EUROPA TOOL

Clarkson

osborn

TECHNICAL DATA

- THREAD MILL PROGRAMMING
- ICON GUIDE
- GENERAL DATA
- TROUBLESHOOTING
- MATERIAL CHARTS

THREAD MILL PROGRAMMING

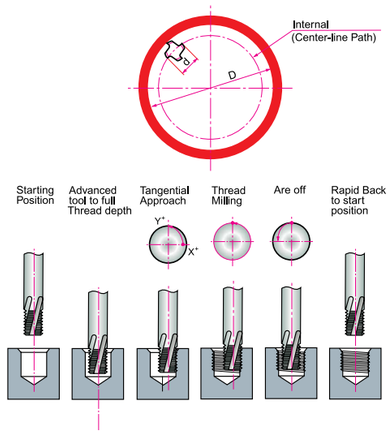
Programme data.

G Codes for Thread Milling

G00	Fast Feed Linear	G41	Cutter Radius Compensation Left	M08	Coolant On
G01	Linear Movement	G42	Cutter Radius Compensation Right	X	Horizontal Co-ordinate
G02	Circular/Helical Interpolation C.W.	G43	Tool Length Compensation Plus	Y	Horizontal Co-ordinate
G03	Circular/Helical Interpolation A.C.W.	G49	Tool Length Compensation Cancel	Z	Vertical Co-ordinate
G17	X, Y Plane(Vertical Machining)	G90	Absolute Command	I	X Co-ordinate to Center of Arc Travel
G18	Z, X Plane(Horizontal Machining)	G91	Incremental Command	J	Y Co-ordinate to Center of Arc Travel
G19	Y, Z Plane(Using 90 Head)	M03	Clockwise Rotation of Spindle	S	Spindle Speed R.P.M.
G40	Cutter Radius Compensation Cancel	M05	Spindle stop	F	Feed mm/min

CNC Internal Thread Milling

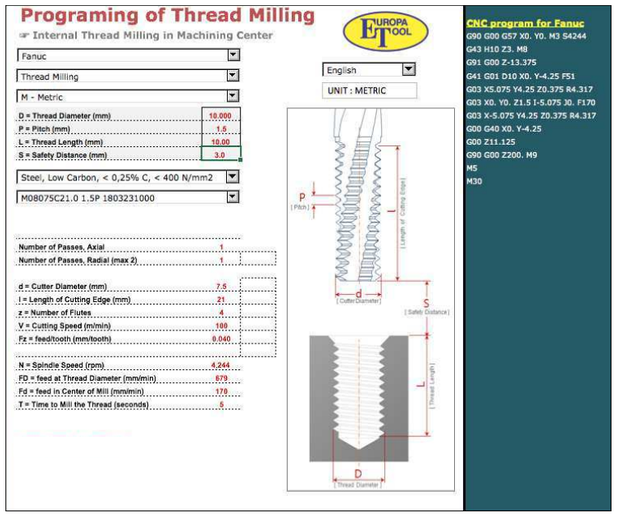
G90	G00	X···	Y···	Z5	S···
G91	G00	Z···(A3+2)			
Y···(A5)					
G41	G01	X··(A6)	F···		
G03	X···(A6)	Y···(A6)	Z···(A4)	I···(A6)	J0
G03	X0	Y0	Y··(A2)	I0	J···(A1)
G03	X···(A6)	Y···(A6)	Z···(A4)	I0	J···(A6)
G00	G40	X··(A6)	Y··(A5)		
G90	Z5				



Explanation of Parameters

A1 : 1/2 Nominal Thread Diameter 1/2D
A2 : Thread Pitch
A3 : Thread Depth
A4 : 1/4P(for climb milling and right-hand thread)
A5 : Beginning of Contour in Y 0.5xP
A6 : Arc Off (A1 - A5)

Download our thread mill programme generator.
Visit http://www.europatool.co.uk/threading/threadmills



ICON GUIDE

Material icons.

AL	Aluminium & Aluminium Alloys
GS	Steels with good machinability Rm<750N/mm²
HS	Heat treated and heat-resistant steels Rm>750N/mm²
VA	Stainless steels
CS	Carbon steels with low contents of alloy Rm<600N/mm²
GV	Any material with at least 8-10% elongation
GG	Grey Cast Iron
TI	Titanium alloys
NI	Nickel alloys
HA	High alloyed steels Rm>1,200N/mm²

Surface treatments.

vap	Steam Tempered
TiN	TiN Coated (Titanium Nitride)
NI	Nitrided
TiAlN	TiAlN Coating (Titanium Aluminium Nitride)
Hardslick	Hardslick Coating (Titanium Aluminium Nitride + WC/C)

Chamfer lead acc. to DIN2197

A	Form A (Chamfer Lead 5-6 Threads)
B	Form B (with GUN-Nose and Chamfer Lead 4-5 Threads)
C	Form C (Chamfer Lead 2-3 Threads)
D	Form D (Chamfer Lead 4-5 Threads)
E	Form E (Chamfer Lead 1.5-2 Threads)

GENERAL INFORMATION

Surface treatments.

❖ STEAM TEMPERING (vap)

Steam tempering applies a Fe_3O_4 coating which reduces the friction between tool and workpiece and prevents cold welding.

❖ NITRIDING (NI)

We recommend this surface treatment for machining materials which affect a hard wear / abrasion, such as Grey cast iron, Al-alloys with Si percentage above 10%.

❖ TiN COATING (TiN)

TiN coating has a hardness of approx. 2,300 HV and is temperature-resistant up to approx. 600℃. This is an excellent all-round coating for normal applications.
Colour : Golden Coefficient of friction against steel : 0.4

❖ TiAlN COATING (TiAlN)

This is a special coating for machining abrasive materials such as Grey cast iron, Al-alloys with silicon, fibre reinforced plastics, etc., or machining under high temperatures, such as insufficient coolant or high speeds ≥ 600m/min. TiAlN coating has a hardness of approx. 3,000 HV and is temperature resistant up to approx. 800℃.
Colour : Violet-Grey Coefficient of friction against steel : 0.4

❖ HARDSLICK COATING

Hardslick combines the advantages of an extremely hard, thermally stable TiAlN coating with the tribological properties of an outer WC/C(Tungsten carbide/carbon) coating. Hardslick coating has a hardness of approx. 3,000 HV and is temperature-resistant up to approx. 800℃.
Colour : Violet-Grey Coefficient of friction against steel : 0.2

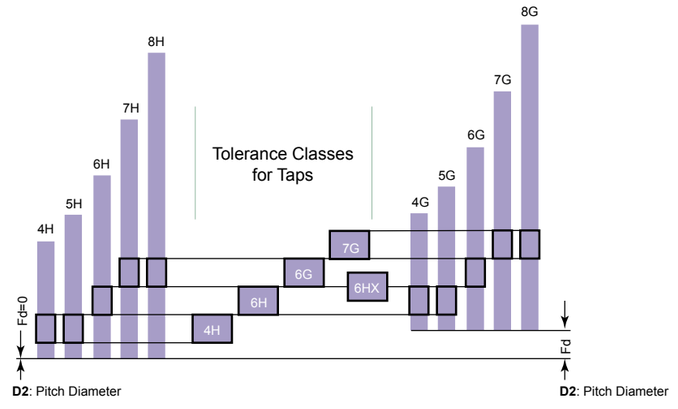
Tapping guide.

TAP SELECTION
The type of tap used depends on the type of material to be machined. Generally, any materials with an elongation of at least 10% can be cold formed, but any other materials need to be cut. Please refer to tap selection guide for most suitable tap.

CORE HOLES
Core holes should be clean and swarf free. In materials that have a tendency to close down after drilling, a slightly larger tapping drill size should be used. Each tap size in this catalogue has a recommended tapping drill size shown in its dimension table.

CUTTING SPEEDS
The correct cutting speed is necessary to control chip flow and establish the best tool life for the tap. Guide values are given in the cutting data charts on pages 86-89. Material hardness and rigidity of workpiece can have a detrimental effect on the tap, so it is worth experimenting with the guide data to establish the best speeds for your particular application.

Tap tolerances.
Tolerance classes of taps and tolerance positions for screw threads as per Metric ISO standard



Tap tolerance ISO	Tap tolerance DIN	Correct class to obtain nut thread with tolerance				
ISO 1	4H	4H	5H			
ISO 2	6H	4G	5G	6H		
ISO 3	6G			6G	7H	8H
	7G				7G	8G

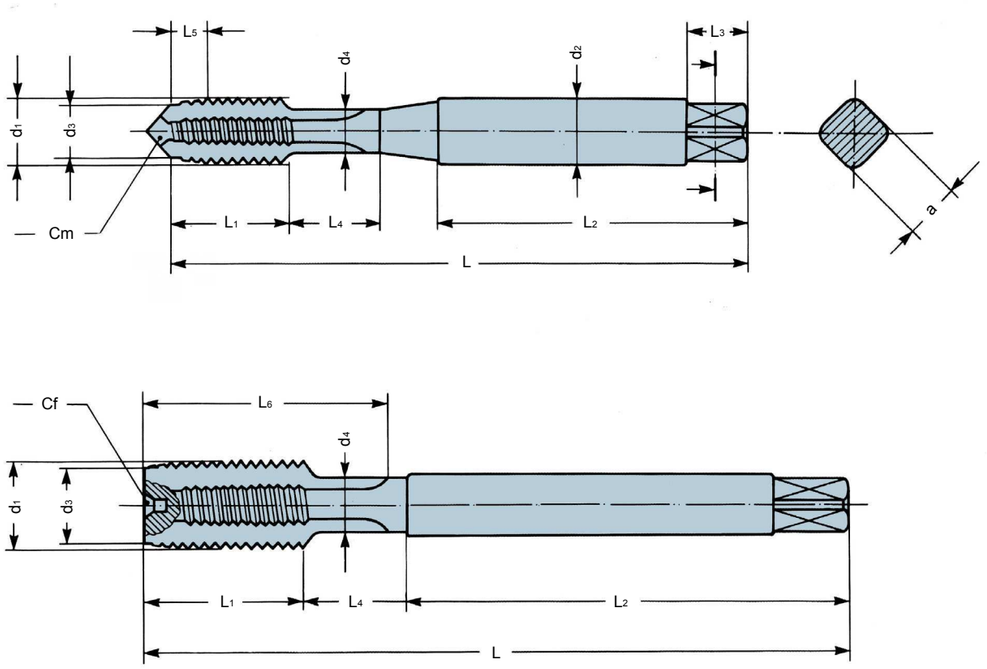
Standard fit for a thread corresponds to tolerance class ISO 2/6H. For more precise fits, without allowance on thread flank, tolerance class ISO 1/4H must be chosen. ISO 3/6G is used in case of loose fits, with large allowance, which is often required for subsequent coatings.

Between classes 6H and 6G taps are produced with tolerance 6HX. These taps are used for tapping abrasive materials, such as cast iron or Al-Si alloys, in order to increase their tool life. Another important application is on cold forming taps, which create the thread by plastic deformation and not by cutting. In this case, due to the elastic return of the material, in order to obtain a thread 6H tolerance, a 6HX tap must be used.

The tolerances described above are collected in the ISO standard ISO 68-1.

GENERAL INFORMATION

Tap terminology.

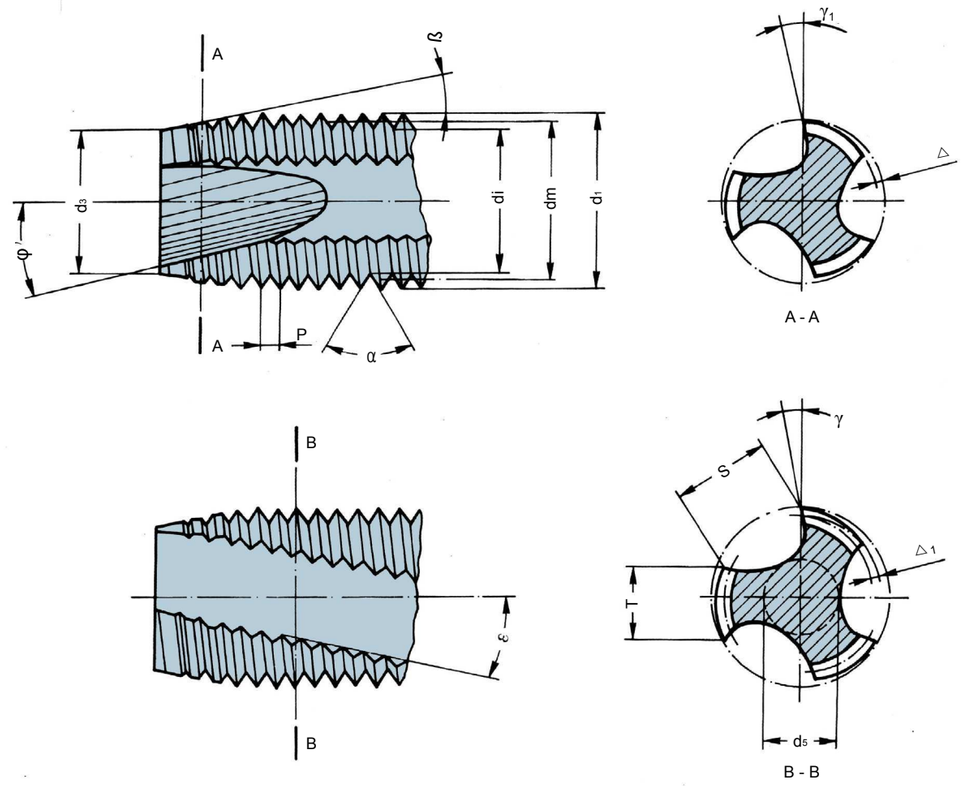


d_1	Major diameter	L	Overall length
d_2	Shank diameter	L_1	Thread length
d_3	Chamfer diameter	L_2	Shank length
d_4	Neck diameter	L_3	Square length
a	Square	L_4	Neck length
Cm	Center male	L_5	Chamfer length
Cf	Center female	L_6	Flute length

TECHNICAL DATA

GENERAL INFORMATION

Tap terminology.



d_1	Major diameter	γ	Gun nose rake angle in front
dm	Flank diameter	△	Chamfer relief
di	Minor diameter	$△_1$	Pitch diameter land relief
d_3	Chamfer diameter	γ	Rake angle
P	Pitch	T	Width of land
a	Flank angle	S	Flute width
ß	Chamfer angle	d_5	Web tickness
φ	Gun nose angle	ε	Angle of spiral flute

GENERAL INFORMATION

Tapping drill sizes for Metric threads.

Metric-ISO threads coarse pitch			
M	Pitch mm.	Maximun core dia. mm.	Drill size mm.
1	0.25	0.785	0.75
1.1	0.25	0.885	0.85
1.2	0.25	0.985	0.95
1.4	0.3	1.16	1.1
1.6	0.35	1.321	1.25
1.7	0.35	1.346	1.3
1.8	0.35	1.521	1.45
2	0.4	1.679	1.6
2.2	0.45	1.838	1.75
2.3	0.4	1.92	1.9
2.5	0.45	2.138	2.05
2.6	0.45	2.176	2.1
3	0.5	2.599	2.5
3.5	0.6	3.01	2.9
4	0.7	3.422	3.3
4.5	0.75	3.878	3.7
5	0.8	4.334	4.2
6	1.0	5.153	5.0
7	1.0	6.153	6.0
8	1.25	6.912	6.8
9	1.25	7.912	7.8
10	1.5	8.676	8.5
11	1.5	9.676	9.5
12	1.75	10.441	10.2
14	2.0	12.21	12.0
16	2.0	14.21	14.0
18	2.5	15.744	15.5
20	2.5	17.744	17.5
22	2.5	19.744	19.5
24	3.0	21.252	21.0
27	3.0	24.252	24.0
30	3.5	26.771	26.5
33	3.5	29.771	29.5
36	4.0	32.27	32.0
39	4.0	35.27	35.0
42	4.5	37.799	37.5
45	4.5	40.799	40.5
48	5.0	43.297	43.0
52	5.0	47.297	47.0
56	5.5	50.796	50.5
60	5.5	54.796	54.5
64	6.0	58.305	58.0
68	6.0	62.305	62.0

Metric-ISO threads fine pitch			
MF	Pitch mm.	Maximun core dia. mm.	Drill size mm.
2.5	0.35	2.221	2.15
3	0.35	2.271	2.65
3.5	0.35	3.221	3.15
4	0.5	3.599	3.5
4.5	0.5	4.099	4.0
5	0.5	4.599	4.5
5.5	0.5	5.099	5.0
6	0.75	5.378	5.2
7	0.75	6.378	6.2
8	0.75	7.378	7.2
8	1.0	7.153	7.0
9	0.75	8.378	8.2
9	1.0	8.153	8.0
10	0.75	9.378	9.2
10	1.0	9.153	9.0
10	1.25	8.912	8.8
11	0.75	10.378	10.2
11	1.0	10.153	10.0
12	1.0	11.153	11.0
12	1.25	10.912	10.8
12	1.5	10.676	10.5
14	1.0	13.153	13.0
14	1.25	12.912	12.8
14	1.5	12.676	12.5
15	1.0	14.153	14.0
15	1.5	13.676	13.5
16	1.0	15.153	15.0
16	1.5	14.676	14.5
17	1.0	16.153	16.0
17	1.5	15.676	15.5
18	1.0	17.153	17.0
18	1.5	16.676	16.5
18	2.0	16.21	16.0
20	1.0	19.153	19.0
20	1.5	18.676	18.5
20	2.0	18.21	18.0
22	1.0	21.153	21.0
22	1.5	20.676	20.5
22	2.0	20.21	20.0
24	1.0	23.153	23.0
24	1.5	22.676	22.5
24	2.0	22.21	22.0
25	1.0	24.153	24.0
25	1.5	23.676	23.5

Metric-ISO threads fine pitch			
MF	Pitch mm.	Maximun core dia. mm.	Drill size mm.
25	2.0	23.21	23.0
26	1.5	24.676	24.5
27	1.0	26.153	26.0
27	1.5	25.676	25.5
27	2.0	25.21	25.0
28	1.0	27.153	27.0
28	1.5	26.676	26.5
28	2.0	26.21	26.0
30	1.0	29.153	29.0
30	1.5	28.676	28.5
30	2.0	28.21	28.0
30	3.0	27.252	27.0
32	1.5	30.675	30.5
32	2.0	30.21	30.0
33	1.5	31.676	31.5
33	2.0	31.21	31.0
33	3.0	30.252	30.0
35	1.5	33.676	33.5
36	1.5	34.676	34.5
36	2.0	34.21	34.0
36	3.0	33.252	33.0
38	1.5	36.676	36.5
39	1.5	37.676	37.5
39	2.0	37.21	37.0
39	3.0	36.252	36.0
40	1.5	38.676	38.5
40	2.0	38.21	38.0
40	3.0	37.252	37.0
42	1.5	40.676	40.5
42	2.0	40.21	40.0
42	3.0	39.252	39.0
45	1.5	43.676	43.5
45	2.0	43.21	43.0
45	3.0	42.252	42.0
48	1.5	46.676	46.5
48	2.0	46.21	46.0
48	3.0	45.252	45.0
50	1.5	48.676	48.5
50	2.0	48.21	48.0
50	3.0	47.252	47.0
52	1.5	50.676	50.5
52	2.0	50.21	50.0
52	3.0	49.252	49.0

GENERAL INFORMATION

Tapping drill sizes for UNC and UNF threads.

Unified Coarse threads			
UNC	TPI	Maximun core dia. mm	Drill size mm.
No.1	64	1.585	1.5
No.2	56	1.872	1.8
No.3	48	2.146	2.1
No.4	40	2.385	2.3
No.5	40	2.697	2.6
No.6	32	2.896	2.85
No.8	32	3.528	3.6
No.10	24	3.95	3.9
No.12	24	4.59	4.5
1/4	20	5.25	5.2
5/16	18	6.68	6.6
3/8	16	8.082	8.0
7/16	14	9.441	9.4
1/2	13	10.881	10.75
9/16	12	12.301	12.25
5/8	11	13.693	13.5
3/4	10	16.624	16.5
7/8	9	19.520	19.5
1	8	22.344	22.25
1.1/8	7	25.082	25.0
1.1/4	7	28.258	28.25
1.3/8	6	30.851	30.75
1.1/2	6	34.026	34.0
1.3/4	5	39.560	39.5
2	4.5	45.367	45.25

Unified Fine threads			
UNF	TPI	Maximun core dia. mm	Drill size mm.
No.0	80	1.306	1.3
No.1	72	1.613	1.6
No.2	64	1.913	1.9
No.3	56	2.197	2.1
No.4	48	2.459	2.4
No.5	44	2.741	2.7
No.6	40	3.012	3.0
No.8	36	3.597	3.5
No.10	32	4.168	4.1
No.12	28	4.717	4.7
1/4	28	5.563	5.5
5/16	24	6.995	6.9
3/8	24	8.565	8.5
7/16	20	9.947	9.9
1/2	20	11.524	11.5
9/16	18	12.969	12.9
5/8	18	14.554	14.5
3/4	16	17.546	17.5
7/8	14	20.493	20.5
1	12	13.363	23.25
1.1/8	12	26.538	26.5
1.1/4	12	29.713	29.5
1.3/8	12	32.888	32.7
1.1/2	12	36.063	36.0

GENERAL INFORMATION

Tapping drill sizes for BSP and BSW threads.

Whitworth Pipe threads			
BSP	TPI	Maximun core dia. mm	Drill size mm.
1/8	28	8.848	8.8
1/4	19	11.89	11.8
3/8	19	15.395	15.25
1/2	14	19.172	19.0
5/8	14	21.128	21.0
3/4	14	24.658	24.5
7/8	14	28.418	28.25
1	11	30.931	30.75
1.1/8	11	35.589	35.5
1.1/4	11	39.592	39.5
1.3/8	11	42.005	42.0
1.1/2	11	45.485	45.2
1.5/8	11	49.67	49.6
1.3/4	11	51.428	51.4
2	11	57.396	57.2
2.1/4	11	63.392	63.3
2.3/8	11	67.08	67.0
2.1/2	11	72.866	72.8
2.3/4	11	79.216	79.1
3	11	85.566	85.5
3.1/4	11	91.662	91.5
3.1/2	11	98.012	98.0
3.3/4	11	104.362	104.0
4	11	110.712	110.5

Whitworth threads			
BSW	TPI	Maximun core dia. mm	Drill size mm.
3/32	48	1.91	1.8
1/8	40	2.59	2.5
5/32	32	3.211	3.1
3/16	24	3.743	3.6
7/32	24	4.538	4.4
1/4	20	5.224	5.4
5/16	18	6.661	6.5
3/8	16	8.052	7.9
7/16	14	9.379	9.3
1/2	12	10.61	10.5
9/16	12	12.176	12.0
5/8	11	13.598	13.5
3/4	10	16.538	16.5
7/8	9	19.411	19.25
1	8	22.185	22.0
1.1/8	7	24.879	24.75
1.1/4	7	28.054	27.75
1.3/8	6	30.555	30.5
1.1/2	6	33.73	33.5
1.5/8	5	35.921	35.5
1.3/4	5	39.096	39.0
1.7/8	4.5	41.648	41.5
2	4.5	44.823	44.5
2.1/4	4	50.42	50.0
2.1/2	4	56.77	56.5
2.3/4	3.5	62.108	62.0
3	3.5	68.459	68.5

Nominal dimensions UNI 4535-64
Production tolerances on tap flank diameter for ISO 6H Nut threads
Limit dimensions - Nut threads ISO 6H

Metric coarse pitch threads

Dimensions in mm

$H = 0.86603P$

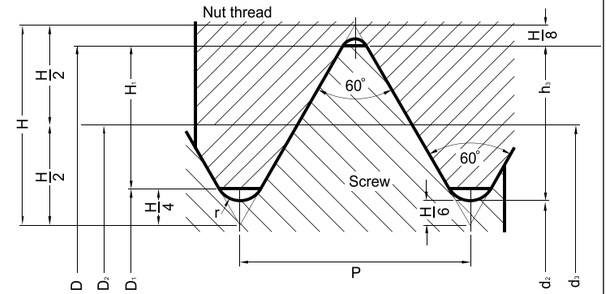
$H_1 = \frac{5}{8}H = 0.54127P$

$h_3 = \frac{17}{24}H = 0.61343P$

$d_2 = D_2 = d - \frac{3}{4}H = d - 0.64952P$

$d_3 = d - 2h_3 = d - 122687P$

$r = \frac{H}{6} = 0.14434P$



Nominal diameter d = D	Pitch P	Flank diameter $d_2 = D_2$	Minor diameter Screw d_3	Minor diameter Nut D_1	Thread depth Screw h_3	Thread depth Nut H_1	Radius r	Flank diameter Tap tolerance 6H d2 min.	Flank diameter Tap tolerance 6H d2 max.	Flank diameter Nut tolerance 6H min.	Flank diameter Nut tolerance 6H max.
M 1,6	0,35	1,373	1,171	1,221	0,215	0,189	0,051	1,393	1,407	1,373	1,458
M 1,8	0,35	1,573	1,371	1,421	0,215	0,189	0,051	1,593	1,607	1,573	1,658
M 2	0,4	1,740	1,509	1,567	0,245	0,217	0,058	1,761	1,776	1,740	1,830
M 2,2	0,45	1,908	1,648	1,713	0,276	0,244	0,065	1,931	1,946	1,908	2,003
M 2,5	0,45	2,208	1,948	2,013	0,276	0,244	0,065	2,231	2,246	2,208	2,303
M 3	0,5	2,675	2,387	2,459	0,307	0,271	0,072	2,699	2,715	2,675	2,775
M 3,5	0,6	3,110	2,764	2,850	0,368	0,325	0,087	3,137	3,155	3,110	3,222
M 4	0,7	3,545	3,141	3,242	0,429	0,379	0,101	3,574	3,593	3,545	3,663
M 4,5	0,75	4,013	3,580	3,688	0,460	0,406	0,108	4,042	4,061	4,013	4,131
M 5	0,8	4,480	4,019	4,134	0,491	0,433	0,115	4,510	4,530	4,480	4,605
M 6	1	5,350	4,773	4,917	0,613	0,541	0,144	5,385	5,409	5,350	5,500
M 7	1	6,350	5,773	5,917	0,613	0,541	0,144	6,385	6,409	6,350	6,500
M 8	1,25	7,188	6,466	6,647	0,767	0,677	0,180	7,226	7,251	7,188	7,348
M 9	1,25	8,188	7,466	7,647	0,767	0,677	0,180	8,226	8,251	8,188	8,348
M 10	1,5	9,026	8,160	8,376	0,920	0,812	0,217	9,068	9,096	9,026	9,206
M 11	1,5	10,026	9,160	9,376	0,920	0,812	0,217	10,068	10,096	10,026	10,206
M 12	1,75	10,863	9,853	10,106	1,074	0,947	0,253	10,911	10,943	10,863	11,063
M 14	2	12,701	11,546	11,835	1,227	1,083	0,289	12,752	12,786	12,701	12,913
M 16	2	14,701	13,546	13,835	1,227	1,083	0,289	14,752	14,786	14,701	14,913
M 18	2,5	16,376	14,933	15,294	1,534	1,353	0,361	16,430	16,466	16,376	16,600
M 20	2,5	18,376	16,933	17,294	1,534	1,353	0,361	18,430	18,466	18,376	18,600
M 22	2,5	20,376	18,933	19,294	1,534	1,353	0,361	20,430	20,466	20,376	20,600
M 24	3	22,051	20,319	20,752	1,840	1,624	0,433	22,115	22,157	22,051	22,316
M 27	3	25,051	23,319	23,752	1,840	1,624	0,433	25,115	25,157	25,051	25,316
M 30	3,5	27,727	25,706	26,211	2,147	1,894	0,505	27,794	27,839	27,727	28,007
M 33	3,5	30,727	28,706	29,211	2,147	1,894	0,505	30,794	30,839	30,727	31,007
M 36	4	33,402	31,093	31,670	2,454	2,165	0,577	33,473	33,520	33,402	33,702
M 39	4	36,402	34,093	34,670	2,454	2,165	0,577	36,473	36,520	36,402	36,702
M 42	4,5	39,077	36,479	37,129	2,760	2,436	0,650	39,152	39,202	39,077	39,392
M 45	4,5	42,077	39,479	40,129	2,760	2,436	0,650	42,152	42,202	42,077	42,392
M 48	5	44,752	41,866	**42,587**	**3,067**	2,706	0,722	44,832	44,885	44,752	45,087
M 52	5	48,752	45,866	46,587	3,067	2,706	0,722	48,832	48,885	48,752	49,087
M 56	5,5	52,428	49,252	50,046	3,374	2,977	0,794	52,512	52,568	52,428	52,783
M 60	5,5	56,428	53,252	54,046	3,374	2,977	0,794	56,512	56,568	56,428	56,783
M 64	6	60,103	56,639	57,505	3,681	3,248	0,866	60,193	60,253	60,103	60,478
M 68	6	64,103	60,639	61,505	3,681	3,248	0,866	64,193	64,253	64,103	64,478
METRIC THREAD MA(OLD UNI 159 PROFILE)											**NUT TOLERANCE SH8**
M 1,7	0,35	1,473	1,246	1,246	0,227	0,227	0,040	1,493	1,507	1,473	1,529
M 2,3	0,4	2,040	1,780	1,780	0,260	0,260	0,040	2,061	2,076	2,040	2,120
M 2,6	0,45	2,308	2,016	2,016	0,292	0,292	0,050	2,331	2,346	2,308	2,388

TROUBLESHOOTING

Trouble	Causes	Solutions
Tapped hole oversize	Incorrect tap in use (cutting geometry unsuitable for application)	Use tap selected from the relevant material group
	Faulty alignment	Ensure that the tap is correctly aligned with the core hole axis
	Cold welding	Improve lubrication and direction of coolant Adjust cutting speed
	Re-ground tap (lead-in is not concentric)	Regrind tap lead correctly on a suitable tap grinding machine

Trouble	Causes	Solutions
Stripped threads	Incorrect tap in use (cutting geometry incorrect for application	Use a tap from the relevant material group.
	Spindle speed and feed rate not synchronized	Check feed rate programming and / or pitch of leading spindle Use a tapping spindle with axial float
	Insufficient start pressure exerted on tap with peel-cut	Increase start pressure

Trouble	Causes	Solutions
Bell mouthed tapped hole	Incorrect start pressure applied to tap	Use a tapping spindle with axial float

Trouble	Causes	Solutions
Unsatisfactory thread surface finish	Incorrect tap in use (Cutting geometry unsuitable for application)	Select tap from the relevant material group
	The tap is blunt	Replace or re-grind tap
	Tap badly re-ground	Re-grind tap again. Check that cutting geometry is suitable for material
	Coolant lacking in lubricating qualities and / or quantity	Ensure the use of a suitable coolant and an adequate supply

TECHNICAL DATA

TROUBLESHOOTING

Trouble	Causes	Solutions
Partial chipping of tap	Swarf jamming	Check cutting speed Use alternative tap type
	Tap has jammed against bottom of core hole	Check hole and thread depths Drill core hole deeper
	Tap incorrectly re-ground (lead-in diameter too small therefore too few cutting teeth)	Ensure that original values ore maintained when regrinding
	Irregular workpiece material structure	Adjust cutting speed Improve lubricating quality of coolant

Trouble	Causes	Solutions
Excessive tap wear	Incorrect cutting speed	Adjust cutting speed to suit workpiece material
	Coolant lacking in lubricating qualities and / or quantity	Ensure the use of a suitable coolant and an ample supply Check that coolant is reaching the cutting zone
	Surface of the core hole is compacted	Check core hole drilling conditions (drill carefully to reduce risk of surface compacting) Check drill cutting edges

Trouble	Causes	Solutions
Tap breakage	Incorrect tap in use (cutting geometry unsuitable for application)	Use tap from the relevant material group
	Centering error	Ensure that axes of tap and core hole are aligned
	Blunt tap	Re-grind tap Ensure that taps are stored carefully
	Tap has reached bottom of core hole	Use tapping spindle with axial float and slipping clutch
	Core hole too small	Select correct size tapping drill

MATERIAL CHART

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	GERMANY		FRANCE AFNOR	GREAT BRITAIN B.S.	EN & OTHER CLASSIFICATIONS	U.S.A. AISI
	W.Nr	DIN				
10 STEEL **P**	**11. Magnetic soft steels - Hardness < 120 HB 30 - Tensile strength < 400 N/mm²**					
	1.1013	RFe 100		OSOA12	EN2	
	1.1014	RFe 80				
	1.1015	RFe 60		230Mo7	EN1	
	1.0718	9 S MnPb 28				
	12. Structural steels - Hardness < 200 HB 30 - Tensile strength < 700 N/mm²					
	12.1 - Structural steels					
	1.0034	RSt 34-2	A34-2 EN	1449 34/20 HR		
	1.0035	St 33	A33	Fe 310-0		
	1.0036	St 37-2		060A35	EN3A,4,5,6,7,8	
	1.0037	RSt 37-2			EN3B	
	1.0044	St 44-2				
	1.0050	St 50-2		4360-50B	EN 207	
	1.0060	St 60-2				
	1.0070	St 70-2				
	1.0116	St 37-3				
	1.0144	St 44-3				
	12.2 - Case carburizing steels					
	1.0301	C 10	AF 34 C 10	040 A 10		M 1010
	1.0401	C 15	AF 37 C 12	080 A 15		M 1015
	1.1121	Ck 10	XC 10	040 A 10		1010
	1.1141	Ck 15	XC 12	040 A 15		1015
	1.5732	14 Ni Cr 10	14 NC 11			3415
	1.7015	15 Cr 3	12 C 3	523 M 15		5015
	1.7131	16 Mn Cr 5	16 MC 4	527 M 17	EN 32	5115
	1.7147	20 Mn Cr 5	20 MC 5			5120
	12.3 - Free machining steels					
	1.0710	15 S 10				
	1.0715	9 S Mn 28	S 250	230 M 07		1213
	1.0718	9 S Mn Pb 28	S 250 Pb			12 L 13
	1.0721	10 S 20	10 F1	210 M 15		1108 1109
	1.0722	10 S Pb 20	10 Pb F 2			11 L 08
	1.0723	15 S 20		210 A 15		
	1.0726	35 S 20	35 MF 6	212 M 36		1140
	1.0727	45 S 20	45 MF 4			1146
	1.0736	9 S Mn 36	S 300			1215
	1.0737	9 S Mn Pb 36	S 300 P			12 L 14
	12.4 - Cast structural steels					
	1.0416	GS - 38				
	1.0446	GS - 45				
	1.0552	GS - 52				
	1.0553	GS - 60	E 36 - 3			
	1.0554	GS - 70				
	13. Plain carbon steels - tempered					
	13.1 - Steels, tempered - Hardness < 250 HB 30 - Tensile strength < 850 N/mm²					
	1.0402	C 22	1 C 22	070 M 20		M 1023
	1.0501	C 35	1 C 35	080 A 32		1035
	1.0503	C 45	1 C 45	060 A 47		1045
	1.0535	C 55	1 C 55	070 M 55		1055
	1.0601	C 60	1 C 60	060 A 62	EN 43	1060
	1.1157	40 Mn 4	35 M 5	150 M 36		1035 1041
	1.1151	Ck 22	2 C 22	055 M 15		1020 1023
	1.1181	Ck 35	2 C 35	080 A 35		1035 1038
	1.1191	Ck 45	2 C 45	080 M 46	EN 9, 10	1045
	1.1203	Ck 55	2 C 55	060 A 57		1055
	1.1221	Ck 60	2 C 60	060 A 62		1060 1064

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	W.Nr	DIN				
10 STEEL **P**	**14. Alloy steels - Hardness < 250 HB 30, < 25 HRC - Tensile strength < 850 N/mm²**					
	14.1 - Cold work tool steels					
	1.2056	90 Cr 3				
	1.2067	100 Cr 6	Y 100 C 6	BL 3		L 1 L 3
	1.2080	X 210 Cr 12	Z 200 C 12	BD 3		D3
	1.2083	X 42 Cr 13	Z 40 C 14			420
	1.2363	X 100 CrMoV5 1	Z 100 CDV 5	BA 2		A 2
	1.2379	X 155 CrVMo 12 1	Z 160 CDV 12	BD 2		D 2
	1.2510	100 MnCrW 4	90 MWCV 5	BO 1		O1
	1.2550	60 WCrV 7	55WC 20	BS 1		S1
	1.2823	70 Si 7				
	1.2826	60 Mn Si Cr 4				
	1.2842	90 MnCrV 8	90 MV 8	BO 2		O 2
	14.2 - High speed steels					
	1.3202	S 12-4-4-5	Z 130 WKCV 12-05-04-04	BT 15		T 15
	1.3207	S 10-4-3-10	Z130 WKCDV10-10-04-04-03	BT 42		T 42
	1.3243	S 6-5-2-5	Z85 WDKCV 06-05-05-04-02	BM 35		M 35
	1.3247	S 2-10-1-8	Z110 DKCWV 09-08-04-02-01	BM 42		M 42
	1.3343	S 6-5-2	Z 85 WDCV 06-05-04-02	BM 2		M 2
	1.3344	S 6-5-3	Z 120 WDCV 06-05-04-03			M 3 / 2
	1.3348	S 2-9-2	Z 100 DCWV 09-04-02-02			M 7
	ASP 23	(S 6-5-3)				
	ASP 30					
	ASP 60					
	14.3 - Tempered steels					
	1.0503	C 45	1 C 45	060 A 47		1045
	1.7220	34 Cr Mo 4	34 Cr Mo 4	708 A 37		4135, 4137
	1.7225	42 Cr Mo 4	42 CD 4	708 A 42	EN 16, 17, 19	4140, 4142
	1.7228	50 Cr Mo 4	50 Cr Mo 4	708 A 47		4150
	14.4 - Nitriding steels					
	1.7779	20 Cr Mo V 13.5				
	1.8504	34 Cr Al 6				
	1.8506	34 Cr Al S 5				
	1.8507	34 Cr Al Mo 5	30 CAD 6.12			A 355 Cl.D
	1.8509	41 Cr Al Mo 7	40 CAD 6.12	905 M 39		A 355 Cl.A
	1.8515	31 Cr Mo 12	30 CD 12	722 M 24		
10 HARDENED STEEL **H**	**15. Alloy steels / Tempered steels - Hardness 250-350 HB 30, 25-38 HRC - Tensile strength 850-1,200 N/mm²**					
	15.1 - Alloy steels for tools					
	1.2311	40 Cr Mn Mo 7				
	1.2312	40 Cr Mn Mo S 86				
	1.2436	X 210 Cr W 12	Z 200 CW 12			
	1.2711	54 Ni Cr Mo V 6				
	1.2713	55 Ni Cr Mo V 6	55 NCDV 7	826 M 40	S 95, S 97, S 98	L 6
	1.2714	56 Ni Cr Mo V 7				
	1.2743	60 Ni Cr Mo V 12 4				
	1.2766	35 Ni Cr Mo 16				
	15.2 - Alloy steels for hot work					
	1.2343	X 38 Cr Mo V 5 1	Z 38 CDV 5	BH 11		H 11
	1.2344	X 40 Cr Mo V 5 1	Z 40 CDV 5	BH 13		H 13
	1.2365	X 32 Cr Mo V 3 3	32 DCV 28	BH 10		H 10
	1.2367	X 40 Cr Mo V 5 3	Z 38 CDV 5.3			
	1.2581	X 30 W Cr V 9 3	Z 30 WCV 9.3	BH 21		H 21
	1.2622	X 60 W Cr Mo V 9				
	1.2678	X 45 CoCrWV 5 5 5				
	1.2550	60 WCr V 7	55 WC 20	BS 1		S 1
	1.2567	X 30 W Cr V 5 3	Z 32 WCV 5			

TECHNICAL DATA

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	W.Nr	DIN				
10 HARDENED STEEL **H**	15.3 -Hardened tempered steels - Hardness may differ according to presentation and dimensions of material					
	1.5864	35 Ni Cr 18				
	1.6580	30 Cr Ni Mo 8	30 Cr Ni Mo 8		S99	
	1.7361	32 Cr Mo 12	30 CD 12	722 M 24		
	1.7707	30 Cr Mo V 9				
	1.8161	58 Cr V 4				
	15.4 - Nitriding steels					
	1.8515	31 Cr Mo 12	30 CD 12	722 M 24		
	1.8519	31 Cr Mo V 9		830 M 31		
	1.8523	39 Cr Mo V 13 9		897 M 39		
	1.8550	34 Cr Al Ni 7		826 M 40		
	16. Alloy steels / Hardened tempered steels - Hardness > 38 HRC - Tensile strength > 1,200 N/mm² To this group belong most of the materials of group 15, but present a higher tensile strength					
	1.2713	100 Mn Cr W 12			Hardox 400	M42
	1.3247	X 210 Cr 12			Hardox 500	4140
	1.2080				Hardox 600	8130
	1.3343				P20	
20 STAINLESS STEEL **M**	**21. Free machining stainless steels - Hardness < 250 HB 30 - Tensile strength < 850 N/mm²**					
	1.4104	X 12 Cr Mo S 17	Z 13 CF 17	416 S 37	EN 56	430 F
	1.4305	X 10 Cr Ni S 18 09	Z 8 CNF 18-09	303 S 21	EN 60	303
	22. Austenitic stainless steels - Hardness < 250 HB 30 - Tensile strength < 850 N/mm²					
	1.4300	X 12 Cr Ni 18 8		320 S 12		
	1.4301	X 5 Cr Ni 18 10	Z 6 CN 18-09	304 S 15	EN 80, EN 58 + C	304
	1.4311	X 2 CrNiN 18 10	Z 3 CN 18-07 Az	304 S 61		304 LN
	1.4406	X 2 CrNiMoN 17 12 2	Z 3 CND 17 11 02	316 S 61		316 LN
	1.4433	X 2 CrNiMo 18 15		316 S		
	1.4435	X 2 CrNiMo 18 14 3	Z3 CND 17-12-03	316 S 11		316 L
	1.4539	X 1 CrNiMoCu 25 20 5	Z 1 NCDU 25-20	321 S 17		UNS N08904
	1.4541	X 6 CrNiTi 18 10	Z 6 CNT 18 10	321 S 18	EN 58 J, 316	321
	1.4571	X 6 CrNiMoTi 17 12 2	Z 6 CNDT 17 12	320 S 18		316 Ti
	1.4573	X 10 CrNiMoTi 18 12		320 S 33		
	1.4828	X 15 CrNiSi 20 12	Z 15 CNS 20-12	309 S 24		309
	22.1 - Cast austenitic stainless steels					
	1.4308	G-X 6 CrNi 18 9	Z 6 CN 18.10 M	304 C 15(LT196)		CF-8
	1.4313	G-X 5 CrNi 13 4	Z 8 CD 17-01	425 C 12		CA 6 -NM
	1.4408	G-X 6 CrNiMo 18 10		316 C 16(LT196)		CF-8M
	1.4581	G-X 5 CrNiMoNb 18 10	Z 4 CNDNb 18.12M	318 C 17		
	23. Martensitic stainless steels - Hardness < 320 HB 30 - Tensile strength < 1,100 N/mm²					
	1.4021	X 20 Cr 13	Z 20 C 13	420 S 37		420
	1.4034	X 46 Cr 13	Z 44 C 14	(420 S 45)		
	1.4057	X 20 CrNi 17 2	Z 15 CN 16-02	431 S 29		431
	1.4112	X 90 CrMoV 18				
	1.4116	X 45 CrMoV 15			EN 58, b.e.j.t	
	1.4125	X 105 CrMo 17	Z 100 CD 17		Duplex alloys	440 C
	1.4718	X 45 CrSi 9 3	Z 45 CS 9	401 S 45		HNV 3
	1.4747	X 80 CrNiSi 20	Z 80 CSN 20-02	443 S 65		HNV 6
	1.4086	G-X 120 Cr 29				
	1.4106	G-X 10 CrMo 13				
	1.4138	G-X 120 CrMo 29 2				
	23.1 Ferritic stainless steels - Hardness < 320 HB 30 - Tensile strength < 1,100 N/mm²					
	1.4002	X 6 Cr Al 13	Z 8 CA 12	405 S 17		405
	1.4006	X 10 Cr 13	Z 10 C 13	410 C 21	Super Duplex	410
	1.4016	X 6 Cr 17	Z 8 C 17	430 S 17		430
	1.4510	X 6 Cr Ti 17	Z 8 CT 17			430 Ti
	1.4512	X 6 Cr Ti 12	Z 6 CT 12	409 S 19		409
	23.2 Ferritic-Austenitic stainless steels - Hardness < 320 HB 30 - Tensile strength < 1,100 N/mm²					
	1.4460	X 8 CrNiMo 27 5	Z 5 CND 27-05 Az			329
	1.4582	X 4 CrNiMoNb 25 7				
	1.4821	X 20 CrNiSi 25 4				17-4PH

TECHNICAL DATA

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	W.Nr	DIN				
30 CAST IRON **K**	**31. Grey graphite cast irons - Hardness < 150 HB 30 - Tensile strength < 500 N/mm²**					
	0.6010	GG-10	Ft 10 D			A 48-20 B
	0.6015	GG-15	Ft 20 D	Grade 150	Grey cast iron soft	A 48-25 B
	0.6020	GG-20	Ft 25 D	Grade 220		A 48-30 B
	0.6025	GG-25	Ft 30 D	Grade 260		A 48-40 B
	0.6030	GG-30	Ft 30 D	Grade 300		A 48-45 B
	0.6035	GG-35	Ft 35 D	Grade 350		A 48-50 B
	0.6040	GG-40	Ft 40 D	Grade 400		A 48-60 B
	31.1 - Meehanite - Hardness < 150 HB 30 - Tensile strength < 500 N/mm²					
		GF - 150				
		GD - 260				
	32. Grey graphite cast irons - Hardness 150 - 300 HB 30 - Tensile strength 500 - 1,000 N/mm²					
	0.6020	GG - 20	Ft 25 D	Grade 220	Grey cast iron hard	A 48-30 B
	0.6025	GG - 25	Ft 30 D	Grade 260		A 48-40 B
	0.6030	GG - 30	Ft 30 D	Grade 300		A 48-45 B
	0.6035	GG - 35	Ft 35 D	Grade 350		A 48-50 B
	0.6040	GG - 40	Ft 40 D	Grade 400		A 48-60 B
	32.1 - Meehanite - Hardness 150-300 HB 30 - Tensile strength 500-1,000 N/mm²					
		GF - 150				
		GD - 260				
	33. Nodular graphite, malleable cast irons - Hardness < 200 HB 30 - Tensile strength < 700 N/mm²					
	0.7033	GGG-35.3				
	0.7040	GGG-40	FGS 400-12	420 / 12		60-40-18
	0.7043	GGG-40.3	FGS 370-17	370 / 17		
	0.7050	GGG-50	FGS 500-7	500 / 7		
	0.7060	GGG-60	FGS 600-3	600 / 3	S.G.iron, Meehanite	65-45-12
	0.8035	GTW-35		700/2,30g/72	Black & White Heart	80-55-06
	0.8040	GTW-40				
	0.8045	GTW-45				
	0.8065	GTW-65				
	0.8135	GTS-35				
	0.8145	GTS-45				
	0.8155	GTS-55				
	0.8165	GTS-65				
	33.1 - Meehanite - Hardness < 200 HB 30 -Tensile strength < 700 N/mm²					
		SF 400				
		SPF 600				
	34. Nodular graphite, tempered malleable cast irons - Hardness 200-300 HB 30 - Tensile strength 700-1,000 N/mm² Also materials from Group 33 tempered					
	0.7070	GGG-70	FGS 700-2	700 / 2	S.G.iron,Meehanite	100-70-03
	0.7080	GGG-80	FGS 800-2	800 / 2	Black & White Heart	120-90-02
	34.1 - Meehanite - Hardness 200-300 HB 30 - Tensile strength 700-1,000 N/mm²					
		SH 800		420/12, P 440/7		
		SH 1000				
40 TITANIUM **S**	**41. Titanium, unalloyed - Hardness < 200 HB 30 - Tensile strength < 700 N/mm²**					
	3.7024.1LN	Ti 99.5				
	3.7034.1LN	Ti 99.7				
	3.7035	Ti 2				
	3.7055	Ti 99.4		TA 1-9	Ti 99,0	
	3.7064.1LN	Ti 99.2				
	3.7065	Ti 4				
	3.7255	Ti 3 Pd				
	42. Titanium alloys - Hardness < 270 HB 30 - Tensile strength < 900 N/mm²					
		Ti4Al4 Mn				
	3.7144 LN	Ti5Al2Sn				
	3.7124 LN	Ti2Cu		TA 10-14, TA 17	Ti - 2AL	
	3.7164 LN	Ti6Al4V		TA 18		
	3.7174 LN	Ti6Al6V2Sn				
		Ti6Al2Sn4Zr2Mo				
		Ti4Al4Mo2Sn0.5Si				

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	W.Nr	DIN				
40 TITANIUM **S**	**43. Titanium alloys - Hardness 270-300 HB 30 - Tensile strength 900-1,300 N/mm²**					
		Ti10Al2Fe3Al				
		Ti5Al5V5Mo3Cr			Ti AL	
		Ti7Al4Mo		TA 10-13, TA 28		
		Ti3Al8V6Cr4Zr4Mo				
		Ti6Al6V6Sn				
		Ti15V3Cr3Sn3Al				
50 NICKEL ALLOYS **S**	**51. Nickel, unalloyed - Hardness < 150 HB 30 - Tensile strength < 500 N/mm²**					
	2.1504 LN	Ni Al Bz				
	2.4042	Ni 99 CSi		NA 11, NA 12	Nickel 200	
	2.4060	Ni 99.6			Nickel 270	
	2.4062	Ni 99.4 Fe				
	52. Heat resisting nickel alloys - Hardness < 270 HB 30 - Tensile strength < 900 N/mm²					
	2.4360 LN	Monel 400				
	2.4374 LN	Monel 500				
	2.4617	Hastelloy B 2			Nimonic 75	
	2.4665	Hastelloy X		HR 203		
	2.4812	Hastelloy C		3027-76	Hastelloy C	
	2.4816	Inconel 600, 617, 625			Haynes Alloys 263	
	1.4876	Incoloy 800, 825				
	2.4983	Udimet 500				
	53. Heat resisting nickel alloys - Hardness 270-410 HB 30 - Tensile strength 900-1,400 N/mm²					
	2.4631	Nimonic 80 A			Nimonic 80	
	2.4632	Nimonic 90				
	2.4634	Nimonic 105				
	2.4662	Nimonic 901		HR 8		
	2.4668	Inconel 718		HR 401, 601	Rene 41	
	2.4669	Inconel 750-X				
	2.4670 LN	Nimocast 713			Incoloy 925	
	2.4674 LN	Nimocast PK 24				
	2.4856	Inconel 625			Monel K-500	
	2.6554 LN	Waspaloy				
60 COPPER **N**	**61. Copper, unalloyed - Hardness < 100 HB 30 - Tensile strength < 350 N/mm²**					
	2.0060	E - Cu 57				
	2.0070	SE - Cu			Commerially Pure	
	2.0090	SF - Cu		C 101		
	2.1356	Cu Mn 3				
	2.1522	Cu Si 2 Mn				
	62. Short chip copper alloys - Hardness < 200 HB 30 - Tensile strength < 700 N/mm²					
	62.1 - Brass					
	2.0360	Cu Zn 40(MS 60)				
	2.0380	Cu Zn 39 Pb 2 (MS 58)		CZ120, CZ109		
	2.0410	Cu Zn 44 Pb 2		PB104		
	2.0561	Cu Zn 40 Al 1			2.1030, 2.1080	
	2.0580	Cu Zn 40 Mn 1 Pb				
	2.0771	Cu Ni 7 Zn 39 Mn 5 Pb3				
	62.2 - Bronzes					
	2.1086	G-Cu Sn 10 Zn				
	2.1093	G-Cu Sn 6 Zn Ni				
	2.1096	G-Cu Sn 5 Zn Pb				
	63. Long chip copper alloys - Hardness < 200 HB 30 - Tensile strength < 700 N/mm²					
	63.1 - Brass					
	2.0250	Cu Zn 20				
	2.0265	Cu Zn 30				
	2.0321	Cu Zn 37		CZ108, CZ106		
	2.0335	Cu Zn 36 (Ms 63)				

MATERIAL CHART

Please note: These charts are not cross-reference charts.
Materials are grouped according to machinability and are not necessarily identical in chemical composition.

ISO GROUP	STANDARDS					
	GERMANY		FRANCE AFNOR	GREAT BRITAIN B.S.	EN & OTHER CLASSIFICATIONS	U.S.A. AISI
	W.Nr	DIN				
60 COPPER **N**	63.2 - Bronzes					
	2.1020	Cu Sn 6				
	2.1030	Cu Sn 8				
	2.1080	Cu Sn 6 Zn 6				
	63.3 - Copper alloys tempered by forging					
	2.1245	Cu Be 1.7				
	2.1247	Cu Be 2				
	2.1293	Cu Cr Zr				
	64. Cu - Al - Fe alloys Hardness < 440 HB 30 - Tensile strength < 1,500 N/mm²					
	64.1 - Ampco					
		Ampco 18			Ampco 18	
		Ampco 20		AB 1 type		
		Ampco 25			Ampco 26	
70 ALUMINIUM **N**	**71. Aluminium - Magnesium, unalloyed - Hardness < 100 HB 30 - Tensile strength < 350 N/mm²**					
	3.0250	Al 99.5 H		LM0, 1B		
	3.0280	Al 99.8 H				
	3.0305	Al 99.9				
	3.3308	Al 99.9 Mg 0.5				
	72. Aluminium alloys, Si < 0.5% - Hardness < 180 HB 30 - Tensile strength < 600 N/mm²					
	72.1 - Forging aluminium alloys					
	3.0515	Al Mn 1		LM5, 10, 12		
	3.0516	S-Al Mn				
	3.0525	Al Mn 1 Mg 0.5			6061	
	3.0615	Al Mg Si Pb				
	3.1325	Al Cu Mg 1				
	3.1355	Al Cu Mg 2				
	3.3315	Al Mg 1				
	3.3535	Al Mg 3				
	3.4365	Al Zn Mg Cu 1.5				
	72.2 - Cast aluminium alloys					
	3.1841	G - Al Cu 4 Ti				
	3.3241	G - Al Mg 3 Si				
	3.3292	GD - Al Mg 9				
	73. Aluminium alloys, 0.5-10% Si - Hardness < 180 HB 30 - Tensile strength < 600 N/mm²					
	73.1 - Cast aluminium alloys					
	3.2134	G - AL SI 5 CU 1 MG		LM2, 4	6063	
	3.2152	GD - Al Si 6 Cu 4		LM16, 18, 21	6082	
	3.2162	GD - AL SI 8 CU 3		LM22, 24, 25		
	3.2373	G - AL SI 9 MG		LM26, 27		
	74. Aluminium alloys, Si > 10% - Hardnes < 180 HB 30 - Tensile strength < 600 N/mm²					
	74.1 - Cast aluminium alloys					
	3.2381	G - AL SI 10 MG		LM6,12,13		
	3.2383	G - AL SI 10 MG (CU)		LM20,28		
	3.2581	G - AL SI 12		LM29, 30		
	3.2583	G - AL SI 12 (CU)				
	3.2982	GD - AL SI 12 (CU)				
	74.2 - Cast aluminium - magnesium alloys					
	3.5106	G - MG AG 3 SE 2 ZR 1				
	3.5662	G - MG AL 6				
	3.5812	G - MG AL 8 ZN 1				
	3.5912	G - MG AL 9 ZN 1				
80 SYNTHETIC MATERIAL **O**	**81. Thermoplastics**					
				Nylon		Nylon
				PVC Cellulose		PVC
				Acetate	Acetal	
	82. Thermosetting Plastics					
				Tufnol		
				Bakelite		Bakelite
	83. Reinforced Plastics					
				CFRP, GFRP		
				Printed Circuit Board		
				Kevlar		Kevlar

TECHNICAL DATA