

MAPAL machining groups

Code letter according to DIN ISO 513	MAPAL machining groups (MMG)	OLD: MAPAL machining groups (MZG)	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	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	P1.2	Unalloyed steel	≤ 0.75% C	Annealed	900	270
	P1-5		Unalloyed steel	≤ 0.75% C	Quenched and tempered	1,000	300
	P2-1	P2.1	Low-alloyed steel	-	Annealed	600	180
	P2-2		Low-alloyed steel	-	Quenched and tempered	930	275
	P2-3	P2.2	Low-alloyed steel	-	Quenched and tempered	1,000	300
	P2-4		Low-alloyed steel	-	Quenched and tempered	1,200	350
	P3-1	P3.1	High-alloyed steel and high-alloyed tool steel	-	Annealed	680	200
	P3-2	P3.2	High-alloyed steel and high-alloyed tool steel	-	Quenched and tempered	1,100	325
	P3-3	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	P4.1, P6.1	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	M1.1, M2.1	Stainless steel	Austenitic	Quenched	680	200
	M1-2	-	Stainless steel	Austenitic (super-austenitic)	Precipitation-hardened	1,010	300
	M2-1	M1.2, M3.1	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	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	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	K2.2	Cast iron with spheroidal graphite GJS	Pearlitic	-	700	250
	K2-4	K2.3	Heat-treated spheroidal graphite ADI	Austenitic ferritic	-	1,400	480
	K3-1	K3.1	Cast iron with vermicular graphite GJV	Ferritic	-	400	240
	K3-2	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	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	N1.2	Aluminium – cast alloys	Si ≤ 7%	Not precipitation hardening	-	-
	N1-5	N1.3	Aluminium – cast alloys	7% > Si ≤ 12%	Not precipitation hardening	260	75
	N1-6		Aluminium – cast alloys	7% > Si ≤ 12%	Hardened	310	90
	N1-7	N1.4	Aluminium – cast alloys	Si > 12%	Heat-resistant	450	130
	N2-1	N2.1	Copper and copper alloys	Pb > 1% (free-machining alloy)	-	390	110
	N2-2	N2.3	Copper and copper alloys	CuSn (Bronze, electrolytic copper)	-	340	100
	N2-3	N2.3	Copper and copper alloys	CuZn, CuSnZn (Brass, red bronze)	-	310	90
	N2-4	N2.2	Copper and copper alloys	CuAl, CuNi (Special alloys)	-	> 400	-
	N3-1	N3.1	Non-metallic workpiece materials	Graphite > 8 µm particle size	-	-	-
	N3-2	N3.2	Non-metallic workpiece materials	Graphite ≤ 8µm particle size	-	-	-
	N4-1	N4.1	Non-metallic workpiece materials	Thermoplastics	-	-	-
	N4-2	N4.2	Non-metallic workpiece materials	Thermosets	-	-	-
	N4-3	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	S1.1	Titanium, Ti alloys	Pure titanium & α alloys	-	680	200
	S2-1	S2.1	Titanium, Ti alloys	α + β alloys	Hardened	1,260	375
	S2-2	S2.2	Titanium, Ti alloys	β alloys	-	1,400	410
	S3-1	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	S4.1	High-temperature alloys, super alloys	Ni or Co basis	Hardened	1,180	350
H	H1-1	H1.1	Hardened steel	-	Hardened and tempered	-	< 45 HRC
	H1-2	H1.2	Hardened steel	-	Hardened and tempered	-	< 50 HRC
	H1-3	H1.2	Hardened steel	-	Hardened and tempered	-	< 54 HRC
	H2-1	H2.1	Hardened steel	-	Hardened and tempered	-	< 60 HRC
	H2-2	H2.2	Hardened steel	-	Hardened and tempered	-	< 64 HRC
	H2-3	H2.3	Hardened steel	-	Hardened and tempered	-	< 68 HRC
	H3-1	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	C1.1	Plastic range	Reinforced with aramid fibre (AFK)	-	-	-
	C1-2	C1.2	Plastic range	(Duroplastic), CFK/GFK	-	-	-
	C1-3	C1.3	Plastic range	(Thermoplastic), CFK/GFK	-	-	-
	C2-1	C2.1	Carbon range, reinforced with carbon fibre (CFC)	-	-	-	-
	C3-1	C3.1	Metal matrix (MMC) and ceramics	-	-	-	-
	C4-1	C4.1	Sandwich construction	Honeycomb core (honeycomb)	-	-	-
	C4-2	C4.2	Sandwich construction	Foam core	-	-	-
	C5-1	C5.1	Multilayer composite (stack)	Non-metallic non-ferrous metal composite	-	-	-
	C5-2	C5.2	Multilayer composite (stack)	Non-metallic metal composite	-	-	-
	C5-3	C5.3	Multilayer composite (stack)	Non-metallic non-metal composite	-	-	-
	C5-4	C5.4	Multilayer composite (stack)	Non-ferrous metallic non-ferrous metal composite	-	-	-
	C5-5	C5.5	Multilayer composite (stack)	Non-ferrous metallic metal composite	-	-	-
	C5-6	C5.6	Multilayer composite (stack)	Metallic metal composite	-	-	-
X*	X1-1	K1.1, K1.2	Mixed machining	Cast iron (GJL – GJS)	-	-	-
	X1-2	K1.1, sintered	Mixed machining	Cast iron – sintered steel	-	-	-
	X2-1	N1.2, K1.1	Mixed machining	Aluminium – cast iron (GJL)	-	-	-
	X2-2	N1.2, K1.2	Mixed machining	Aluminium – cast iron (GJS)	-	-	-
	X2-3	N1.2, sintered	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.