

MAPAL Zerspanungsgruppen

Zerspanungsgruppe	Werkstoff	Festigkeit/Härte [N/mm ²] [HRC]	Häufig bearbeitete Werkstoffe	
P	P1.1	Bau-, Automaten-, Einsatz- und Vergütungsstähle, unlegiert	< 700 N/mm ²	1.0122 (S235/St 37), 1.0401 (C15), 1.0503 (C45), 1.0570 (S355/St 52), 1.1213 (Cf53)
	P1.2	Bau-, Automaten-, Einsatz- und Vergütungsstähle, unlegiert	< 1.200 N/mm ²	1.1249 (Cf70)
	P2.1	Nitrier-, Einsatz- und Vergütungsstähle, legiert	< 900 N/mm ²	1.7131 (16MnCr5)
	P2.2	Nitrier-, Einsatz- und Vergütungsstähle, legiert	< 1.400 N/mm ²	1.7227 (42CrMoS4)
	P3.1	Werkzeug-, Wälzlager-, Feder- und Schnellarbeitsstähle*	< 800 N/mm ²	1.2343 (X37CrMoV5-1), 1.2762 (75CrMoNiW6-7)
	P3.2	Werkzeug-, Wälzlager-, Feder- und Schnellarbeitsstähle*	< 1.000 N/mm ²	1.2367 (X38CrMoV5-3), 1.2713 (55NiCrMoV6)
	P3.3	Werkzeug-, Wälzlager-, Feder- und Schnellarbeitsstähle*	< 1.500 N/mm ²	1.2379 (X153CrMoV12) 1.2738 (40CrMnNiMo8-6-4)
	P4.1	Rostfreie Stähle, ferritisch und martensitisch		1.4510 (X3CrTi17), 1.4589 (X5CrNiMoTi15-2)
	P5.1	Stahlguss		1.7231 (G42CrMo4)
	P6.1	Rostfreier Stahlguss, ferritisch und martensitisch		
M	M1.1	Rostfreie Stähle, austenitisch	< 700 N/mm ²	1.4301 (V2A), 1.4571 (V4A)
	M1.2	Rostfreie Stähle, ferritisch/austenitisch (Duplex)	< 1.000 N/mm ²	1.4362 (Alloy 2304), 1.4501, 1.4662 (LDX 2404)
	M2.1	Rostfreier Stahlguss, austenitisch	< 700 N/mm ²	
M3.1	Rostfreier Stahlguss, ferritisch/austenitisch (Duplex)	< 1.000 N/mm ²		
K	K1.1	Gusseisen mit Lamellengraphit (Grauguss), GJL	< 300 N/mm ²	GJL-250 (GG-25), GJL-260 (GG-26 Cr)
	K2.1	Gusseisen mit Kugelgraphit, GJS	< 500 N/mm ²	GJS-400 (GGG-40), GJS-450 (GGG-45)
	K2.2	Gusseisen mit Kugelgraphit, GJS	≤ 800 N/mm ²	GJS-600 (GGG-60), GJS-800-2 (GGG-80), GJS-800-8 (ADI 800)
	K2.3	Gusseisen mit Kugelgraphit, GJS	> 800 N/mm ²	GJS-900-2 (GGG-90), GJS-1000-5 (ADI 1000), GJS-1200-2 (ADI 1200), GJS-1400-1 (ADI 1400)
	K3.1	Gusseisen mit Vermiculargraphit, GJV; Temperguss, GJM	< 500 N/mm ²	GJV-300, GJV-400, GJMW-400-5 (GTW-40)
K3.2	Gusseisen mit Vermiculargraphit, GJV; Temperguss, GJM	> 500 N/mm ²	GJV-500, GJV-700	
N	N1.1	Aluminium, unlegiert und legiert < 3 % Si		Alloy 2024, Alloy 7075, Al99
	N1.2	Aluminium, legiert ≤ 7 % Si		AlSi7
	N1.3	Aluminium, legiert > 7-12 % Si		AlSi9, AlSi9Cu
	N1.4	Aluminium, legiert > 12 % Si		AlSi12, AlSi17
	N2.1	Kupfer, unlegiert und niedriglegiert	< 300 N/mm ²	SE-Cu
	N2.2	Kupfer, legiert	> 300 N/mm ²	CuSn6
	N2.3	Messing, Bronze, Rotguss	< 1.200 N/mm ²	CuZn33, CuAl9Mn3
	N3.1	Graphit, > 8 µm		
	N3.2	Graphit, ≤ 8 µm		
	N4.1	Kunststoff, Thermoplaste		PA, PE, PC, PS, PVC, PP, PTFE, POM, PMMA
N4.2	Kunststoff, Duroplaste		PU, PF, EP, UP, VE, CR	
N4.3	Kunststoff, Schaumstoffe		EPS, PUR, PVC-E, PS-E, PP-E	
C	C1.1	Kunststoffmatrix, Aramidfaserverstärkt (AFK)		Nomex, Kevlar, Twaron, KOREX
	C1.2	Kunststoffmatrix (duroplastisch), CFK/GFK		IMS, HTA
	C1.3	Kunststoffmatrix (thermoplastisch), CFK/GFK		GMT-PP, PEEK
	C2.1	Kohlenstoffmatrix, Kohlenstofffaserverstärkt (CFC)		CF222, CF225, CF226, CF227, CF260
	C3.1	Metallmatrix (MMC)		CeramTec AO-403 (AlSi9MgMn-Al2O3), Al/Cu/Mg-SiO2/Al2O3/AlN/TiC/SiC/BN/TiB2
	C4.1	Sandwichkonstruktion, Wabenkern (Honeycomb)		
	C4.2	Sandwichkonstruktion, Schaumkern		PLASCORE PAMG-XR1 5052, PCGA-XR1 3003, PAMG-XR1 5056, Micro-Cell (core made of Alloy 5052/5056)
	C5.1	Schichtverbund (Stack), Nichtmetall-Nichteisenmetall-Verbund		CFK-Aluminium, IMS/HTA + Alloy 2024/6061/7075
	C5.2	Schichtverbund (Stack), Nichtmetall-Metall-Verbund		CFK-Titan, IMS/HTA + TiAl6V4/AMS4905
	C5.3	Schichtverbund (Stack), Nichtmetall-Nichtmetall-Verbund		CFK-CFK
C5.4	Schichtverbund (Stack), Nichteisenmetall-Nichteisenmetall-Verbund		Aluminium-Aluminium	
C5.5	Schichtverbund (Stack), Nichteisenmetall-Metall-Verbund		Aluminium-Titan	
C5.6	Schichtverbund (Stack), Metall-Metall-Verbund		Titan-Inox	
S	S1.1	Titan, Titanlegierungen	< 400 N/mm ²	
	S2.1	Titan, Titanlegierungen	< 1.200 N/mm ²	TiAl6V4
	S2.2	Titan, Titanlegierungen	> 1.200 N/mm ²	
	S3.1	Nickel, unlegiert und legiert	< 900 N/mm ²	1.3912 (Invar, Ni36)
	S3.2	Nickel, unlegiert und legiert	> 900 N/mm ²	
S4.1	Hochwarmfeste Superlegierung, Ni-, Co-, und Fe-basiert		Hardox, Hastelloy, Incoloy, Inconel, NIMONIC, Stellite, Waspaloy	
S5.1	Wolfram- und Molybdänlegierungen			
H	H1.1	Gehärteter Stahl/Stahlguss	< 44 HRC	1.2738 HH, 1.2085, Toolox 33, Toolox 44
	H1.2	Gehärteter Stahl/Stahlguss	< 55 HRC	1.2343, 1.2311, 1.2312, 1.2714, 1.2083, 1.2738
	H2.1	Gehärteter Stahl/Stahlguss	< 60 HRC	1.1730, 1.2379, 1.2358, 1.2767, 1.4112, ASP 2012
	H2.2	Gehärteter Stahl/Stahlguss	< 65 HRC	1.2379, 1.2363, 1.2436, 1.2842, ASP 2005, Vanadis 23
	H2.3	Gehärteter Stahl/Stahlguss	< 68 HRC	ASP 2017, ASP 2023, Vanadis 30, Vanadis 60
H3.1	Verschleißbeständiger Guss/Hartguss, GJN			

* Wenn die Legierungsbestandteile Cr, Mo, Ni, V, W in Summe > 8 %, dann die nächsthöhere MAPAL Zerspanungsgruppe wählen.

MAPAL machining groups

Machining group		Workpiece material	Strength/hardness [N/mm ²] [HRC]	Frequently machined workpiece materials
P	P1	P1.1 Structural, machining, case hardened and tempering steels, unalloyed	< 700 N/mm ²	1.0122 (S235/St 37), 1.0401 (C15), 1.0503 (C45), 1.0570 (S355/St 52), 1.1213 (CF53)
		P1.2 Structural, machining, case hardened and tempering steels, unalloyed	< 1,200 N/mm ²	1.1249 (CF70)
	P2	P2.1 Nitriding, hardening and tempering steels, alloyed	< 900 N/mm ²	1.7131 (16MnCr5)
		P2.2 Nitriding, hardening and tempering steels, alloyed	< 1,400 N/mm ²	1.7227 (42CrMoS4)
	P3	P3.1 Tool steels, roller bearing steels, spring steels and high-speed steels*	< 800 N/mm ²	1.2343 (X37CrMoV5-1), 1.2762 (75CrMoNiW6-7)
		P3.2 Tool steels, roller bearing steels, spring steels and high-speed steels*	< 1,000 N/mm ²	1.2367 (X38CrMoV5-3), 1.2713 (55NiCrMoV6)
		P3.3 Tool steels, roller bearing steels, spring steels and high-speed steels*	< 1,500 N/mm ²	1.2379 (X153CrMoV12) 1.2738 (40CrMnNiMo8-6-4)
	P4	P4.1 Stainless steels, ferritic and martensitic		1.4510 (X3CrTi17), 1.4589 (X5CrNiMoTi15-2)
	P5	P5.1 Cast steel		1.7231 (G42CrMo4)
	P6	P6.1 Stainless cast steels, ferritic and martensitic		
M	M1	M1.1 Stainless steels, austenitic	< 700 N/mm ²	1.4301 (V2A), 1.4571 (V4A)
		M1.2 Stainless steels, ferritic/austenitic (duplex)	< 1,000 N/mm ²	1.4362 (Alloy 2304), 1.4501, 1.4662 (LDX 2404)
	M2	M2.1 Stainless cast steel, austenitic	< 700 N/mm ²	
	M3	M3.1 Stainless cast steel, ferritic/austenitic (duplex)	< 1,000 N/mm ²	
K	K1	K1.1 Cast iron with lamellar graphite (grey cast iron), GJL	< 300 N/mm ²	GJL-250 (GG-25), GJL-260 (GG-26 Cr)
		K2.1 Cast iron with spheroidal graphite, GJS	< 500 N/mm ²	GJS-400 (GGG-40), GJS-450 (GGG-45)
	K2	K2.2 Cast iron with spheroidal graphite, GJS	≤ 800 N/mm ²	GJS-600 (GGG-60), GJS-800-2 (GGG-80), GJS-800-8 (ADI 800)
		K2.3 Cast iron with spheroidal graphite, GJS	> 800 N/mm ²	GJS-900-2 (GGG-90), GJS-1000-5 (ADI 1000), GJS-1200-2 (ADI 1200), GJS-1400-1 (ADI 1400)
	K3	K3.1 Cast iron with vermicular graphite, GJV; malleable cast iron, GJM	< 500 N/mm ²	GJV-300, GJV-400, GJMW-400-5 (GTW-40)
		K3.2 Cast iron with vermicular graphite, GJV; malleable cast iron, GJM	> 500 N/mm ²	GJV-500, GJV-700
N	N1	N1.1 Aluminium, unalloyed and alloyed < 3% Si		Alloy 2024, Alloy 7075, Al99
		N1.2 Aluminium, alloyed ≤ 7% Si		AlSi7
		N1.3 Aluminium, alloyed > 7 - 12% Si		AlSi9, AlSi9Cu
		N1.4 Aluminium, alloyed > 12% Si		AlSi12, AlSi17
	N2	N2.1 Copper, unalloyed and low alloyed	< 300 N/mm ²	SE-Cu
		N2.2 Copper, alloyed	> 300 N/mm ²	CuSn6
		N2.3 Brass, bronze, gunmetal	< 1,200 N/mm ²	CuZn33, CuAl9Mn3
	N3	N3.1 Graphite, > 8 µm		
		N3.2 Graphite, ≤ 8 µm		
	N4	N4.1 Plastic, thermoplastics		PA, PE, PC, PS, PVC, PP, PTFE, POM, PMMA
		N4.2 Plastic, duroplastics		PU, PF, EP, UP, VE, CR
		N4.3 Plastic, foam materials		EPS, PUR, PVC-E, PS-E, PP-E
C	C1	C1.1 Plastic range, reinforced with aramid fibre (AFK)		Nomex, Kevlar, Twaron, KOREX
		C1.2 Plastic range (duroplastic), CFK/GFK		IMS, HTA
		C1.3 Plastic range (thermoplastic), CFK/GFK		GMT-PP, PEEK
	C2	C2.1 Carbon range, reinforced with carbon fibre (CFC)		CF222, CF225, CF226, CF227, CF260
		C3.1 Metal matrix (MMC)		CeramTec AO-403 (AlSi9MgMn-Al2O3), Al/Cu/Mg-SiO2/Al2O3/AlN/TiC/SiC/BN/TiB2
	C4	C4.1 Sandwich construction, honeycomb core (Honeycomb)		
		C4.2 Sandwich construction, foam core		PLASCORE PAMG-XR1 5052, PCGA-XR1 3003, PAMG-XR1 5056, Micro-Cell (core made of alloy 5052/5056)
	C5	C5.1 Multilayer composite (stack), non-metallic non-ferrous metal composite		CFK-aluminium, IMS/HTA + Alloy 2024/6061/7075
		C5.2 Multilayer composite (stack), non-metallic metal composite		CFK-titanium, IMS/HTA + TiAl6V4/AMS4905
		C5.3 Multilayer composite (stack), non-metallic non-metal composite		CFK-CFK
		C5.4 Multilayer composite (stack), non-ferrous metallic non-ferrous metal composite		Aluminium-aluminium
		C5.5 Multilayer composite (stack), non-ferrous metallic metal composite		Aluminium-titanium
C5.6 Multilayer composite (stack), metallic metal composite			Titanium Inox	
S	S1	S1.1 Titanium, titanium alloys	< 400 N/mm ²	
		S2.1 Titanium, titanium alloys	< 1,200 N/mm ²	TiAl6V4
	S2	S2.2 Titanium, titanium alloys	> 1,200 N/mm ²	
		S3.1 Nickel, unalloyed and alloyed	< 900 N/mm ²	1.3912 (Invar, Ni36)
	S3	S3.2 Nickel, unalloyed and alloyed	> 900 N/mm ²	
		S4.1 High-temperature super alloy, Ni-, Co-, and Fe-based		Hardox, Hastelloy, Incoloy, Inconel, NIMONIC, Stellite, Waspaloy
S5	S5.1 Molybdenum and tungsten alloys			
H	H1	H1.1 Hardened steel / cast steel	< 44 HRC	1.2738 HH, 1.2085, Toolox 33, Toolox 44
		H1.2 Hardened steel / cast steel	< 55 HRC	1.2343, 1.2311, 1.2312, 1.2714, 1.2083, 1.2738
	H2	H2.1 Hardened steel / cast steel	< 60 HRC	1.1730, 1.2379, 1.2358, 1.2767, 1.4112, ASP 2012
		H2.2 Hardened steel / cast steel	< 65 HRC	1.2379, 1.2363, 1.2436, 1.2842, ASP 2005, Vanadis 23
	H2	H2.3 Hardened steel / cast steel	< 68 HRC	ASP 2017, ASP 2023, Vanadis 30, Vanadis 60
		H3	H3.1 Wear-resistant cast / chill casting, GJN	

* If the alloy parts Cr, Mo, Ni, V, W are in total > 8%, select the next highest MAPAL machining group.