10^6 S/m.
2) homogeneous single phase α–brass. Excellent cold heading quality, difficult to hot forge and to machine.
3) heterogeneous two phase ($\alpha + \beta$) brass. Good machinibility, suitable for hot forging but difficult for cold heading.
4) see next page, clause 7.

It is noted that copper alloys with a content of less than 85% copper and thus also brass, are highly susceptible to stress corrosion, which can occur under tensile stresses particularly in an atmosphere containing ammonia or alkalinitrate.
This selective type of corrosion is also called “season disease” or “dezincification” and can cause unexpected cracking without deformation.
For cold headed products it is frequently necessary to stress relieve on + 250-300 °C.
To obviate any risk, stainless steel will be a technically better alternative.

3. Mechanical properties

Identification symbol	Nominal size		Tensile strength	0,2% Yield limit	Elongation
	above	up to and including	N/mm² min.	N/mm² min.	in % min.
CU 1	–	M39	240	160	14
CU 2	–	M6	440	340	11
	M6	M39	370	250	19
CU 3	–	M6	440	340	11
	M6	M39	370	250	19
CU 4	–	M12	470	340	22
	M12	M39	400	200	33
CU 5	–	M39	590	540	12
CU 6	M6	M39	440	180	18
CU 7	M12	M39	640	270	15

The mechanical properties of brass bolts and screws are comparable with the property class 4.6 of steel fasteners and are in this respect directly interchangeable. However the elongation and impact strength are considerably lower through cold-working causing rupture even under little and short term overloading. Because of this it is advised to use stainless steel instead of brass for dynamic and shocking loads.
Brass can be applied to + 175-200 °C, decreasing the yield limit by about 10%.
Brass cannot be strengthened by heat treatment.

FABORY

STANDARD

ISO : 8839
EN : 28839
DIN : 267 Part 18 (W)

COPPER AND COPPER ALLOYS

BRASS AND KUPRODUR

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4. Minimum rupture torques in Nm for sizes up to and including M5

Identification Symbol	Nominal size						
	M1,6	M2	M2,5	M3	M3,5	M4	M5
CU 1	0,06	0,12	0,24	0,4	0,7	1	2,1
CU 2	0,10	0,21	0,45	0,8	1,3	1,9	3,8
CU 3	0,10	0,21	0,45	0,8	1,3	1,9	3,8
CU 4	0,11	0,23	0,5	0,9	1,4	2	4,1
CU 5	0,14	0,28	0,6	1,1	1,7	2,5	5,1

The rupture torques have been calculated according to:

$$M_d = \tau . \frac{\pi d_s^3}{16}$$

$$\tau = \frac{R_m}{\sqrt{3}} \qquad d_s = \frac{d_2 + d_3}{2}$$

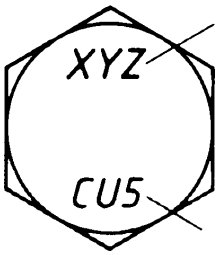
M_d = rupture torque Nm
τ = admissable torsional strength N/mm²
d_s = diameter of the stress cross-section mm
d_2 = nominal effective diameter mm
d_3 = nominal minor diameter mm
R_m = tensile strength N/mm²

5. Tightening torques in Nm for CU 2 (brass Ms 63)

Nominal size	M2	M2,5	M3	M3,5	M4	M5	M6	M8	M10
Tightening torque	0,14	0,29	0,5	0,79	1,2	2,2	3,9	9	17

These values are for reference only.
They should be verified if necessary, on the basis of practical findings.

6. Marking: guarantee for quality



Mark of origin

Material identification symbol

Hexagon head bolts and nuts and socket cap screws made from copper and copper alloys with metric screw thread from M5 upwards must be marked with the material identification symbol and the mark of origin as in the figure. (In this metal group a property class indication, as is usual for steel and stainless steel, does not exist).
The nuts can be marked on one of their end faces or on one of their key flats.
All other fasteners shall generally not be marked, unless it is mutually agreed to do so.

7. Kuprodur (CU 5)

For chemical composition and mechanical properties see the preceding page.
Kuprodur is a copper, nickel, silicon alloy with 98% copper and the following specific features:
– this alloy can be heat-treated, gaining high mechanical properties, which even increase at low temperatures e.g. the elongation and impact strength at -60 °C are about 25% higher.
– temperature-resistant to + 250 °C. Under constant load considerable relaxation with regard to creep has to be taken into account.
– high electrical specific conductivity = 18 . 10^{-6} S/m.
– non-magnetizability = + 0,066 . 10^{-6} cm^3 .g^{-1}.
– not susceptible to stress corrosion and very resistant to many acids, alkalis, sea water and atmospheric influences, comparable with pure copper.
Kuprodur therefore is very often applied in nuclear power plants, and in the water treatment, shipbuilding, low temperature technics, electro-technical and chemical equipment industries.

Pre-loads in N and tightening torques in Nm (with average friction coëfficient = 0,125)

Nominal size	M5	M6	M8	M10	M12	M16
Preload N	5550	7800	14300	22800	33400	63000
Tightening torque Nm	4,7	8	19	39	67	165

These guide values apply to a joint made from copper.