Non-ferrous metal

Properties of screws and nuts made from aluminum alloys

Non-binding information depending on manufacturer

The values in the table are for: density = 2,8 kg/dm^3, coefficient of thermal expansion = 23,6 · 10^{-6} · K^{-1}, modulus of elasticity = 70 000 N/mm^2

Material designation EN AW-	Material number EN AW-	Designation		Information provided by Bossard	Stage of preparation of the screws/nuts[3] EN 515	$R_{p\,0,2}$ [N/mm^2] min.	R_m [N/mm^2] min.	A[2] [%] min.	Used for
		DIN 209-1 Material number	EN 28839						
Al Mg5	5019	3.3555	AL 2	–	soft work hardened	200	280–310	6	very good level of corrosion-resistance, seawater-resistant, low strength
Al Si1 Mg Mn	6082	3.2315	AL 3	–	hardened T6	250	310	7	very good level of corrosion-resistance, medium strength
Al Mg SiCu Mn	6056	–	AL 9	–	hardened T6	360	420	8	high corrosion resistance, maximum strength with good ductility
Al Mg Si	6060	–	(~AL 3)	P40	hardened T8	240	270	6	Bossard connecting elements
Al Mg1 Si 0,8 Cu Mn	6013	–	–	–	hardened T8	370	400	10	still a good level of corrosion-resistance, high strength
Al Cu4 Mg Si	2017	3.1325	AL 4	–	hardened T6	290	420	6	high strength mountings but lowest level of corrosion resistance[1]
Al Zn6 Cu Mg Zr	7050	3.4144	–	–	hardened T73	400	500	6	high strength mountings but lowest level of corrosion resistance[1]
Al Zn5,5 Mg Cu	7075	3.4365	AL 6	–	hardened T73	440	510	7	
Al Zn5,5 Mg Cu	7075	3.4364	(–) (~AL 6)	P65 P60	hardened T6 hardened T73	460 420	530 490	7 11	Bossard connecting elements DIN 931, DIN 7985, DIN 975

[1] Subject to stress corrosion cracking due to the high copper content
[2] Elongation at break A – Test on bolt with 2 x d grip length
[3] T6 – Solution heat-treated and artificially aged
T8 – Solution heat-treated, cold-formed, and artificially aged
T73 – Solution heat-treated and artificially overaged (artificially aged) in order to achieve the best stress corrosion resistance

Aluminum properties in comparison

Non-binding information depending on manufacturer

Material designation	Melting point [°C]	Density ρ $\left[\frac{kg}{dm^3}\right]$	Thermal conductivity $\left[\frac{W}{m \cdot K}\right]$	Electrical conductivity $\left[\frac{m}{\Omega \cdot mm^2}\right]$	Tensile strength [N/mm^2]
Alu 7075 (AL6)	635	2,81	130	19,1	510
Al Zn5,5 Mg Cu P60 (~AL 6)	–	2,7	–	33,3	490
Al Zn5,5 Mg Cu P65 (~AL 6)	–	2,7	–	33,3	530
Stainless steel 304	1450	7,9	15	1,37	700
Copper	1080	8,94	390	57	235
Brass	890	8,5	8500	14,3	370
Polyamide PA6	220	1,13	0,24	10^{-17}	80

Properties of screws and nuts made from copper alloys

Non-binding information depending on manufacturer

Material designation	Material number	Des. from EN 28839	State of structure F = R_m/10	Density ρ [kg/dm³]	Electrical conductivity $\left[\frac{m}{\Omega \cdot mm^2}\right]$	Coefficient of thermal expansion a 30/100 °C $\left[\frac{mm}{mm \cdot K}\right]$	Mechanical properties at 20 °C [3] $R_{p\,0,2}$ [N/mm²] min.	Rm [N/mm²] min.	A_5 [2] [%] min.	E-Modul [N/mm²]	Used for
E-Cu 58 OF-Cu	2.0065 2.0040	Cu 1	F20 soft F20 [1]	8,94	58,0 56,0	$17{,}0 \cdot 10^{-6}$	150 320	200 350	40 7	110 000	parts with a high electrical conductivity
Cu-ETP E-Cu57	2.0060	Cu 1	–	8,94	–	–	160	240	14	–	–
CuZn37 (brass)	2.0321 · 10 2.0321 · 26	Cu 2	F29 soft F37 [1]	8,44	15,5	$20{,}2 \cdot 10^{-6}$	250 250	290 370	45 27	110 000	normal fastenings
CuZn37 (MS 63)	2.0321	Cu 2	–	8,44	–	–	250	370	19	–	–
CuZn39 Pb3 (MS 58)	2.0401	Cu 3	–	–	–	–	250	370	19	–	–
CuNi12 Zn24 (nickel silver)	2.0730 · 10 2.0730 · 30	–	F34 soft F54 soft	8,67	4,4	$18{,}0 \cdot 10^{-6}$	290 440	330 540	40 8	125 000	very good corrosion resistant, silver colors
CuSn6 (Resistan)	2.1020	Cu 4	–	–	–	–	200	400	33	–	–
CuNi1,5Si CuNi3Si	2.0853 · 73 2.0857 · 73	Cu 5 –	hardened hardened	8,8 8,8	> 18,0 > 15,0	$16{,}0 \cdot 10^{-6}$ $16{,}0 \cdot 10^{-6}$	540 780	590 830	12 10	140 000 144 000	high-strength fastening, with very good electrical conductivity
CuNi1Si (Kuprodur)	2.0853	Cu 5	–	–	–	–	540	590	12	–	seawater-resistant
CuZn40 Mn1 Pb	2.0580	Cu 6	–	–	–	–	180	440	18	–	–
CuAl10 Ni5 Fe4	2.0966	Cu 7	–	–	–	–	270	640	15	–	–
CuBe2	2.124 · 75	–	hardened	8,3	~10	$16{,}7 \cdot 10^{-6}$	1050	1200	2	125 000	high-strength fastening, corrosion resistant, good electrical conductivity

[1] Cold strain hardening
[2] Elongation at break A_5 – Test on machined test rod with 5 x d test length
[3] 1 N/mm² = 1 MPa

Minimum breaking torque for screws up to M5 according to ISO 8839

Threads nominal Ø	Minimum breaking torque[1] [Nm] for material										
	CU1	CU2	CU3	CU4	CU5	AL1	AL2	AL3	AL4	AL5	AL6
M1,6	0,06	0,10	0,10	0,11	0,14	0,06	0,07	0,08	0,1	0,11	0,12
M2	0,12	0,21	0,21	0,23	0,28	0,13	0,15	0,16	0,2	0,22	0,25
M2,5	0,24	0,45	0,45	0,5	0,6	0,27	0,3	0,3	0,43	0,47	0,5
M3	0,4	0,8	0,8	0,9	1,1	0,5	0,6	0,6	0,8	0,8	0,9
M3,5	0,7	1,3	1,3	1,4	1,7	0,8	0,9	0,9	1,2	1,3	1,5
M4	1	1,9	1,9	2	2,5	1,1	1,3	1,4	1,8	1,9	2,2
M5	2,1	3,8	3,8	4,1	5,1	2,4	2,7	2,8	3,7	4	4,5

[1] The torque test is to be carried out in according to ISO 898-7

Special materials

Designation Material number	Description and range of application, based on information provided by the manufacturer
Hastelloy® B B-2 2.4617 B-3 2.4600	Highly corrosion resistant nickel-molybdenum alloy with excellent resistance against reducing media, in particular against all concentrations of hydrochloric acid up to boiling point, moist chlorine water gas, sulphuric acid, phosphoric acid and alkaline solutions. Adequate resistance to oxidising and reducing gases up to 800 °C. Not recommended for strongly oxidising agents, iron and copper salts (see Hastelloy C). **Application:** Components subject to strong chemical action, turbo-superchargers for jet engines etc.
Hastelloy® C C-4 2.4610 C-22 2.4602 C-276 2.4819 C-2000 2.4675	Highly corrosion resistant nickel-chrome-molybdenum alloy with particularly high resistance against aggressive, oxidising and reducing media – bleach solutions which contain free chlorine, chlorites, hypochlorites, sulphuric acid and phosphoric acid, organic acids such as vinegar and formic acid, solutions of nitrates, sulphates and sulphites, chlorides and chlorates, chromates and cyanogen compounds. **Application:** Components subject to strong chemical action, in chemical processes and plants, exhaust cleaning systems, in the production of fibres and paper, waste disposal etc.
Hastelloy® G G-3 2.4619 G-30 2.4603	Nickel-chrome-iron alloy with excellent resistance to corrosion in oxidising media. **Application:** In chemical process engineering, particularly suitable for the production of phosphoric acid and nitric acid, desulphurization plant etc.
Inconel® 600 2.4816 601 2.4851 625 2.4856 718 2.4668	Nickel-chrome alloy with good industrial properties at high temperatures up to and above 1000 °C and an excellent resistance to oxidation. Even resists corrosion from caustic materials. **Application:** Heat treatment plant, nuclear energy technology, gas turbines, linings, ventilators and fans, chemical industry etc.
Monel® 400 2.4360 K-500 2.4375	Nickel-copper alloy with high strength and toughness over a wide range of temperatures. Excellent resistance to corrosion by salt water and a large number of acids and alkaline solutions. Also suitable for parts used in presses and forges. **Application:** Valves, pumps, mountings, mechanically stressed components exposed to seawater etc.
Nimonic® 75 2.4951 80A 2.4952 90 2.4969 105 2.4634	The nickel-based chrome materials are alloys with a particularly high fatigue strength and resistance to oxidisation. For high mechanical stresses at temperatures up to 1000 °C. A wide variety of penetration hardening methods allow the relaxation and creep behaviour to be controlled. **Application:** Rotating components subject to high temperatures, springs, fasteners, combustion chamber components, blades, washers, shafts etc.
Titanium Gr. 1 3.7025 Gr. 2 3.7035 Gr. 3 3.7055 Gr. 4 3.7065	Reactive material with high strength in relation to its low density. Excellent resistance to corrosion in oxidising metals which contain chloride. **Application:** Components for weight-saving construction requiring high strength, subject to strong oxidising stresses, particularly in the presence of chlorides. Chemical industry, seawater desalination, power station technology, medical technology etc.
Titanium Gr.5 3.7164/ 3.7165	Titanium alloy with a high specific strength. **Application:** Components for the air and space industries, chemical processing technology, rotating components, fasteners, vehicle engineering etc.
Titanium Gr. 7 3.7235 Gr. 11 3.7225	Pure titanium alloyed with palladium. Increased resistance to corrosion, particularly against moist media which contain chloride. Grade 11 has increased properties of deformation. **Application**: Chemical and petrochemical plant, housings etc.

Thermoplastics

Reference values of physical characteristics according to manufacturer's data

Mechanical properties

Material abbreviation DIN 7728	Density [g/cm³] DIN 53479	Tensile strength [N/mm²] DIN 53455	Fracture resistance % DIN 53455	Elasticity module [N/mm²] DIN 53457	Ball penetration hardness, 10-sec Value [N/mm²] DIN 53456	Impact strength [kJ/m²] DIN 53453	Ductility [kJ/m²] DIN 53453
PE-HD	0,94/0,96	18/35	100/1000	700/1400	40/65	without fracture	without fracture
PE-LD	0,914/0,928	8/23	300/1000	200/500	13/20	without fracture	without fracture
PP	0,90/0,907	21/37	20/800	1100/1300	36/70	without fracture	3/17
POM	1,41/1,42	62/70	25/70	2800/3200	150/170	100	8
PA 6	1,13	70/85	200/300	1400	75	without fracture	without fracture
PA 66	1,14	77/84	150/300	2000	100	without fracture	15/20

Electrical properties

Material abbreviation DIN 7728	Specific resistance [Ω cm] DIN 53482	Surface resistance [Ω] DIN 53482	Dielectric constant DIN 53483		Dielectric loss factor δ DIN 53483		Dielectric strength		Surface leakage current resistance DIN 53480	
			50 Hz	10^6 Hz	50 Hz	10^6 Hz	[kV/25 µm] ASTM D 149	[kV/cm] DIN 53481	KA	KB/KC
PE-HD	$> 10^{17}$	10^{14}	2,35	2,34	$2{,}4 \cdot 10^{-4}$	$2{,}0 \cdot 10^{-4}$	> 700	–	3 c	> 600
PE-LD	$> 10^{17}$	10^{14}	2,29	2,28	$1{,}5 \cdot 10^{-4}$	$0{,}8 \cdot 10^{-4}$	> 700	–	3 b	> 600
PP	$> 10^{17}$	10^{13}	2,27	2,25	$< 4 \cdot 10^{-4}$	$< 5 \cdot 10^{-4}$	800	500/650	3 c	> 600
POM	$> 10^{15}$	10^{13}	3,7	3,7	0,005	0,005	700	380/500	3 b	> 600
PA 6	10^{12}	10^{10}	3,8	3,4	0,01	0,03	350	400	3 b	> 600
PA 66	10^{12}	10^{10}	8,0	4,0	0,14	0,08	400	600	3 b	> 600

Thermal properties

Material abbreviation DIN 7728	Operating temperature °C			Dimensional stability °C		Linear coefficient of expansion	Thermal conductivity	Specific heat
	max. short therm	max. permanent	min. permanent	VSP (Vicat 5 kg) DIN 53460	ASTM D 648 1,86/0,45 [N/mm²]	$K^{-1} \cdot 10^{-6}$	[W/mK]	[kJ/kg K]
PE-HD	90/120	70/80	–50	60/70	50	200	0,38/0,51	2,1/2,7
PE-LD	80/90	60/75	–50	–	35	250	0,32/0,40	2,1/2,5
PP	140	100	0/–30	85/100	45/120	150	0,17/0,22	2,0
POM	110/140	90/110	–60	160/173	110/170	90/110	0,25/0,30	1,46
PA 6	140/180	80/100	–30	180	80/190	80	0,29	1,7
PA 66	170/200	80/120	–30	200	105/200	80	0,23	1,7

Abbreviation	Significance
PE-HD	High density polyethylene
PE-LD	Low density polyethylene
PP	Polypropylene
POM	Polyoxymethylene, Polyacetale
PA 6	Polyamide 6
PA 66	Polyamide 6.6

Instructions for screws made of thermoplastic materials

- Mechanical and physical properties, especially tensile strength and preload as well as colour, tolerances of threaded section and head geometry are subject to climatic conditions. Consult DIN 34810 and ISO 4759-1 for tolerance values, advice and assembly torques.
- Preload can fall via stress relaxation. Instructions for construction and design are to be followed on the basis of VDI 2544.

Chemical resistance

Material abbreviation	Water, cold	Water, hot	Acids, dilute	Acids, strong	Acids, oxidised	Acid hydrofluoric	Detegrents, weak	Detegrents, strong	Saline solutions	Halogen, dry	EC aliphatic	EC chlorinated	Alcohol	Ether-salicylic	Cetone	Ether	Aldehydes	Amines	Organic acids	EC aromatic	Fuels	Mineral oils	Greases, oils	EC chlorinated, non-saturated	Turpentine	Water absorption, % ASTM D 570
PE-HD	●	●	●	●	○	◐	●	●	●	○	●	◐	●	●	●	◐	◐	●	●	◐	◐	●	●	○	○	< 0,01
PE-LD	●		●	◐	○	◐	●	●	●	○	●	○	◐	◐	◐	○			●	○	○	◐	◐	○	○	< 0,01
PP	●	●	●	◐	○	◐	●	●	●	◐	●	○	●	◐	◐	○	●	●	◐	◐	◐	●	●	○	○	0,01 to 0,03
POM	●	●	◐	○	○	○	●	●	●	○	●	●	●	○	◐	●	◐	◐	●	◐	●	●	●	●	◐	0,22 to 0,25
PA 6	●	◐	○	○	○	○	●	◐	●	○	●	◐	●	●	●	●	◐	●	◐	●	●	●	○	◐	◐	1,3 to 1,9

●resistant ◐resistant with reservation ○inconstant

Abbreviation	Significance
PE-HD	High density polyethylene
PE-LD	Low density polyethylene
PP	Polypropylene
POM	Polyoxymethylene, Polyacetale
PA 6	Polyamide 6

Elastomere

Combustibility

Material shortmark ISO 1629			CR	FPM	NBR	EPDM	TPE
Material designation			Chloropren-Caoutchouc	Flourine-Caoutchouc	Acrylonitrile-Buta-diene-Caoutchouc	Ethylene-Propylene-Diene-Caoutchouc	Thermoplastic Elastomer
Combustibility			UL 94 - V2	UL 94 - V2	UL 94 HB	UL 94 HB	UL 94 HB
Temperature range[1]	min.		–30 °C	–20 °C	–30 °C	–40 °C	–30 °C
	max.	continually	+100 °C	+200 °C	+120 °C	+130 °C	+80 °C
		intermittent	+120 °C	+280 °C	+150 °C	+170 °C	+120 °C

[1] Minus values in temperature range apply only to parts in idle state without impact stress.

Chemical resistance[2]

Material shortmark ISO 1629	CR	FPM	NBR	EPDM	TPE
Material designation	Chloropren-Caoutchouc	Flourine-Caoutchouc	Acrylonitrile-Butadiene-Caoutchouc	Ethylene-Propylene-Diene-Caoutchouc	Thermoplastic Elastomer
Alcohol	A	A	A	A	A
Benzine	C	A	A	C	B
Diesel oil	C	A	A	C	B
Mineral oil	B	A	A	B	B
Animal and vegetarian greases	B	A	A	B	A
Weak alkaline solution	A	B	B	A	A
Strong alkaline solution	B	C	C	A	B
Weak acids	B	A	B	A	A
Strong acids	C	A	C	A	A
Water	C	A	C	A	A
Ozone	C	A	C	A	A

[2] The following details should be regarded as guidelines only. Any more definite information can only be given with reference to the particular application in hand. For example, a precision part may fail simply on account of a slight change in volume, or aggressive media may in fact be usable as cleansing agent if only briefly in contact with the material in question.

A Very good, chemical resistance. Constant action of medium causes no damage to plastic within a period of 30 days. The plastic may remain resistant over a period of several years.

B Good to limited chemical resistance. Constant action of medium may cause slight damage within a period of 7 to 30 days, this damage some times being reversible (swelling, softening, reduction in mechanical strength, discolouration).

C Low chemical resistance. Unsuitable for subjection to constant action of medium. Damage may occur immediately (reduction in mechanical strength, deformation, discolouration, cracks, dissolution).

Chemical ingredients

Material shortmark ISO 1629	CR	FPM	NBR	EPDM	TPE
Material designation	Chloropren-Caoutchouc	Flourine-Caoutchouc	Acrylonitrile-Butadiene-Caoutchouc	Ethylene-Propylene-Diene-Caoutchouc	Thermoplastic Elastomer
halogen free	–	–	yes	yes	yes
phosphate free	yes	yes	yes	yes	yes
silicone free	yes	yes	yes	yes	yes