

Stainless Steel

The basic austenitic composition is the familiar 18% chromium and 8% nickel alloy. Both chromium and nickel can be increased to further improve corrosion resistance and additional elements, such as molybdenum, can be added to enhance this characteristic.

Austenitic steels are non-magnetic and it is not possible to harden them by heat treatment. The only method of hardening these steels is through cold forming or deformation when strain hardening takes place rapidly. The steel can be restored to a fully softened condition by annealing, sometimes referred to as solution treatment.

Stainless Steel

Type AISI 303 S21 (form EN58AM) Colour Code: White (Austenitic - non-magnetic)

Free machining quality (contains sulphur). Good corrosion resistance and weldability is fair, but oxy-acetylene is not generally recommended. Can be cold formed but severe sharp corner bends should be avoided.

Typical application - Repetitive machining, Automatics etc.

Type AISI 304 S15 (form. EN58E) Colour Code: Yellow (Austenitic - non-magnetic)

General purpose stainless, machineability is fair, has good general corrosion resistance, weldability is good. (Oxy-acetylene is not generally recommended). Cold forming is very good; also has good polishing qualities. Non-magnetic when annealed, slightly magnetic when cold worked.

Typical application - Suitable for General Engineering, hospital, laundry etc.

Type AISI 316 S16 (form. EN58J) Colour Code: Red (Austenitic - non-magnetic)

High corrosion resistance, especially salt water and acid. Machineability fair. Weldability good. Cold forming good. Non-magnetic when annealed, slightly magnetic when cold worked.

Typical application - Petro-Chemical, Marine, Hospital, Catering Equipment.

Type AISI 321 S20 (form. EN58B) Colour Code: Blue (Austenitic - Non-magnetic)

Good corrosion and oxidation resistance. Weldability very good, machineability fair. Cold forming good. Non-magnetic when annealed, slightly magnetic when cold worked.

Typical application - General Engineering, Petro-Chemical Engineering.

Summary Of Corrosion Resistance of Stainless Steel

MARTENSITIC STEEL

These steels which commonly contain 13% Chromium, have the least general resistance to corrosion of the steel family and can, therefore, be used where corrosive conditions are relatively light. A typical example would be cutlery.

FERRITIC STEELS

The most common ferritic steel is B.S. 1449 : 430S17 containing 17% chromium and this offers improved resistance to corrosion over martensitic steels. Although not up to the standard of austenitic steels it can be used for motor car trim, and domestic decorative fittings such as trim on refrigerators, gas cookers etc.

AUSTENITIC STEEL

A group of steels which are by far the most important and consequently the most widely used. The 18/8 type of steel resists corrosion under a wide range of circumstances and is typically used in food, dairy, brewery and other processing industries, together with certain kinds of chemical plant.

MOLYBDENUM

Molybdenum can be added to the 18/8 type of steel to give even more enhanced corrosion resistance, and thus type 316 steels containing between 2.0% and 3.0% of molybdenum are principally used in the chemical and petrochemical industries where resistance to, for example, corrosion media containing chlorides is required. The point should be made, however, that even these steels are not immune to all kinds of chemical attack from such reducing solutions as hydrochloric or oxalic acid, particularly when these acids are hot and/ or highly concentrated.

Analysis & Application

Type	Obsolete EN MO	Description	Typical Usage
Martensitic : Magnetic, hardenable, moderate corrosion resistance			
410	56A	12% chromium.	Pump and gas turbine parts, general engineering.
416	56AM	Free machining form of 410. Sulphur bearing. Available in bar form only.	Knives blades, valves.
420	56B	Heat resistant.	
431	57	17% chromium. 2 1/2% nickel. Available in bar form only.	
Ferritic : Magnetic, chromium steel, immune to chloride stress corrosion cracking			
430	60	17% chromium.	Sinks, decoration, automotive trim, washing machine drums. Automotive trim - below the waist and wiper blades.
434	61	17% chromium, 1% molybdenum. Resistant to atmospheric and pitting corrosion.	Automotive exhaust system
409		12% chromium plus titanium. Weldable up to 2.5mm thick.	Structural, bulk handling chutes, hoppers & railway wagons, transport, mining.
4003		Modified form of 409, weldable in heavy section.	
Austenitic : Non-magnetic, chromium/nickel steels, good weldability. Good general corrosion resistance			
301		17% chromium, 7% nickel. High work hardening rate. Formability.	Structural, springs, wheel covers, wear plates.
302		18% chromium, 9% nickel. Good formability.	Similar to 304
303	58A 58AM	Free machining form of 302. Available in bar form only.	
304	58E	18% chromium, 9% nickel. Good formability.	Sinks, architecture, automotive exhausts, cutlery, holloware and flatware, water tubing.
304L		Low carbon form of 304.	Brewery, dairy, food and pharmaceutical production plant. Sinks, holloware.
304DDQ		Deep drawing quality of 304.	Eyelets, spun parts.
305		18% chromium, 12% nickel. Good formability.	Similar to 310
309		23% chromium, 14% nickel. High oxidation resistance.	
310	58J	25% chromium, 20% nickel. Very high oxidation resistance.	Furnaces, heat exchanges, metallurgical plant. Service temp up to 1100°C.
316		17% chromium, 11% nickel, 2.5% molybdenum. High corrosion resistance.	Chemical and petrochemical process plant architecture, brewery plant.
316L		Low carbon form of 316.	
317	58B+C	18% chromium, 12% nickel, 2.5% molybdenum plus titanium. Very high corrosion resistance.	Chemical and petrochemical process plant, acetic acid distillation.
317L		Low carbon form of 317.	
321		18% chromium, 10% nickel plus titanium.	Heating elements, aircraft parts, chemical and petrochemical process plant.
325	58BM	Free machining form of 321. Sulphur bearing. Available in bar form only.	
347	58F+G	18% chromium, 10% nickel plus niobium. Resistant to sensitisation and hot concentrated nitric acid.	Process plant, aircraft parts.



Mechanical Properties of Austenitic Stainless Steel Fasteners

ISO 3506 Steel Grade A2 and A4

Property Class	Diameter Range	Bolts Screws & Studs		Nuts	
		Tensile Strength N/mm ² min	Yield Stress N/mm ² min	Ductility (Total Elongation)	Proof Load Stress N/mm ² min
70	up to M20	700	450	0.4d	700

- Property values are determined on finished products - not on machine tested pieces.
- Tensile stress values are calculated in terms of the nominal (mean) tensile stress area of the thread.
- Yield stress is defined as the stress to give 0.2% permanent strain.
- Total elongation is the increase in total length at fracture after tensile loading expressed as a factor of the thread diameter.
- d = nominal thread diameter
- Above M20, the higher strength property classes should have the property values specifically agreed upon between user and manufacturer because at the tensile strength factors given, alternative values of stress at 0.2% permanent strain may occur.

Inch/Metric Conversion Table

Inch	mm	Inch	mm	Inch	mm	Inch	mm				
1/32	0.031	0.794	9/32	0.281	7.144	17/32	0.531	13.494	25/32	0.781	19.844
1/16	0.063	1.587	5/16	0.312	7.937	9/16	0.562	14.287	13/16	0.812	20.637
3/32	0.094	2.381	11/32	0.343	8.731	19/32	0.593	15.081	27/32	0.843	21.431
1/8	0.125	3.175	3/8	0.375	9.525	5/8	0.625	15.875	7/8	0.875	22.225
5/32	0.156	3.968	13/32	0.406	10.319	21/32	0.656	16.669	29/32	0.906	23.019
3/16	0.187	4.762	7/16	0.437	11.112	11/16	0.687	17.462	15/16	0.937	23.812
7/32	0.218	5.556	15/32	0.468	11.906	23/32	0.718	18.256	31/32	0.968	24.606
1/4	0.250	6.350	1/2	0.500	12.700	3/4	0.750	19.050	1	1.000	25.400

in.	mm	in.	mm	in.	mm	in.	mm
0.001	0.0254	0.190	4.826	0.460	11.684	0.730	18.542
0.002	0.0508	0.200	5.080	0.470	11.938	0.740	18.796
0.003	0.0762	0.210	5.334	0.480	12.192	0.750	19.050
0.004	0.1016	0.220	5.588	0.490	12.446	0.760	19.304
0.005	0.1270	0.230	5.842	0.500	12.700	0.770	19.558
0.006	0.1524	0.240	6.096	0.510	12.954	0.780	19.812
0.007	0.1778	0.250	6.350	0.520	13.208	0.790	20.066
0.008	0.2032	0.260	6.604	0.530	13.462	0.800	20.320
0.009	0.2286	0.270	6.858	0.540	13.716	0.810	20.574
0.010	0.2540	0.280	7.112	0.550	13.970	0.820	20.828
0.020	0.5080	0.290	7.366	0.560	14.224	0.830	21.082
0.030	0.7620	0.300	7.620	0.570	14.478	0.840	21.336
0.040	1.0160	0.310	7.874	0.580	14.732	0.850	21.590
0.050	1.2700	0.320	8.128	0.590	14.986	0.860	21.844
0.060	1.5240	0.330	8.382	0.600	15.240	0.870	22.098
0.070	1.7780	0.340	8.636	0.610	15.494	0.880	22.352
0.080	2.0320	0.350	8.890	0.620	15.748	0.890	22.606
0.090	2.2860	0.360	9.144	0.630	16.002	0.900	22.860
0.100	2.5400	0.370	9.398	0.640	16.256	0.910	23.114
0.110	2.7940	0.380	9.652	0.650	16.510	0.920	23.368
0.120	3.0480	0.390	9.906	0.660	16.764	0.930	23.622
0.130	3.3020	0.400	10.160	0.670	17.018	0.940	23.876
0.140	3.5560	0.410	10.414	0.680	17.272	0.950	24.130
0.150	3.8100	0.420	10.668	0.690	17.526	0.960	24.384
0.160	4.0640	0.430	10.922	0.700	17.780	0.970	24.638
0.170	4.3180	0.440	11.176	0.710	18.034	0.980	24.892
0.180	4.5720	0.450	11.430	0.720	18.288	0.990	25.146

Mechanical Properties

Softening Temperatures & Details of Intergranular Corrosion Test of Austenitic Stainless Steel

Steel Grade	Proof Stress		Tensile Strength R_m min N/mm ²	*Elongation Test A.min	Hardness HV.max. †	Condition	Softening Temperature Range		Sensitisation Time For Intergranular Corrosion Test min
	Rp0.2, min N/mm ²	Rp0.1.0, min N/mm ²					Min	Max	
284S16	300	335	630	40%	220	Softened	1000°C	1120°C	Nil
301S21	215	250	540	40%	220	Softened	1000°C	1120°C	Nil
304S11	180	215	480	40%	135	Softened	1000°C	1120°C	30
304S15	195	230	500	40%	190	Softened	1000°C	1120°C	15
304S16	195	230	500	40%	190	Softened	1000°C	1120°C	15
304S31	195	230	500	40%	190	Softened	1000°C	1120°C	Nil
305S19	185	220	490	40%	185	Softened	1000°C	1120°C	Nil
309S24	205	240	510	40%	205	Softened	1000°C	1120°C	Nil
310S24	205	240	510	40%	205	Softened	1000°C	1120°C	Nil
315S16	205	240	510	40%	205	Softened	1000°C	1120°C	15
316S11	190	225	490	40%	195	Softened	1000°C	1120°C	30
316S13	190	225	490	40%	195	Softened	1000°C	1120°C	30
316S31	205	240	510	40%	205	Softened	1000°C	1120°C	15
316S33	205	240	510	40%	205	Softened	1000°C	1120°C	15
317S12	195	230	490	40%	195	Softened	1000°C	1120°C	30
317S16	205	240	510	40%	205	Softened	1000°C	1120°C	15
320S31	210	245	510	40%	205	Softened	1000°C	1120°C	30
320S33	210	245	510	40%	205	Softened	1000°C	1120°C	30
321S31	200	235	500	35%	200	Softened	1000°C	1120°C	30
347S31	205	240	510	35%	200	Softened	1000°C	1120°C	30

1 N/mm² = 1 MPa

* = Elongation measured on flat test pieces using 50mm gauge length or 5.65/s₀. For cylindrical test pieces, a gauge length of 5.64/s₀ is used.

† = For items of adequate thickness the Brinell hardness test may be used, applying the same limiting HB hardness values as given for HV.

Softening Temperatures Ferritic & Martensitic Steels

Steel Grade	Proof stress, R _{p0.2} N/mm ²	Tensile Strength R _m min N/mm ²	Elongation* A.min	Hardness HV, max.†			Temperature Range					
				Plate	Sheet/ Strip	Condition	Softening Min	Softening Max	Hardening‡ Min	Hardening‡ Max	Tempering Min	Tempering Max
Ferritic Steels												
403S17	245	420	20%	190	175	Softened	700°C	780°C	—	—	—	—
405S17	245	420	20%	190	175	Softened	700°C	780°C	—	—	—	—
409S19	200	350	20%	190	175	Softened	700°C	950°C	—	—	—	—
430S17	245	430	20%	190	175	Softened	750°C	820°C	—	—	—	—
434S17	245	430	20%	—	185	Softened	750°C	820°C	—	—	—	—
Martensitic Steels												
410S21	—	—	—	190	185	Softened #Hardened &Tempered	700°C	780°C	950°C	1020°C	650°C	750°C
420S45	—	—	—	230	220	Softened #Hardened &Tempered	700°C	780°C	950°C	1050°C	150°C	250°C

1N/mm² = 1 MPa

* = Elongation measured on flat test piece using 50mm gauge length or 5.65/s₀. For cylindrical test pieces, a gauge length of 5.65 s₀ is used.

† = For items of adequate thickness the Brinell hardness test may be used, applying the same limiting HB hardness values as given for HV.

‡ = For guidance only



Fabrication Data

Working Information

	301S1	302S25	304S16	304S12	305S19	303S21	303S41	309S24	310S24	316S16
Blanking	B	B	B	B	B	—	—	B	B	B
Brake Forming	B	A	A	A	A	—	—	A	A	A
Brazing	B	B	B	B	B	B	D	B	B	B
Buffing	A	A-B	A-B	B	A-B	B	D	B	B	B
Coining	B-C	B	B	A	A-B	A	D	B	B	B
Deep Drawing	A-B	A	A	A	B	—	—	B	B	B
Drilling	C-D	C	C	C	C	B-C	B	C	C	C
Embossing	B-C	B	B	B	B	—	C	B	B	B
Forging-Cold	C	B	B	B	B	B	D	B-C	B-C	B
Forging-Hot	B	B	B	B	B	B	B	B	B	B
Hardening By Cold Work										
a) Annealed	115.00	90.00	85.00	82.00	80.00	—	—	90.00	95.00	90.00
	kg/m ³	80.80	63.30	59.70	58.00	56.20	—	63.30	66.80	63.30
b) 25% Red.	169.00	142.00	138.00	140.00	130.00	—	—	130.00	126.00	134.00
	kg/mm ²	119.00	100.00	97.00	98.00	91.00	—	91.00	89.00	94.00
c) 50% Red.	220.00	180.00	178.00	182.00	170.00	—	—	169.00	165.00	165.00
	kg/mm ²	155.00	127.00	125.00	128.00	119.00	—	119.00	116.00	116.00
Hardening By Heat Treatment	No	No	No	No	No	No	No	No	No	No
Heading-Cold	C	B	B	B	A-B	A	A	—	A-B	B
Heading-Hot	C	A	A	A	A	A	A	—	A	A
Machining	A	C	C	C	C	B-C	B-C	—	C	C
Magnetic	Not	Not	Not	Not	Not	Not	Not	Not	Not	Not
Punching	C	B	B	B	B	—	—	B	B	B
Polishing	A	A	A	A	A	A	D	B	B	B
Roll-Forming	B	A	A	A	A	—	—	B	A	A
Sawing	C	C	C	C	C	C	B	C	C	C
Shearing	B	B	B	B	B	B	C	B	B	B
Soldering	B	B	B	B	B	B	C-D	B	B	B
Spinning	D	B-C	B-C	B-C	A	—	—	B-C	B	B
Spot Welding (resistance)	A	A	A	A	A	B	D	A	A	A
Welding (coated electrodes)	B	A-B	A	A	A	B	D	B	B	A
Welding (oxy-acetylene)	D	D	D	D	D	D	D	D	D	D
Welding Metal Inert Gas Arc	A-B	A-B	A	A	A	B-C	D	A	A	A
Welding Tungsten Inert Gas Arc	A	A	A	A	A	B	D	A	A	A

A = Excellent B = Good C = Fair D = Not generally recommended
 † = Develops magnetism after cold reduction †† = Develops less magnetism after cold reduction * = Severe sharp bends to be avoided

970 PART 1 (1983) WROUGHT STEEL

Standard	Old											German
B.S.	EN-	C	Si	Min	P	S	Cr	Mo	Ni	Others	Standard	
302 S 31	—	≤ 0.12%	≤ 1.00%	≤ 2.00%	≤ 0.045%	≤ 0.030%	17.0%-19.0%	—	8.0%-10.0%	—	—	
303 S 31	—	≤ 0.12%	≤ 1.00%	≤ 2.00%	≤ 0.060%	0.15%-0.35%	17.0%-19.0%	≤ 1.00%	8.0%-10.0%	—	—	
303 S 42	—	≤ 0.12%	≤ 1.00%	≤ 2.00%	≤ 0.060%	≤ 0.060%	17.0%-19.0%	≤ 1.00%	8.0%-10.0%	Se0.15%Ni0.35%	—	
304 S 11	—	≤ 0.03%	≤ 1.00%	≤ 2.00%	≤ 0.045%	≤ 0.030%	17.0%-19.0%	—	9.0%-12.0%	—	1.4306	
304 S 15	58E	≤ 0.06%	≤ 1.00%	≤ 2.00%	≤ 0.045%	≤ 0.030%	17.5%-19.0%	—	8.0%-11.0%	—	1.4301	
304 S 31	—	≤ 0.07%	≤ 1.00%	≤ 2.00%	≤ 0.045%	≤ 0.030%	17.0%-19.0%	—	8.00%-11.0%	—	1.4301	
310 S 31	—	≤ 0.15%	≤ 1.50%	≤ 2.00%	≤ 0.045%	≤ 0.030%	24.0%-26.0%	—	19.0%-22.0%	—	—	
316 S 11	—	≤ 0.03%	≤ 1.00%	≤ 2.00%	≤ 0.045%	≤ 0.030%	16.5%-18.5%	2.00%-2.50%	11.0%-14.0%	—	1.4404/1.4435	
316 S 13	—	≤ 0.03%	≤ 1.00%	≤ 2.00%	≤ 0.045%	≤ 0.030%	16.5%-18.5%	2.50%-3.00%	11.5%-14.5%	—	—	
316 S 31	—	≤ 0.07%	≤ 1.00%	≤ 2.00%	≤ 0.045%	≤ 0.030%	16.5%-18.5%	2.00%-2.50%	10.5%-13.5%	—	1.4401/1.4436	
316 S 33	—	≤ 0.07%	≤ 1.00%	≤ 2.00%	≤ 0.045%	≤ 0.030%	16.5%-18.5%	2.50%-3.00%	11.0%-14.0%	—	1.4401/1.4436	
320 S 31	—	≤ 0.08%	≤ 1.00%	≤ 2.00%	≤ 0.045%	≤ 0.030%	16.5%-18.5%	2.00%-2.50%	11.0%-14.0%	Ti5XC-0.80%	1.4571	
321 S 31	—	≤ 0.08%	≤ 1.00%	≤ 2.00%	≤ 0.045%	≤ 0.030%	17.0%-19.0%	—	9.0%-14.0%	Ti5XC-0.80%	—	
325 S 31	—	≤ 0.12%	≤ 1.00%	≤ 2.00%	≤ 0.045%	0.15%-0.35%	17.0%-19.0%	—	8.0%-11.0%	Ti5XC-0.90%	—	
347 S 31	—	≤ 0.08%	≤ 1.00%	≤ 2.00%	≤ 0.045%	≤ 0.030%	17.0%-19.0%	—	9.0%-12.0%	Nb10xC1.00%	1.4550	
403 S 17	—	≤ 0.08%	≤ 1.00%	≤ 1.00%	≤ 0.040%	≤ 0.030%	12.0%-14.0%	—	≤ 0.5%	—	1.4000	
410 S 21	56A	0.09%-0.15%	≤ 1.00%	≤ 1.00%	≤ 0.040%	≤ 0.030%	11.5%-13.5%	—	≤ 1.0%	—	1.4006	
416 S 21	56AM	0.09%-0.15%	≤ 1.00%	≤ 1.50%	≤ 0.060%	0.15%-0.35%	11.5%-13.5%	≤ 0.60%	≤ 1.0%	—	1.4005	
416 S 29	56 BM	0.14%-0.20%	≤ 1.00%	≤ 1.50%	≤ 0.060%	0.15%-0.35%	11.5%-13.5%	≤ 0.60%	≤ 1.0%	—	—	
416 S 37	56CM	0.20%-0.28%	≤ 1.00%	≤ 1.50%	≤ 0.060%	0.15%-0.35%	12.0%-14.0%	≤ 0.60%	≤ 1.0%	—	—	
416 S 41	56 AM	0.09%-0.15%	≤ 1.00%	≤ 1.50%	≤ 0.060%	≤ 0.060%	11.5%-13.5%	≤ 0.60%	≤ 1.0%	Se0.15%Ni0.35%	—	
420 S 29	56 B	0.14%-0.20%	≤ 1.00%	≤ 1.00%	≤ 0.040%	≤ 0.030%	11.5%-13.5%	—	≤ 1.0%	—	1.4024	
420 S 37	56 C	0.20%-0.28%	≤ 1.00%	≤ 1.00%	≤ 0.040%	≤ 0.030%	12.0%-14.0%	—	≤ 1.0%	—	1.4021	
430 S 17	—	≤ 0.08%	≤ 1.00%	≤ 1.00%	≤ 0.040%	≤ 0.030%	16.0%-18.0%	—	≤ 0.5%	—	1.4016	
431 S 29	57	0.12%-0.20%	≤ 1.00%	≤ 1.00%	≤ 0.040%	≤ 0.030%	15.0%-18.0%	—	2.0%-3.0%	—	1.4057	

Shaft Strengths and Rotations

MATERIAL TYPE	SHAFT DIAMETER (mm)											
	Ø6	Ø10	Ø12	Ø15	Ø17	Ø20	Ø25	Ø30	Ø40	Ø50	Ø75	Ø100
Nm MILD STEEL EN15A EN3 35,000 KN/m ²	1.5	6.6	11.5	23	34	55	105	180	440	840	2800	6600
Nm EN8 EN32 EN58 45,000 KN/m ²	1.9	8.5	15.0	28	43	70	135	230	550	1000	3600	8500
Nm EN16 EN19 EN24 EN36 60,000 KN/m ²	2.5	12.0	20.0	39	56	95	180	310	750	1500	4800	12000

$$\text{Torque (Nm)} = \frac{9550 \times \text{Kw}}{\text{Rpm}}$$

All chart figures shown in this book are only meant as a guide and no responsibility can be taken by ondrives for the use thereof.

$$\text{KW} = \text{HP} \times 0.746$$

		SHAFT ROTATION - H.P. TRANSMITTED FOR GIVEN RPM AND Nm															
Nm		0.1	0.5	1	2	5	8	10	15	20	25	30	50	100	200	500	1000
RPM	5								0.010	0.014	0.017	0.022	0.035	0.07	0.15	0.35	0.70
	10						0.011	0.014	0.020	0.028	0.035	0.041	0.070	0.15	0.28	0.70	1.40
	20					0.014	0.023	0.028	0.040	0.056	0.070	0.085	0.140	0.28	0.55	1.40	2.80
	50			0.014	0.035	0.055	0.070	0.100	0.140	0.170	0.210	0.250	0.350	0.70	1.40	3.50	7.00
	100		0.014	0.028	0.070	0.115	0.140	0.210	0.280	0.350	0.410	0.500	0.700	1.45	2.80	7.00	14.00
	200		0.021	0.042	0.082	0.140	0.230	0.280	0.420	0.570	0.700	0.850	1.500	2.90	5.60	14.00	28.00
	300		0.028	0.055	0.110	0.280	0.450	0.550	0.850	1.100	1.400	1.700	2.800	5.60	11.00	28.00	56.00
	400		0.035	0.070	0.140	0.350	0.560	0.700	1.050	1.400	1.750	2.100	3.500	7.00	14.00	35.00	70.00
	500	0.010	0.051	0.100	0.210	0.520	0.850	1.050	1.600	2.100	2.700	3.100	5.200	10.40	21.00	52.00	107.00
	1000	0.015	0.070	0.140	0.280	0.700	1.150	1.400	2.100	2.800	3.500	4.200	7.000	14.00	28.00	70.00	140.00
1500	0.022	0.100	0.210	0.400	1.000	1.700	2.100	3.100	4.200	5.100	6.200	10.500	21.00	41.00	100.00	210.00	
2000	0.029	0.140	0.280	0.550	1.400	2.300	2.800	4.100	5.500	7.000	8.400	14.000	28.00	56.00	140.00	280.00	
3000	0.044	0.210	0.420	0.820	2.100	3.500	4.200	6.200	8.500	10.000	12.500	21.000	43.00	85.00	210.00	420.00	
4000	0.060	0.270	0.560	1.100	2.800	4.500	5.500	8.500	11.000	14.000	18.000	28.000	58.00	110.00	280.00	560.00	
5000	0.072	0.350	0.700	1.400	3.500	5.600	7.000	10.500	14.000	17.000	21.000	35.000	70.00	140.00	350.00	700.00	
8000	0.120	0.550	1.100	2.300	5.500	9.200	11.000	17.000	23.000	28.000	34.000	56.000	115.00	230.00	550.00	1150.00	
10000	0.150	0.700	1.400	2.800	7.000	11.500	14.000	21.000	29.000	35.000	42.000	71.000	140.00	280.00	700.00	1400.00	



Shaft and Bore Limits & Fits

Housing Bore Tolerances (deviation from nominal dimensions)

Nominal Diameter mm		TOLERANCE OF HOUSING SHAFT DIAMETER (Unit = 0.001mm)											
Over	Incl.	d6		e6		f6		g5		h5		h6	
		High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
-	3	-20	-26	-14	-20	-6	-12	-2	-6	0	-4	0	-6
3	6	-30	-38	-20	-28	-10	-18	-4	-9	0	-5	0	-8
6	10	-40	-49	-25	-34	-13	-22	-5	-11	0	-6	0	-9
10	18	-50	-61	-32	-43	-16	-27	-6	-14	0	-8	0	-11
18	30	-65	-78	-40	-53	-20	-33	-7	-16	0	-9	0	-13
30	40	-80	-96	-50	-66	-25	-41	-9	-20	0	-11	0	-16
40	50	-80	-96	-50	-66	-25	-41	-9	-20	0	-11	0	-16
50	65	-100	-119	-60	-79	-30	-49	-10	-23	0	-13	0	-19
65	80	-100	-119	-60	-79	-30	-49	-10	-23	0	-13	0	-19
80	100	-120	-142	-72	-94	-36	-58	-12	-27	0	-15	0	-22
100	120	-120	-142	-72	-94	-36	-58	-12	-27	0	-15	0	-22
120	140	-145	-170	-85	-110	-43	-68	-14	-32	0	-18	0	-25
140	160	-145	-170	-85	-110	-43	-68	-14	-32	0	-18	0	-25
160	180	-145	-170	-85	-110	-43	-68	-14	-32	0	-18	0	-25
180	200	-170	-199	-100	-129	-50	-79	-15	-35	0	-20	0	-29
200	225	-170	-199	-100	-129	-50	-79	-15	-35	0	-20	0	-29
225	250	-170	-199	-100	-129	-50	-79	-15	-35	0	-20	0	-29
250	280	-190	-222	-110	-142	-56	-88	-17	-40	0	-23	0	-32
280	315	-190	-222	-110	-142	-56	-88	-17	-40	0	-23	0	-32
315	355	-210	-246	-125	-161	-62	-98	-18	-43	0	-25	0	-36
355	400	-210	-246	-125	-161	-62	-98	-18	-43	0	-25	0	-36
400	450	-230	-270	-135	-175	-68	-108	-20	-47	0	-27	0	-40
450	500	-230	-270	-135	-175	-68	-108	-20	-47	0	-27	0	-40

Nominal Diameter mm		TOLERANCE OF HOUSING BORE DIAMETER (Unit = 0.001mm)											
Over	Incl.	F6		F7		G6		G7		H6		H7	
		High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
-	3	+12	+6	+16	+6	+8	+2	+12	+2	+6	0	+10	0
3	6	+18	+10	+22	+10	+12	+4	+16	+4	+8	0	+12	0
6	10	+22	+13	+28	+13	+14	+5	+20	+5	+9	0	+15	0
10	18	+27	+16	+34	+16	+17	+6	+24	+6	+11	0	+18	0
18	30	+33	+20	+41	+20	+20	+7	+28	+7	+13	0	+21	0
30	40	+41	+25	+50	+25	+25	+9	+34	+9	+16	0	+25	0
40	50	+41	+25	+50	+25	+25	+9	+34	+9	+16	0	+25	0
50	65	+49	+30	+60	+30	+29	+10	+40	+10	+19	0	+30	0
65	80	+49	+30	+60	+30	+29	+10	+40	+10	+19	0	+30	0
80	100	+58	+36	+71	+36	+34	+12	+47	+12	+22	0	+35	0
100	120	+58	+36	+71	+36	+34	+12	+47	+12	+22	0	+35	0
120	140	+68	+43	+83	+43	+39	+14	+54	+14	+25	0	+40	0
140	160	+68	+43	+83	+43	+39	+14	+54	+14	+25	0	+40	0
160	180	+68	+43	+83	+43	+39	+14	+54	+14	+25	0	+40	0
180	200	+79	+50	+96	+50	+44	+15	+61	+15	+29	0	+46	0
200	225	+79	+50	+96	+50	+44	+15	+61	+15	+29	0	+46	0
225	250	+79	+50	+96	+50	+44	+15	+61	+15	+29	0	+46	0
250	280	+88	+56	+108	+56	+49	+17	+69	+17	+32	0	+52	0
280	315	+88	+56	+108	+56	+49	+17	+69	+17	+32	0	+52	0
315	355	+98	+62	+119	+62	+54	+18	+75	+18	+36	0	+57	0
355	400	+98	+62	+119	+62	+54	+18	+75	+18	+36	0	+57	0
400	450	+108	+68	+131	+68	+60	+20	+83	+20	+40	0	+63	0
450	500	+108	+68	+131	+68	+60	+20	+83	+20	+40	0	+63	0

SURFACE FINISH CONVERSION CHART		
Micro Inch (Cia)	Metric (microns) Equivalent (Ra)	European
1	0.025	N1
2	0.050	N2
4	0.100	N3
8	0.200	N4
16	0.400	N5
32	0.810	N6
63	1.600	N7
125	3.180	N8
250	6.350	N9
500	12.700	N10
1000	25.400	N11

Shaft and Bore Limits & Fits

Housing Bore Tolerances (deviation from nominal dimensions)

Nominal Diameter mm		TOLERANCE OF HOUSING SHAFT DIAMETER (Unit = 0.001mm)											
Over	Incl.	h7		h8		h9		h10		j5		j6	
		High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
-	3	0	-10	0	-14	0	-25	0	-40	+2	-2	+4	-2
3	6	0	-12	0	-18	0	-30	0	-48	+3	-2	+6	-2
6	10	0	-15	0	-22	0	-36	0	-58	+4	-2	+7	-2
10	18	0	-18	0	-27	0	-43	0	-70	+5	-3	+8	-3
18	30	0	-21	0	-33	0	-52	0	-84	+5	-4	+9	-4
30	40	0	-25	0	-39	0	-62	0	-100	+6	-5	+11	-5
40	50	0	-25	0	-39	0	-62	0	-100	+6	-5	+11	-5
50	65	0	-30	0	-46	0	-74	0	-120	+6	-7	+12	-7
65	80	0	-30	0	-46	0	-74	0	-120	+6	-7	+12	-7
80	100	0	-35	0	-54	0	-87	0	-140	+6	-9	+13	-9
100	120	0	-35	0	-54	0	-87	0	-140	+6	-9	+13	-9
120	140	0	-40	0	-63	0	-100	0	-160	+7	-11	+14	-11
140	160	0	-40	0	-63	0	-100	0	-160	+7	-11	+14	-11
160	180	0	-40	0	-63	0	-100	0	-160	+7	-11	+14	-11
180	200	0	-46	0	-72	0	-115	0	-185	+7	-13	+16	-13
200	225	0	-46	0	-72	0	-115	0	-185	+7	-13	+16	-13
225	250	0	-46	0	-72	0	-115	0	-185	+7	-13	+16	-13
250	280	0	-52	0	-81	0	-130	0	-210	+7	-16	+16	-16
280	315	0	-52	0	-81	0	-130	0	-210	+7	-16	+16	-16
315	355	0	-57	0	-89	0	-140	0	-230	+7	-18	+18	-18
355	400	0	-57	0	-89	0	-140	0	-230	+7	-18	+18	-18
400	450	0	-63	0	-97	0	-155	0	-250	+7	-20	+20	-20
450	500	0	-63	0	-97	0	-155	0	-250	+7	-20	+20	-20

Nominal Diameter mm		TOLERANCE OF HOUSING BORE DIAMETER (Unit = 0.001mm)									
Over	Incl.	H8		H9		H10		J6		J7	
		High	Low	High	Low	High	Low	High	Low	High	Low
-	3	+14	0	+25	0	+40	0	+2	-4	+4	-6
3	6	+18	0	+30	0	+48	0	+5	-3	+6	-6
6	10	+22	0	+36	0	+58	0	+5	-4	+8	-7
10	18	+27	0	+43	0	+70	0	+6	-5	+10	-8
18	30	+33	0	+52	0	+84	0	+8	-5	+12	-9
30	40	+39	0	+62	0	+100	0	+10	-6	+14	-11
40	50	+39	0	+62	0	+100	0	+10	-6	+14	-11
50	65	+46	0	+74	0	+120	0	+13	-6	+18	-12
65	80	+46	0	+74	0	+120	0	+13	-6	+18	-12
80	100	+54	0	+87	0	+140	0	+16	-6	+22	-13
100	120	+54	0	+87	0	+140	0	+16	-6	+22	-13
120	140	+63	0	+100	0	+160	0	+18	-7	+26	-14
140	160	+63	0	+100	0	+160	0	+18	-7	+26	-14
160	180	+63	0	+100	0	+160	0	+18	-7	+26	-14
180	200	+72	0	+115	0	+185	0	+22	-7	+30	-16
200	225	+72	0	+115	0	+185	0	+22	-7	+30	-16
225	250	+72	0	+115	0	+185	0	+22	-7	+30	-16
250	280	+81	0	+130	0	+210	0	+25	-7	+36	-16
280	315	+81	0	+130	0	+210	0	+25	-7	+36	-16
315	355	+89	0	+140	0	+230	0	+29	-7	+39	-18
355	400	+89	0	+140	0	+230	0	+29	-7	+39	-18
400	450	+97	0	+155	0	+250	0	+33	-7	+43	-20
450	500	+97	0	+155	0	+250	0	+33	-7	+43	-20

TOLERANCE BAND IN MICRONS (0.001mm) UNITS			
over	incl.	m6	S7
0	3	+2 / +8	-6 / -16
3	6	+4 / +12	-10 / -22
6	10	+6 / +15	-13 / -28
10	18	+7 / +18	-16 / -34
18	30	+8 / +21	-20 / -41
30	50	+9 / +25	-25 / -50
50	80	+11 / +30	-30 / -60

Inertia and the Use of Inertia Figures to Aid Selection

Example Gearbox

3:1 ratio, 90% efficient, 0.52kg cm² (0.000052kg m²) reflected inertia at input

So, if acceleration = 10 Rads/sec²

Input torque needed = inertia (in kg m²) x acceleration (rads/sec)

Input torque needed = 0.000052 kg m² x 10 rads/sec = 0.00052Nm

Also, if inertia of load 0.0062 kg m² (62 kg cm²) at output of unit

Reflected inertia at input will go upto 0.00817 kg m² (81.7kg cm²)

Torque now will need to be 0.0817Nm.

Using the calculations below :-

$$J_T = J_M + \frac{J_L}{R^2 n}$$

J_T (kg m²) x acceleration at input (radians per second) = acceleration torque needed Nm

J_T = total reflected inertia at input of gearbox unit (kg m²)

J_M = reflected inertia of gearbox (kg m²)

J_L = inertia of load at gearbox output (kg m²)

R = ratio :1

n = efficiency %

1 radian (rad) = 57.5928°

1 kg m² = 10,000 kg cm²

1 kg m² = 1,000,000,000 g mm²

1 m² = 1,000,000 mm²

1 m² = 10,000 cm²

1.0 x 10⁻² = 0.01

1.0 x 10⁻³ = 0.001

1.0 x 10⁻⁴ = 0.0001

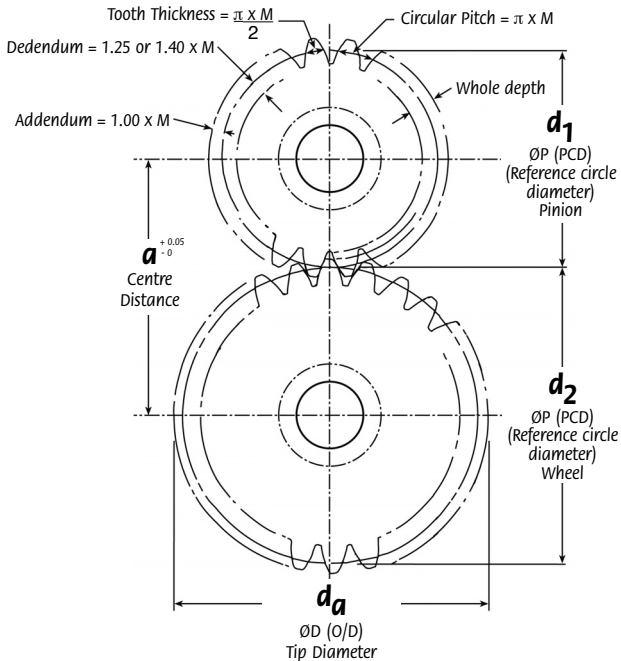
1.0 x 10⁻⁵ = 0.00001

1.0 x 10⁻⁶ = 0.000001

1.0 x 10⁻⁷ = 0.0000001

Spur Gears - 20° Pressure Angle

BS436 pt 2 : 1970



For Spur Gears - Helical Gears - Worms & Wormwheels

$$\text{Gear Centre Distance } a = \frac{d_1 + d_2}{2}$$

$$\text{Ratio} = \frac{Z_2 \text{ No. of teeth wheel : driven}}{Z_1 \text{ No. of teeth pinion : driven}} = :1$$

M = Module

Alignment Adjustment

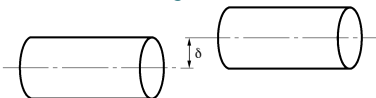
① Flexible couplings transmit torque and rotational angle while absorbing misalignment. When the misalignment exceeds allowable values, vibration may result or the life of the coupling may become shortened. Make sure to adjust the alignment accordingly.

② There are three types of shaft misalignment, namely in terms of parallel misalignment, angular misalignment and shaft end play. Adjust the alignment to be below allowable values listed in the specification table of each product listed in the catalogue (where applicable).

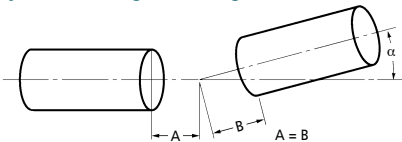
③ The maximum misalignment listed is the allowable value when only one of the misalignments exists. In case two or more misalignments exist at the same time, the allowable values will be less than $\frac{1}{2}$ of the maximum misalignment listed in the specification tables.

④ Misalignments are sometimes caused not only by equipment assembly, but also by vibration, heat expansion, wear of bearings, etc. during operation. Therefore, it is recommended to adjust the shaft misalignment to be below $\frac{1}{2}$ of maximum values.

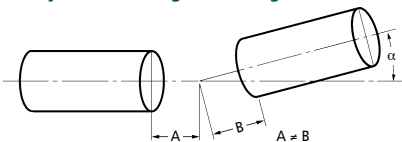
Parallel Offset Misalignment



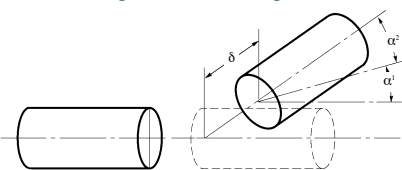
Symmetrical Angular Misalignment



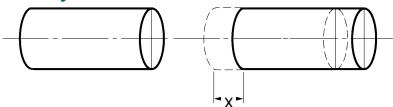
Non-Symmetrical Angular Misalignment



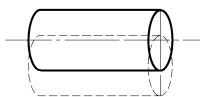
Combined Angular-Offset Misalignment



End-Play



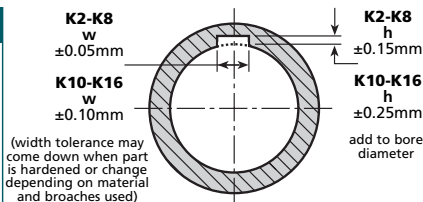
Run Out



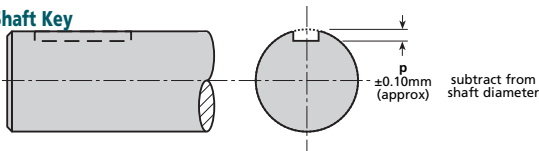
Keyway Sizes & Tapping Drill Sizes

Keyway Sizes

Ref	w mm	h mm	P mm
K2	2	1.07	1.25
K3	3	1.50	1.85
K4	4	1.86	2.55
K5	5	2.35	3.05
K6	6	2.83	3.55
K8	8	3.34	4.10
K10	10	3.34	5.10
K12	12	3.35	5.10
K14	14	3.80	5.50
K16	16	4.30	6.00



Shaft Key



Other keyway tolerance standards
(we may be able to quote on some of these depending on product type - tooling costs may be charged extra).

On width values only (not depth)

Free Fit

Normal Fit

Close Fit

H9

D10

N9

Js9

P9

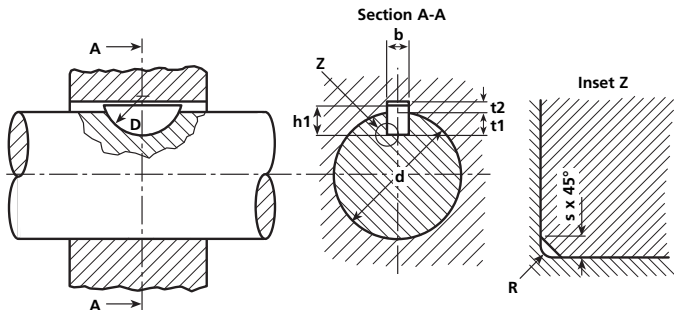
Bore or Shaft Ø up to & incl.		Keyway	Pin Hole Dia.	Grub Screw
4	6	-	1.50	M3
6	8	K2	2.00	M3
8	10	K3	3.00	M3
10	12	K4	4.00	M4
12	17	K5	5.00	M5
17	22	K6	6.00	M6
22	30	K8	8.00	M8
30	38	K10	10.00	M10
38	44	K12	10.00	M10
44	50	K14	10.00	M12
50	58	K16	10.00	M12



Woodruff Keys and Keyways Metric Sizes

Key size for nominal $b \times h_1 \times D$ or equivalent Whitney form	Width b			Depth				Radius R	
	Nominal	Tolerance		Shaft t_1		Hub t_2		Max. Min.	
		Normal Fit							
		Shaft (N9)	Hub (Js9)	Nom.	Tol.	Nom.	Tol.		
1.0 x 1.4 x 4	1.0			1.0		0.6		0.16	0.08
1.5 x 2.6 x 7	1.5			2.0	+0.1	0.8		0.16	0.08
2.0 x 2.6 x 7	2.0	-0.004	+0.012	1.8	-0.0	1.0		0.16	0.08
2.0 x 3.7 x 10	2.0	-0.029	-0.012	2.9		1.0		0.16	0.08
2.5 x 3.7 x 10	2.5			2.7		1.2	+0.1	0.16	0.08
3.0 x 5.0 x 13	3.0			3.8		1.4	-0.0	0.16	0.08
3.0 x 6.5 x 16	3.0			5.3		1.4		0.16	0.08
4.0 x 6.5 x 16	4.0			5.0	+0.2	1.8		0.25	0.16
4.0 x 7.5 x 19	4.0			6.0	-0.0	1.8		0.25	0.16
5.0 x 6.5 x 16	5.0			4.5		2.3		0.25	0.16
5.0 x 7.5 x 19	5.0	+0.000	+0.015	5.5		2.3		0.25	0.16
5.0 x 9.0 x 22	5.0	-0.030	-0.015	7.0		2.3		0.25	0.16
6.0 x 9.0 x 22	6.0			6.5	+0.3	2.8		0.25	0.16
6.0 x 11.0 x 28	6.0			7.5	-0.0	2.8	+0.2	0.25	0.16
8.0 x 11.0 x 28	8.0	+0.000	+0.018	8.0		3.3	-0.0	0.40	0.25
10.0 x 13.0 x 32	10.0	-0.036	-0.018	10.0		3.3		0.40	0.25

Woodruff Keys and Keyways, Metric Sizes

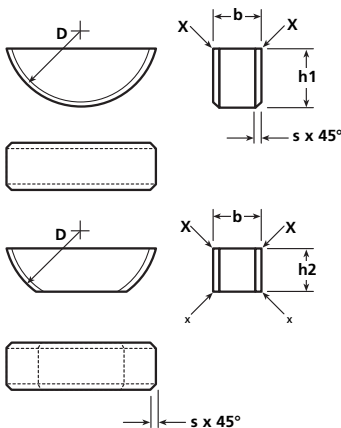


Woodruff Keys and Keyways

Metric Sizes

Width b		Height h1		Diameter D		Chamfer s			
Nominal	Tolerance (h9)	Nominal	Tolerance (h11)	Nominal	Tolerance (h11)	Min.	Max.		
1.0	+0.000 -0.025	1.4	+0.000	4	+0.000 -0.120	0.16	0.25		
1.5		2.6	-0.060	7	+0.000 -0.150	0.16	0.25		
2.0		2.6	+0.000	10		0.16	0.25		
2.0		3.7	+0.000	10	0.16	0.25			
2.5		3.7	-0.075	13	+0.000	0.16	0.25		
3.0		5.0	+0.000 -0.090	+0.000 -0.180	16	+0.000	0.16	0.25	
3.0	6.5	16			-0.180	0.25	0.40		
4.0	6.5	19			+0.000	0.25	0.40		
4.0	7.5	19			-0.210				
5.0	+0.000 -0.030	6.5			+0.000 -0.180	16	+0.000	0.25	0.40
						19	-0.210	0.25	0.40
5.0	7.5	22	+0.000	0.25	0.40				
5.0	9.0	22	-0.210	0.25	0.40				
6.0	9.0	25	+0.000 -0.250	0.25	0.40				
6.0	10.0	28		0.40	0.60				
8.0	+0.000	11.0	+0.000	32	+0.000	0.40	0.60		
10.0	-0.036	13.0	-0.110						

Dimensions and Tolerances for Woodruff Keys



Threads, Fixings & Tolerances

Recommended Tapping Drill Sizes

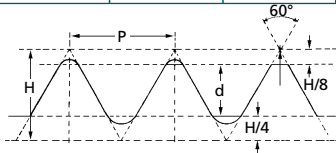
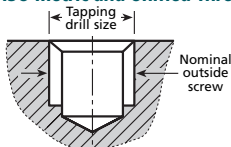
(when cold forming using DIN 371 cold forming taps)

Note: Larger drills must only be used if cold forming (rolling). Check with your tool supplier. Normally only done on malleable materials such as aluminium, bronze, soft steels etc.

Tap	Drill Size mm	Pitch mm
M3	Ø2.80	0.50
M4	Ø3.70	0.70
M5	Ø4.65	0.80
M6	Ø5.55	1.00
M8	Ø7.40	1.25
M10	Ø9.30	1.50
M12	Ø11.20	1.75

Basic Thread Forms (cut):

ISO Metric and Unified Thread



Tapping Drill Ø mm	Thread	Pitch mm	Outside Ø mm
1.60	M2	0.40	2.00
2.05	M2.5	0.45	2.50
2.50	M3	0.50	3.00
3.30	M4	0.70	4.00
4.20	M5	0.80	5.00
5.00	M6	1.00	6.00
6.00	M7	1.00	7.00
6.80	M8	1.25	8.00
8.50	M10	1.50	10.00
10.20	M12	1.75	12.00
12.00	M14	2.00	14.00
14.00	M16	2.00	16.00
15.50	M18	2.50	18.00
17.50	M20	2.50	20.00
19.50	M22	2.50	22.00
21.00	M24	3.00	24.00

The basic form is derived from an equilateral triangle which is truncated 1/8 of the height at the major diameter and 1/4 of the height at the minor diameter. The corresponding flats have a width of P/8 and P/4 respectively. In practice, clearance is provided beyond the P/8 flat on internal threads and beyond the P/4 flat on external threads.

These clearances are usually rounded but may be flat.

$$\begin{aligned}
 H &= \text{angular depth} &&= 0.866025P \\
 H/8 &= \text{shortening of major diameter} &&= 0.108253P \\
 H/4 &= \text{shortening of minor diameter} &&= 0.216506P \\
 d &= 5/8 \text{ in } H &&= 0.541266P \\
 P &= \text{pitch} &&= \frac{1}{\text{No. of threads per inch}}
 \end{aligned}$$

Thread m	Course	Pitch	Metric Drill and Tap Reference Data			
			Fine	Tap Drill Diameter	Tight	Clearance Hole Normal
2.00	0.40	0.25	1.60	2.20	2.40	2.60
2.50	0.45	0.35	2.05	2.70	2.90	3.10
3.00	0.50	0.35	2.50	3.20	3.40	3.60
3.50	0.60	0.35	2.90	3.70	3.90	4.20
4.00	0.70	0.50	3.30	4.30	4.50	4.80
5.00	0.80	0.50	4.20	5.30	5.50	5.80
6.00	1.00	0.75	5.00	6.40	6.60	7.00
7.00	1.00	0.75	6.00	7.40	7.60	8.00
8.00	1.25	1.00	6.80	8.40	9.00	10.00
10.00	1.50	1.25	8.50	10.50	11.00	12.00
12.00	1.75	1.25	10.20	13.00	13.50	14.50

International Specifications

Material Equivalents

En.	B.S.	Workstoff	AFNOR (France)	DIN	USA
1A	220M7	1.0711	AF37C12XC18	9521	1212
	080M15	1.0401	AF42C20XC25	C15	1015
3A	070M20	1.0402	AF55C35XC38	C22	1020
5C	080A32	1.0501	AF50C30	C35	1035
	070M26	1.0406	C25	C70	1025
6	080M30		AF60C40		
8	080M40	1.0511	AF55C34XC38	C40	1040
8A & 8B	080A35/37	1.0501	XC42H1	C822	1035
8C	080A40	1.1186	35MF6	CK40	1040
8M	212M36	1.0726	AF65C45	35520	1140
8	080M46	1.0503		C45	1045
9	070M55	1.0535	32C4	C55	1055
18B	530A32	1.7033	42CD4	34Cr4	5132
19A	708M40	1.7225	35CD4	42CrMo4	4140;4142
19B	708A37	1.7220	35NCD6	34CrMo4	4135;4137
24	817M40	1.6582	35NCD14	34CrNiMo6	4340
26	0826M40	1.6746	35NCD16	32NiCrMo145	
30B	835M30	1.6747	100C6	30NiCrMo166	
31	535A99	1.3505		100Cr6	52100
202	214M15		AF34C10XC10		
32A	045M10	1.0301		C10	1010
32M	212M15	1.0723	12NC15	15520	
36A	655M13	1.5752	16NCD17	14NiCr14	3415, 3310, 9314
39B	835M15	1.6723	30CD12		
40B	722M24	1.7361	XC48H1	32CrMo12	
43A	080M50	1.1206	Z12CF13	CK50	1050
56	416S21	1.4005	Z10CNF18.09	X12CrS13	416
58	303S21/3	1.4305	Z6CND17.12	X10CrNiS189	303
58J	316S16	1.4436		X5CrNiMo17133	316

Material Strengths

Material Spec. B.S. 970	Condition	Tensile Stress lb/in ²	Surface Stress Factor Sc	Bending Stress Factor Sb	Tensile Strength N/mm ²	Elongation After Fracture	0.2% Proof Stress N/mm ²
Nylon 66		9,500		3,900	0.62 - 0.82	20% - 200%	—
Delrin (polyacetal)		10,117			69	75%	—
Tufnol	CARP	16,000	560	4,500	—	—	—
Cast Iron	GR17 (260)	35800	1,400	9,000	260	—	—
Aluminium	HR15N		500	13,000	295	6% - 8%	230
Alloy Aluminium	7016	CA 102	900	9,000	420 - 720	18% - 40%	140 - 660
Phosphor Bronze	PB2	26,800	700	7,000	360 - 500	6.25%	170 - 280
(EN32) 045M10		71,680	1,400	17,000	430	18%	—
(EN32) 045M10	Case Hardened	71,680	9,200	40,000	—	—	—
(EN8) 080M40		78,400	1,400	19,000	510 - 550	16% - 17%	—
(EN8) 080M40	Induction/Through	78,400	2,800	17,000	—	—	—
(EN24) 817M40		112,000	3,000	32,000	850 - 1550	5% - 13%	635 - 1125
(EN24) 817M40	Induction/Through	112,000	5,000	26,500	—	—	—
(EN36) 655M13	Case Hardened	123,200	11,000	50,000	—	—	—
(EN58AM) 303S21		78,400	1,800	20,000	480 - 510	35% - 40%	180 - 200

General Information

SI Units & Conversions for Characteristics of Mechanical Fasteners

Property	Unit	Symbol	From	Conversion To	Multiply by	Approx. Equivalent
Length	metre	m	inch	mm	25.40	25mm = 1in.
	centimetre	cm	inch	cm	2.54	300mm = 1ft.
	millimetre	mm	foot	mm	304.80	1m = 39.37in.
Mass	kilogram	kg	ounce	g	28.35	28g = 1oz.
	gram	g	pound ton (2240lb)	kg	0.4536	1kg = 2.2lb = 35oz.
	tonne (megagram)	t		kg	984.20	1t = 2205lbs.
Density	kilogram per cub. metre	kg/m ³	pounds per cu. ft.	kg/m ³	16.02	16kg/m ³ = 1lb/ft ³
Temp.	deg. Celsius	°C	deg. Fahr.	°C	(°F-32) x5/9	0°C = 32°F 100°C = 212°F
Area	square metre	m ²	sq. inch	mm ²	645.20	645mm ² = 1in ²
	square millimetre	mm ²	sq. ft.	m ²	0.0929	1m ² = 11 ft ²
Volume	cubic metre	m ³	cu. in.	mm ³	16387	16400mm ³ = 1in ³
	cubic centimetre	cm ³	cu. ft.	m ³	0.02832	1m ³ = 35ft ³
	cubic millimetre	mm ³	cu. yd.	m ³	0.7645	1m ³ = 1.3yd ³
Force	newton	N	ounce (Force)	N	0.278	1N = 3.6 ozf
	kilonewton	kN	pound (Force)	kN	0.00445	4.4N = 1 lbf
	meganeutron	Mn	Kip	MN	0.00445	1kN = 225 lbf
Stress	megapascal	Mpa	pounds/in ² (psi)	MPa	0.0069	1MPa = 145 psi
	newtons/sq.mm	N/m ²	Kip/in ² (ksi)	MPa	6.895	7MPa = 1 ksi
Torque	newton-metres	N-m	inch-ounce	N-m	0.00706	1N-m = 0.1416119 oz.in.
			inch-pound	N-m	0.113	1N-m = 8.8507 lb.in.
			foot-pound	N-m	1.356	1N-m = 0.7375621 lb.ft. 1.4 N-m = 1 ft.lb.

Rockwell • Brinell • Tensile Conversion

Rockwell "C" Scale HRC	Vickers Hv	Brinell Hardness HB	Tensile Strength MPa (approx)	Rockwell "C" Scale HRC	Vickers Hv	Brinell Hardness HB	Tensile Strength MPa (approx)
68	940	-	-	38	372	353	1170
67	900	-	-	37	363	344	1140
66	865	-	-	36	354	336	1100
65	832	739	-	35	345	327	1070
64	800	722	-	34	336	319	1030
63	772	705	-	33	327	311	1010
62	746	688	-	32	318	301	980
61	720	670	-	31	310	294	960
60	697	654	2320	30	302	286	940
59	674	634	2260	29	294	279	910
58	653	615	2200	28	286	271	890
57	633	595	2140	27	279	264	870
56	613	577	2080	26	272	258	850
55	595	560	2010	25	266	253	830
54	577	543	1950	24	260	247	810
53	560	525	1890	23	254	243	790
52	544	512	1830	22	248	237	770
51	528	496	1770	21	243	231	760
50	513	481	1720	20	238	226	740
49	498	469	1660	(19)	-	-	720
48	484	455	1610	(18)	230	219	710
47	471	443	1550	(17)	-	-	700
46	458	432	1510	(16)	222	212	690
45	446	421	1460	(15)	-	-	680
44	434	409	1420	(14)	213	203	670
43	423	400	1380	(13)	-	-	660
42	412	390	1340	(12)	204	194	640
41	402	381	1300	(11)	-	-	630
40	392	371	1250	(10)	196	187	620
39	382	362	1210	(8)	188	179	600



SI Units Symbols & Names

System	Units	Length	Mass	Time	Temp.	Acceler-ation	Force	Stress	Pressure	Energy	Power
SI		m	kg	s	K, °C	m/s ²	N	Pa	Pa	J	W
CGS		cm	g	s	°C	Gal	dyn	dyn/cm ²	dyn/cm ²	erg	erg
Engineering Unit		m	kgf•S/m	s	°C	m/s ²	kgf	kgf/m ²	kgf/m ²	kgf•m	kgf•ms

SI Units			Units other than SI			Conversion Factors from SI Units
Parameter	Names of Units	Symbols	Name of Units	Symbols		
Angle	Radian	rad	Degree	°		180/π
			Minute	'		10 800/π
			Second	"		648 000/π
Length	Metre	m	Micron	μ		10 ⁶
			Angstrom	Å		10 ¹⁰
Area	Square metre	m ²	Acre	a		10 ²
			Hectare	ha		10 ⁴
Volume	Cubic metre	m ³	Litre	l, L		10 ³
			Decilitre	dl, dL		10 ⁴
Frequency	Hertz	Hz	Cycle	s ⁻¹		1
Speed of Rotation	Revolution per sec.	s ⁻¹	Revolution per minute	rpm		60
Speed	Metre per second	m/s	Kilometer per hour	km/h		3 600/1 000
			Knot	kt		3 600/1 852
Acceleration	Metre per sec./sec.	m/s ²	g	g		1/9.806 65
Mass	Kilogram	kg	Ton	t		10 ³
Force	Newton	N	Kilogram-force	kgf		1/9.806 65
			Ton-force	tf		1/9.806 65x10 ³
			Dyne	dyn		105
Torque or Moment Stress	Newton-metre	N•m	Kilogram-force metre	kgf•m		1/9.806 65
			Pascal	Pa (N/m ²)		Kilogram-force per sq. cm Kilogram-force per sq. mm

Multiples	Prefix	Symbols	Multiples	Prefix	Symbols
10 ¹⁸	Exa	E	10 ⁻¹	Deci	d
10 ¹⁵	Peta	P	10 ⁻²	Centi	c
10 ¹²	Tera	T	10 ⁻³	Milli	m
10 ⁹	Giga	G	10 ⁻⁶	Micro	μ
10 ⁶	Mega	M	10 ⁻⁹	Nano	n
10 ³	Kilo	k	10 ⁻¹²	Pico	p
10 ²	Hecto	h	10 ⁻¹⁵	Femto	f
10 ¹	Deca	da	10 ⁻¹⁸	Ato	a

SI Units

Symbols & Names

Parameter	SI Units		Units other than SI		Conversion Factors from SI Units
	Names of Units	Symbols	Name of Units	Symbols	
Pressure	Pascal (Newton per sq. metre)	Pa (N/m ²)	Kilogram-force per sq. metre	kgf/m ²	1/9.806 65
			Water Column	mH ₂ O	1/(9.806 65x10 ³)
			Mercury Column	mmHg	760/(1.013 25x10 ³)
			Torr	Torr	760/(1.013 25x10 ³)
			Bar	bar	10 ⁵
Energy	Joule (Newton-metre)	J (N•m)	Atmosphere	atm	1/(1.013 25x10 ⁵)
			Erg	erg	10 ⁷
			Calorie(International)	calIT	1/4.186 8
			Kilogram-force metre	kgf•m	1/9.806 65
			Kilowatt hour	kW•h	1/(3.6x10 ⁶)
Work	Watt (Joule per second)	W (J/s)	French horse power	PS•h	=3.776 72x10 ⁷
			Kilogram-force metre per second	kgf•m/s	1/9.806 65
			Kilocalorie per hour	kcal/h	1/1.163
			French horse power	PS	=1/735.498 8
Viscosity	Pascal second	Pa•s	Poise	P	10
Viscosity Index					
Kinematic Viscosity	Square metre	m ² /s	Stokes	St	10 ⁴
Kinematic Viscosity Index	per second		Centistokes	cSt	10 ⁶
Temperature	Kelvin, Degree Celsius	K °C	Degree	°C	(see note (1))
Electric Current	Ampere	A	Ampere	A	1
Magnetomotive Force					
Voltage	Volt	V	(Watts per ampere)	(W/A)	1
Electromotive Force					
Magnetic Field Strength	Ampere per metre	A/m	Oersted	Oe	4π/10 ³
Magnetic Flux Density	Tesla	T	Gauss	Gs	10 ⁴
			Gamma	γ	10 ⁹
Electrical Resistance	Ohm	Ω	(Volts per ampere)	(V/A)	1

Note: (1) The conversion from TK into $\theta = T - 273.13$ but for a temperature difference, it is $\Delta T = \Delta\theta$. However, ΔT and $\Delta\theta$ represent temperature differences measured using the Kelvin and Celsius scales respectively.

Remarks: The names and symbols in () are equivalent to those directly above them or on their left. Example of conversion 1N/9.806 65kgf.

Module Calculations

The majority of pages in this catalogue present Torque figures. The table below summarises the broad outline of them. However, these values are relative to our standard gears and can only be used as reference to carry out your own calculations. They are based on two gears of 20 teeth turning with 1000 rpm input speed used for 12 hours per day, with a good lubrication, and thus require to be adjusted with your application. To calculate the module which you need, your torque figure should be adjusted by the coefficients A, B, C and D

$$\frac{\text{Transmitted Torque}}{A \times B \times C \times D} < \text{Nomial Torque}$$

Example :

Transmitting 20Nm at 500t rpm for 6 hours per day with gears of 20 teeth (input) and 100 teeth (output):

$$\frac{20}{0.25 \times 1.27 \times 1.15 \times 1.1} < 49.80$$

Several solutions are possible, eg: 1.75 Mod spur gears (G1.75 heat treated), 2 Mod HD spur gears (YG2 untreated), 1.5 Mod helical gears (heat treated SH1.5)

Torque Figures Output torque (Nm) for two gears of 50 teeth at 1000rpm (input speed)	Module									
	0.25 Mod	0.3 Mod	0.4 Mod	0.5 Mod	0.6 Mod	0.7 Mod	0.75 Mod	0.8 Mod	0.9 Mod	1 Mod
Spur Gears										
G/PG/SSG/HG (34C10, Stainless)	0.05	0.07	0.147	0.391	0.63	0.6	0.99	1	1.91	2.6
G/PG (34C10 Hardened)	0.23	0.32	0.698	1.85	2.91	3.2	4.57	5	8.82	12
YG/XG (35NCD6, 12NC15)	-	-	-	-	-	-	-	4	-	10.6
YG/XG (35NCD6 Hardened)	-	-	-	-	-	-	-	5.8	-	15.5
YG/XG (12NC15 Hardened)	-	-	-	-	-	-	-	11	-	29.3
GB (Brass)	-	-	-	0.195	-	-	-	0.54	-	1.25
ZG/ZPG (Delrin)	-	-	0.04	0.1	-	-	-	0.3	-	0.7
Helical Gears										
SH/PSH (34C10)	-	-	0.28	0.53	-	1.73	-	2.25	-	4.23
SH/PSH (34C10 Hardened)	-	-	1.12	2.09	-	6.83	-	8.92	-	16.74
ZSH/ZPSH (Delrin)	-	-	-	0.13	-	0.4	-	0.5	-	1
H/PH (34C10)	-	-	0.056	0.127	-	0.272	-	0.395	-	0.747
H/PH (34C10 Hardened)	-	-	0.375	0.705	-	1.791	-	2.596	-	4.908
ZH/ZPH (Delrin)	-	-	-	0.03	-	-	-	0.1	-	0.18
Worms & Wheels										
M/PM et W/SW (Bronze/Steel)	-	-	0.57	1.01	-	-	-	2.82	-	5.87
M/PM et WH/SWH (Bronze/Hardened Steel)	-	-	1	1.86	-	-	-	5.26	-	10.06
ZM/ZPM et ZW/ZSW (Delrin)	-	-	0.14	0.25	-	-	-	0.7	-	1.32
ZM/ZPM et W/SW (Delrin/Steel)	-	-	0.36	0.65	-	-	-	1.84	-	3.42

A Variation of the number of teeth of the driving wheel

Number of teeth	COEFA
100	2.00
75	1.50
50	1.00
40	0.75
30	0.50
20	0.25

B Variation of the number of teeth of the driven gear

Number of teeth	COEF.B
100	1.27
50	1.00
30	0.80
20	0.63

Note: for worms and wheels, only use B, C et D.

C Speed variations

Speed (rpm)	COEFC
2000	0.85
1000	1.00
500	1.15
100	1.54
10	2.38

D Variation of the operating time

Operating time over one day (H)	COEF.D
24	0.90
12	1.00
6	1.10
3	1.22
1	1.44
½	1.58

Torque Figures Output torque (Nm) for two gears of 50 teeth at 1000rpm (input speed)										
	1.25 Mod	1.5 Mod	1.75 Mod	2 Mod	2.5 Mod	3 Mod	4 Mod	5 Mod	6 Mod	8 Mod
Spur Gears										
G/PG/SSG/HG (34C10, Stainless)	3.8	8.88	16	25	48	88	200	294	441	918
G/PG (34C10 Hardened)	18	41.5	75	119	228	421	953	1570	2350	5360
YG/XG (35NCD6, 12NC15)	17	32	48	70	122	223	420	-	-	-
YG/XG (35NCD6 Hardened)	24	46	69	103	178	325	665	-	-	-
YG/XG (12NC15 Hardened)	47	88	132	195	337	615	1256	-	-	-
GB (Brass)	-	-	-	-	-	-	-	-	-	-
ZG/ZPG (Delrin)	1	2.4	-	6	11	18	55	90	140	179
Helical Gears										
SH/PSH (34C10)	6.61	12.71	-	33.89	66.17	114.2	338	-	-	-
SH/PSH (34C10 Hardened)	43.45	50.29	-	134	261.7	451.9	1340	-	-	-
ZSH/ZPSH (Delrin)	1.5	3	-	8	12	20	-	-	-	-
H/PH (34C10)	1.386	2.32	-	5.2	9.71	16.17	36.07	-	-	-
H/PH (34C10 Hardened)	9.108	15.28	-	34.18	63.84	106.3	237.1	-	-	-
ZH/ZPH (Delrin)	0.4	0.7	-	1.5	3	5	-	-	-	-
Worms & Wheels										
M/PM et W/SW (Bronze/Steel)	11.41	16.8	-	45	81	139	309	-	-	-
M/PM et WH/SWH (Bronze/Hardened Steel)	20.25	30	-	79	124	200	417	-	-	-
ZM/ZPM et ZW/ZSW (Delrin)	2.75	3.97	-	11	16	27	61	-	-	-
ZM/ZPM et W/SW (Delrin/Steel)	7.02	10.05	-	28.3	40	69	154	-	-	-

