

MAPAL machining groups

Code letter according to DIN ISO 513	MAPAL machining groups (MMG)	Workpiece material groups				
		Main workpiece material groups and machining groups				
		Workpiece material	Structure, composition	Condition	Tensile strength	Hardness
R _m (N/mm²)	HB					
P	P1-1	Unalloyed steel	≤ 0.15% C	Annealed	420	125
	P1-2	Unalloyed steel	≤ 0.45% C	Annealed	650	190
	P1-3	Unalloyed steel	≤ 0.45% C	Quenched and tempered	850	250
	P1-4	Unalloyed steel	≤ 0.75% C	Annealed	900	270
	P1-5	Unalloyed steel	≤ 0.75% C	Quenched and tempered	1,000	300
	P2-1	Low-alloyed steel	-	Annealed	600	180
	P2-2	Low-alloyed steel	-	Quenched and tempered	930	275
	P2-3	Low-alloyed steel	-	Quenched and tempered	1,000	300
	P2-4	Low-alloyed steel	-	Quenched and tempered	1,200	350
	P3-1	High-alloyed steel and high-alloyed tool steel	-	Annealed	680	200
	P3-2	High-alloyed steel and high-alloyed tool steel	-	Quenched and tempered	1,100	325
	P3-3	High-alloyed steel and high-alloyed tool steel	-	Quenched and tempered	1,250	370
	P4-1	Bainitic steel, ultra-high-carbon steel	-	Bainitic quenched and tempered	1,650	480
	P5-1	Stainless steel	Ferritic / martensitic	Quenched and tempered	680	200
	P5-2	Stainless steel	Martensitic	Quenched and tempered	800	240
P5-3	Stainless steel	Martensitic	Precipitation-hardened	1,200	350	
M	M1-1	Stainless steel	Austenitic	Quenched	680	200
	M1-2	Stainless steel	Austenitic (super-austenitic)	Precipitation-hardened	1,010	300
	M2-1	Stainless steel	Austenitic / ferritic (duplex)	Solution-annealed	780	230
	M2-2	Stainless steel	Austenitic / ferritic (super-duplex)	Solution-annealed	780	230
	M3-1	Stainless steel	Heat-resistant austenitic steel	Cast	720	220
K	K1-1	Cast iron with lamellar graphite GJL	Pearlitic / ferritic	-	200	180
	K1-2	Cast iron with lamellar graphite GJL	Pearlitic	-	250	220
	K1-3	Cast iron with lamellar graphite GJL	Pearlitic	-	350	260
	K2-1	Cast iron with spheroidal graphite GJS	Ferritic	-	400	160
	K2-2	Cast iron with spheroidal graphite GJS	Ferritic / pearlitic	-	500	220
	K2-3	Cast iron with spheroidal graphite GJS	Pearlitic	-	700	250
	K2-4	Heat-treated spheroidal graphite ADI	Austenitic ferritic	-	1,400	480
	K3-1	Cast iron with vermicular graphite GJV	Ferritic	-	400	240
	K3-2	Cast iron with vermicular graphite GJV	Pearlitic	-	> 400	280
	K4-1	Malleable cast iron GJMW / GJMB	Ferritic	-	400	130
	K4-2	Malleable cast iron GJMW / GJMB	Pearlitic	-	600	230
	K5-1	Austenitic cast iron GJLA / GJSA	Lamellar graphite	-	210	190
K5-2	Austenitic cast iron GJLA / GJSA	Spheroidal graphite	-	420	180	
N	N1-1	Aluminium – wrought alloys	-	Not precipitation hardening	200	60
	N1-2	Aluminium – wrought alloys	-	Hardened	350	100
	N1-3	Aluminium – wrought alloys	-	Hardened	550	-
	N1-4	Aluminium – cast alloys	Si ≤ 7%	Not precipitation hardening	-	-
	N1-5	Aluminium – cast alloys	7% > Si ≤ 12%	Not precipitation hardening	260	75
	N1-6	Aluminium – cast alloys	7% > Si ≤ 12%	Hardened	310	90
	N1-7	Aluminium – cast alloys	Si > 12%	Heat-resistant	450	130
	N2-1	Copper and copper alloys	Pb > 1% (free-machining alloy)	-	390	110
	N2-2	Copper and copper alloys	CuSn (Bronze, electrolytic copper)	-	340	100
	N2-3	Copper and copper alloys	CuZn, CuSnZn (Brass, red bronze)	-	310	90
	N2-4	Copper and copper alloys	CuAl, CuNi (Special alloys)	-	> 400	-
	N3-1	Non-metallic workpiece materials	Graphite > 8 µm particle size	-	-	-
	N3-2	Non-metallic workpiece materials	Graphite ≤ 8µm particle size	-	-	-
	N4-1	Non-metallic workpiece materials	Thermoplastics	-	-	-
	N4-2	Non-metallic workpiece materials	Thermosets	-	-	-
	N4-3	Non-metallic workpiece materials	Foam materials	-	-	-
	N4-4	Non-metallic workpiece materials	Hard rubber	-	-	-
	N4-5	Non-metallic workpiece materials	Glass	-	-	-
	N5-1	Magnesium alloys	-	-	250	70
S	S1-1	Titanium, Ti alloys	Pure titanium & α alloys	-	680	200
	S2-1	Titanium, Ti alloys	α + β alloys	Hardened	1,260	375
	S2-2	Titanium, Ti alloys	β alloys	-	1,400	410
	S3-1	Nickel, nickel alloys	Unalloyed	-	450	130
	S3-2	Nickel, nickel alloys	Low-alloyed	-	600	230
	S4-1	High-temperature alloys, super alloys	Ni or Co basis	Annealed	840	250
	S4-2	High-temperature alloys, super alloys	Ni or Co basis	Hardened	1,180	350
H	H1-1	Hardened steel	-	Hardened and tempered	-	< 45 HRC
	H1-2	Hardened steel	-	Hardened and tempered	-	< 50 HRC
	H1-3	Hardened steel	-	Hardened and tempered	-	< 54 HRC
	H2-1	Hardened steel	-	Hardened and tempered	-	< 60 HRC
	H2-2	Hardened steel	-	Hardened and tempered	-	< 64 HRC
	H2-3	Hardened steel	-	Hardened and tempered	-	< 68 HRC
	H3-1	Wear-resistant cast iron / chill casting, GJN	Martensitic + carbide	-	-	< 55 HRC
	H3-2	Wear-resistant cast iron / chill casting, GJN	Martensitic + carbide	-	-	≥ 55 HRC
C*	C1-1	Plastic range	Reinforced with aramid fibre (AFK)	-	-	-
	C1-2	Plastic range	(Duroplastic), CFK/GFK	-	-	-
	C1-3	Plastic range	(Thermoplastic), CFK/GFK	-	-	-
	C2-1	Carbon range, reinforced with carbon fibre (CFC)	-	-	-	-
	C3-1	Metal matrix (MMC) and ceramics	-	-	-	-
	C4-1	Sandwich construction	Honeycomb core (honeycomb)	-	-	-
	C4-2	Sandwich construction	Foam core	-	-	-
	C5-1	Multilayer composite (stack)	Non-metallic non-ferrous metal composite	-	-	-
	C5-2	Multilayer composite (stack)	Non-metallic metal composite	-	-	-
	C5-3	Multilayer composite (stack)	Non-metallic non-metal composite	-	-	-
	C5-4	Multilayer composite (stack)	Non-ferrous metallic non-ferrous metal composite	-	-	-
	C5-5	Multilayer composite (stack)	Non-ferrous metallic metal composite	-	-	-
	C5-6	Multilayer composite (stack)	Metallic metal composite	-	-	-
X*	X1-1	Mixed machining	Cast iron (GJL – GJS)	-	-	-
	X1-2	Mixed machining	Cast iron – sintered steel	-	-	-
	X2-1	Mixed machining	Aluminium – cast iron (GJL)	-	-	-
	X2-2	Mixed machining	Aluminium – cast iron (GJS)	-	-	-
	X2-3	Mixed machining	Aluminium – sintered steel	-	-	-
Y*	Y1-1	Powder-metallurgical workpiece materials	Without hard materials	-	-	-
	Y1-2	Powder-metallurgical workpiece materials	With hard materials	-	-	-

* Not classified according to DIN ISO 513 – MAPAL specification.

Code letter according to DIN ISO 513	MAPAL machining groups (MMG)	Example of workpiece material			
		Description	Workpiece material number	Description	Workpiece material number
P	P1-1	S235JR	1.0037	St37-3	1.0116
	P1-2	C10	1.0301	Ck15	1.1141
	P1-3	20Mn5	1.1133	C40R	1.1189
	P1-4	C50R	1.1241	C75W	1.1750
	P1-5	125Cr1	1.2002	65Si7	1.5028
	P2-1	15Mo3	1.5415	19MnB4	1.5523
	P2-2	X42CrMo15	1.2314	51CrMoV4	1.7701
	P2-3	G-S-12CrMo19-5	1.7363	G-S-20MnCrMo6-3	1.7909
	P2-4	31CrMo12	1.8515	39CrMoV13-9	1.8523
	P3-1	16CrMo4-4	1.7337	17Cr3	1.7016
	P3-2	X210CrCoW12	1.2884	40NiCrMo2-2	1.6546
	P3-3	X165CrV12	1.2201	X6NiCrTi26-15	1.2779
	P4-1	20MnCrMo7	1.7911	HB5900	1.0999
	P5-1	X6Cr17	1.4016	X38CrMo14	1.4419
	P5-2	G-X12Cr12	1.4011	G-X170Cr18	1.4088
	P5-3	X110CrMoV15	1.4111	X80CrVMo13-2	1.4153
M	M1-1	X12CrNi18-8	1.4300	G-X4CrNiMo16-5-2	1.4411
	M1-2	X5CrNiMo18-13	1.4447	G-X5CrNiNb19-11	1.4552
	M2-1	G-X40CrNi27-4	1.4340	X2CrMnNiMoN26-5-4	1.4467
	M2-2	X2CrNiMoN25-7-4	1.4410	G-X7NiCrMoCuNb41-20	1.4559
	M3-1	G-X160CrSi18	1.4743	G-X130CrSi29	1.4777
K	K1-1	GG-15	0.6015	GG-20	0.6020
	K1-2	GG-25	0.6025	GG-30	0.6030
	K1-3	GG-35	0.6035	GG-40	0.6040
	K2-1	GGG-35-3	0.7033	GGG-40	0.7040
	K2-2	GGG-50	0.7050	GGG-60	0.7060
	K2-3	GGG-70	0.7070	GGG-90	0.7090
	K2-4	EN-GJS-800-10	5.3400	EN-GJS-HB400	5.3406
	K3-1	GGV-30	-	GGV-35	-
	K3-2	GGV-45	-	GGV-50	-
	K4-1	GTW-35-04	0.8035	GTW-45-07	0.8045
	K4-2	GTS-55-04	0.8155	GTS-70-02	0.8170
	K5-1	GGL-NiCr20-2	0.6660	GGL-NiCr30-3	0.6676
	K5-2	GGG-NiCrNb20-2	0.7659	GGG-Ni35	0.7683
N	N1-1	Al99	3.0205	AlMg4.5	3.3345
	N1-2	AlMgSiPb	3.0615	AlZn4.5Mg1	3.4335
	N1-3	AlCu4SiMg	3.1254	AlCuMgPb	3.1645
	N1-4	G-AlSi5Cu1Mg	3.2134	G-AlSi7Mg	3.2371
	N1-5	G-AlSi11	3.2211	GD-AlSi12	3.2582
	N1-6	G-AlSi9Mg	3.2373	GD-AlSi10Mg	3.2382
	N1-7	AlSi35	-	GK-AlSi25CuNiMg	-
	N2-1	CuZn40MnPb	2.0241	CuZn39Pb3	2.0401
	N2-2	CuSn4	2.1016	G-CuSn10	2.1050
	N2-3	CuZn10	2.0230	CuZn40Al2	2.0550
	N2-4	CuNi25	2.0830	CuAl8Fe3	2.0932
	N3-1	-	-	-	-
	N3-2	-	-	-	-
	N4-1	PA	-	PE	-
	N4-2	PF	-	UP	-
	N4-3	PUR	-	EPS	-
	N4-4	-	-	-	-
	N4-5	-	-	-	-
	N5-1	G-MgZn45E1Zr1	3.5101	GD-MgAl6	3.5662
S	S1-1	TiAl5SN2	3.7114	Ti3Al2.5V	3.7194
	S2-1	TiAl6V4	3.7164	TiAl4Mo4Sn2	3.7185
	S2-2	Ti3Al8V6Cr4Mo4Zr	-	Ti5Al2Sn4Zr4Mo2Cr1Fe	-
	S3-1	Ni99,7Mg	2.4052	Ni99,4Fe	2.4062
	S3-2	G-Ni95	2.4170	G-Ni93Si	2.4180
	S4-1	NiCu30Fe	2.4360	SG-NiCr19NbMoTi	2.4667
	S4-2	NiCu30Al	2.4374	NiCr22Mo9Nb	2.4856
H	H1-1	-	-	-	-
	H1-2	-	-	-	-
	H1-3	-	-	-	-
	H2-1	-	-	-	-
	H2-2	-	-	-	-
	H2-3	-	-	-	-
	H3-1	G-X260NiCr4-2	0.9620	G-X330NiCr4-2	0.9625
	H3-2	G-X300CrMo15-3	0.9635	G-X260Cr27	0.9650
C*	C1-1	Nomex	-	Kevlar	-
	C1-2	IMS	-	HTA	-
	C1-3	GMT-PP	-	PEEK	-
	C2-1	CF222	-	CF225	-
	C3-1	CeramTec AO-403	-	Al/Cu/Mg/-SiO2/Al2O3/AlN	-
	C4-1	-	-	-	-
	C4-2	PAMG-XR1 5056	-	PCGA-XR1	-
	C5-1	CFRP-Titanium	-	IMS/HTA+TiAl6V4	-
	C5-2	CFRP-CFRP	-	-	-
	C5-3	Aluminium-Aluminium	-	-	-
	C5-4	Aluminium-Titanium	-	-	-
	C5-5	Titanium-Inox	-	-	-
	C5-6	CFRP-Aluminium	-	IMS/HTA+Alloy 2024	-
X*	X1-1	AlSi12-42CrMoS4	-	AlSi8Cu3-16MnCr5	-
	X1-2	AlSi7-GG25	-	AlSi9-GG25	-
	X2-1	AlSi12-GGG50	-	AlSi6-GGG60	-
	X2-2	GG25-GGG50	-	GG25-GGG40	-
	X2-3	GGV450-42CrMoS4	-	-	-
Y*	Y1-1	-	-	-	-
	Y1-2	-	-	-	-

* Not classified according to DIN ISO 513 – MAPAL specification.