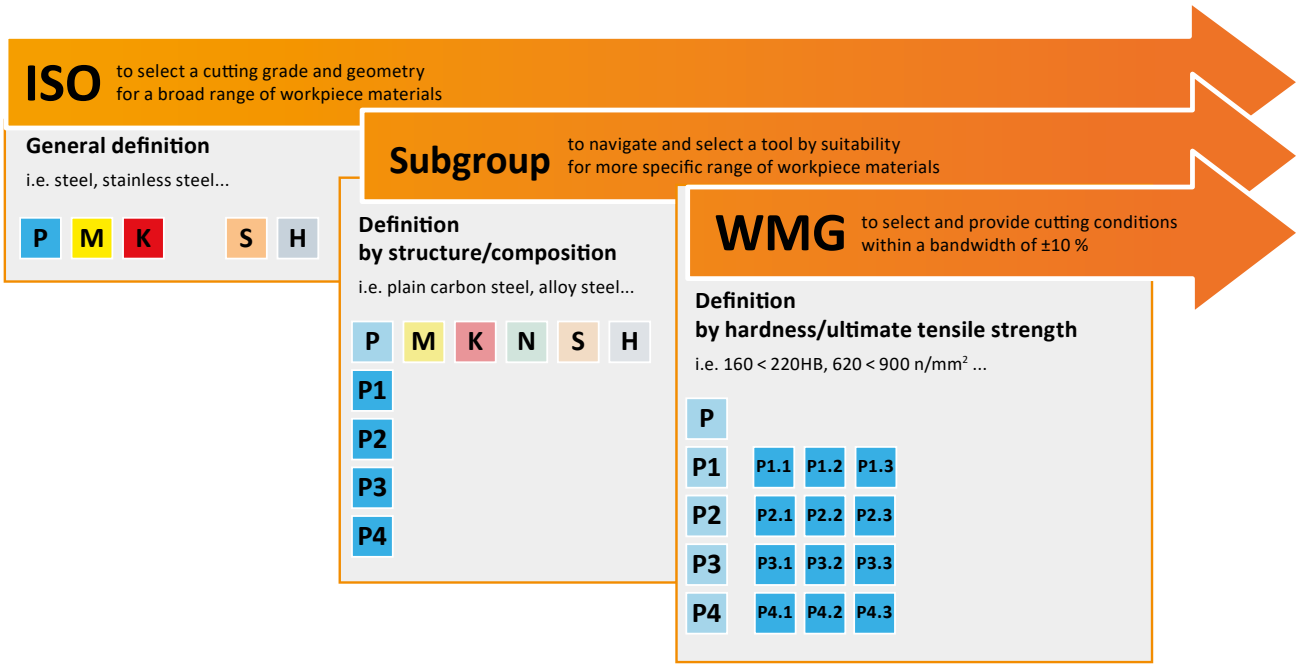
WORKPIECE MATERIAL GROUPS (WMG)



ABOUT DORMER PRAMET'S WORKPIECE MATERIAL CLASSIFICATION

Workpiece material groups ("WMG") are used to support easy and reliable selection of the right cutting tool and starting values for machining conditions in particular applications.

Dormer Pramet classifies workpiece materials into six different colored groups;

- **Blue**: Steel and cast steel (P-group)
- **Yellow**: Stainless steel (M-group)
- **Red**: Cast iron (K-group)
- **Green**: Non-ferrous metals (N-group)
- **Orange**: High-temperature alloys (S-group)
- **Grey**: Hardened materials (H-group)

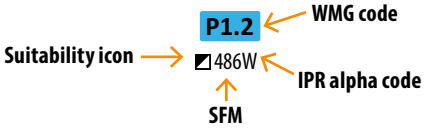
Each of these are divided into subgroups based on their structure and/or composition. For example, P-group steel and cast steel is split into four subgroups, namely;

- P1 – **Free machining steel**
- P2 – **Plain carbon steel**
- P3 – **Alloy steel**
- P4 – **Tool steel**

A final division includes material properties, such as hardness and ultimate tensile strength. This is to provide our customers with a complete tool recommendation, including starting values for cutting speed and feed.

The table on the next page includes a description of each workpiece material group, as well as examples of commonly used designations.

HOW TO USE THE WMG CHART



To find speeds and feeds:

- Select the product you want in our catalog or brochure
- Find the appropriate ISO work material group (WMG) at the top of the page
  - This will let you know if the tool is suitable for your operation and provides the speed (SFM) and alpha character for feed rate (IPR)
- Use the corresponding alpha character to find your cutting feed rate (IPR) in the chart provided in the WMG section of the catalog or brochure (usually near the front of the publication)

ISO		WMG (Workpiece Material Groups)			Hardness HB or HRC	Ultimate tensile strength Mpa	Examples of material (AISI-SAE, ASTM, UNS)	Old Dormer AMG	Old Pramet ISO
P	P1	P1.1	Free machining steel	sulfurized	< 240 HB	≤ 760	1108, 1109,1113, 1117, 1118, 1132, 1137, 1139, 1140, 1141…	1.1	P1
		P1.2	(carbon steels with increased machinability)	sulfurized and phosphorized	< 180 HB	≤ 620	1211, 1212, 1213, 1215…	1.1	P1
		P1.3		sulfurized/phosphorized and leaded	< 180 HB	≤ 550	12L13, 12L14, 12L15…	1.1	P1
	P2	P2.1	Plain carbon steel	containing <0.25%C	< 180 HB	≤ 620	1005, 1006, 1008, 1012, 1013, 1513, 1015, 1020, 1022, 1025, 1024, 1025	1.2	P2
		P2.2	(steels comprised of mainly iron and carbon)	containing <0.55%C	< 240 HB	≤ 830	1026, 1526, 1030, 1035, 1536, 1040, 1541, 1042, 1045, 1548, 1050, 1055	1.3	P2
		P2.3		containing >0.55%C	< 300 HB	≤ 1030	1059, 1060, 1561, 1064, 1565, 1065, 1070, 1074, 1078, 1080, 1086, 1090	1.5	P3
	P3	P3.1	Alloy steel	annealed	< 180 HB	≤ 620	1330 -1345…A2317, A2515…3140…4023 - 4047…4118, 4130 - 4137, 4140 - 4147, 4150, 4161... 4320, 4340... 4419, 4422, 4427… 4615 - 4626… 4718, 4720… 4815 - 4820… E50100	1.4	P3
		P3.2	(carbon steels with an alloying content ≤ 10%)	hardened and tempered	180 - 260 HB	> 620 ≤ 900		1.4	P3
		P3.3			260 - 360 HB	> 900 ≤ 1240		1.5	P4
	P4	P4.1	Tool steel	annealed	< 26 HRC	≤ 900	A-2, D4, F-1, H-13, P-2…	1.4	P3
		P4.2	(special alloy steel for tools, dies and molds)	hardened and tempered	26 - 39 HRC	> 900 ≤ 1240	1.1520, 1.1645, 1.2008, 1.2319, 1.2378…	1.5	P4
		P4.3			39 - 45 HRC	> 1250 ≤ 1450	100CrMo5, 38CrCoWV18-17-17, 40CrMoS4, X40CrMoV5-1	1.6	H1
M	M1	M1.1	Ferritic stainless steel		< 160 HB	≤ 520	405, 409, 429, 430, 430F, 434, 436, 439, 441, 442, 443, 444, 446	2.1	M1
		M1.2	(straight chromium non-hardenable alloys)		160 - 220 HB	> 520 ≤ 700	1.4516, 1.4002, 1.4589, 1.4595, 1.4017, 1.4590, 1.4749, 1.4713, 1.4724	2.1	M1
	M2	M2.1	Martensitic stainless steel	annealed	< 200 HB	≤ 670	403, 410, 420, 422, 455, 490 1.4000, 1.4021, 1.4024, 1.4028, 1.4031, 1.4034, 1.4110, 1.4122,1.4313,1.4418,1.4419, 1.4422, 1.4423, 1.4592, 1.4762	2.3	M2
		M2.2	(straight chromium hardenable alloys)	quenched and tempered	200 - 280 HB	> 670 ≤ 950		2.3	M2
		M2.3		precipitation-hardened	280 - 380 HB	> 950 ≤ 1300		2.4	M2
	M3	M3.1	Austenitic stainless steel		< 200 HB	≤ 750	201, 202, 204, 205, 301, 3012, 303, 304, 305, 308, 316, 317, 321, 347	2.2	M3
		M3.2	(chromium-nickel and chromium-nickel-manganese alloys)		200 - 260 HB	>750 ≤ 870	201L, 301L, 303Se, 304H, 304L, 304LN, 309Cb, 316Ti, 317LMN, 347H	2.2	M3
		M3.3			260 - 300 HB	> 870 ≤ 1040	1.4308, 1.4301, 1.4305, 1.4311, 1.4552, 1.4401, 1.4571, 1.4878, 1.4961	2.2	M3
	M4	M4.1	Austenitic-ferritic **(DUPLEX)** or super-austenitic stainless steel		< 300 HB	≤ 990	310MoLN, 314, 904L, 330, S32304, 1.4362, 1.4462, 1.4854.1.4529	2.3	M4
		M4.2	Precipitation hardening austenitic stainless steel		300 - 380 HB	≤ 1320	630, 632, 635, PH13-8Mo, 15-5PH, PH15-7Mo, S15500, S17400	2.4	M4
K	K1	K1.1	Gray iron **(ASTM A48)** or	ferritic or ferritic-pearlitic	< 180 HB	≤ 190	GG10, GG15, G1800, ASTM Grades 20 and 25	3.1	K1
		K1.2	Automotive Gray iron **(ASTM A159)**	ferritic-pearlictic or pearlitic	180 - 240 HB	> 190 ≤ 310	GG20, GG25, G2500, G3000, A48 Class 25 and 30	3.2	K1
		K1.3	(iron-carbon castings with a lamellar graphite microstructure)	pearlitic	240 - 280 HB	>310 ≤ 390	GG30, GG35, G3500, G4000, A48 Class 50	3.2	K1
	K2	K2.1	Malleable iron **(ASTM A602)**	ferritic	< 160 HB	≤ 400	GTS-35-10, GTW-35-04, GTW-S-38-12, GTW-40-05, A47 grade 22010	3.3	K2
		K2.2	(iron-carbon castings with a graphite-free microstructure)	ferritic or pearlitic	160 - 200 HB	> 400 ≤ 550	GTS-45-06, GTW45-07	3.3	K2
		K2.3		pearlitic	200 - 240 HB	> 550 ≤ 660	GTS55-04, GTS-65-02, GTS-70-02, 5.4204, KTB 550-04	3.4	K2
	K3	K3.1	Ductile iron **(ASTM A536)**	ferritic	< 180 HB	≤ 560	GGG-35,3, GGG-40, GGG-50, A439 types D-2C and D-3A	3.3	K3
		K3.2	(iron-carbon castings with a nodular graphite microsturcture)	ferritic or pearlitic	180 - 220 HB	> 560 ≤ 680	GGG-60, GGG-70, A476, SA-476	3.3	K4
		K3.3		pearlitic	220 - 260 HB	> 680 ≤ 800	GGG-80, A897 grade 1050/700/7, AD 1600, F34800	3.4	K4
	K4	K4.1	Austenitic gray iron **(ASTM A436)**		< 180 HB	≤ 610	GGG & GGL-NiMn 13 7, GGG & GGL-NiCr 20 3, 0.6652, 0.7652		
		K4.2	Austenitic ductile iron **(ASTM A439 or ASTM A571)**		< 240 HB	> 610 ≤ 840	GGL-NiSiCr 30 5 5, GGG-NiSiCCr 30 5 5, 0.6680, 0.7680		
		K4.3	Austempered ductile iron **(ASTM A897)**		< 280 HB	> 840 ≤ 980	A897 GRADE 1, A897 GRADE 2, A897 GRADE 3…		
		K4.4	(iron-carbon alloy castings with an ausferrite microstructure)		280 - 320 HB	> 980 ≤ 1130	EN-GJS-800-8, EN-GJS-800-10, EN-GJS-900-8, EN-GJS-1050-6, EN-GJS-1200-3		
		K4.5			320 - 360 HB	> 1130 ≤ 1280			
	K5	K5.1	Compacted graphite iron CGI **(ASTM A842)**	ferritic	< 180 HB		A842-300, 5.2100, 5.2200, EN-GJV-300, EN-GJV-350		
		K5.2	(iron-carbon castings with a vermicular graphite structure)	ferritic or pearlitic	180 - 220 HB		A842-300, 5.2100, EN-GJV-300, EN-GJV-350, -400, -450		
		K5.3		pearlitic	220 - 260 HB		EN-GJV-400, EN-GJV-450, EN-GJV-500		
N	N1	N1.1	Commercially pure wrought aluminum		< 60 HB	≤ 240	Al99.8, Al99.0Cu, AA1050, AA1100, AA1175, 3.0255, 3.0275, 3.0205	7.1	N1
		N1.2	Wrought aluminum alloys	half hard tempered	60 - 100 HB	> 240 ≤ 400	AlCu4MgSi, AlMn1Mg1, AA2017, AA3003, AA4043, 3.1325, 3.1355	7.1	N1
		N1.3		full hard tempered	100 - 150 HB	> 400 ≤ 590	AlMg1SiPb, AlZn6CuMgZn, AlZn5.5MgCu, AA6262, AA7050, 3.0517	7.2	N2
	N2	N2.1	Cast aluminum alloys		< 75 HB	≤ 240	G-AlCu4S, GAlSiSCu1Mg, G-AlSi7Mg, A295.0, A355.0, LM11, LM21, LM25	7.3	N1
		N2.2			75 - 90 HB	> 240 ≤ 270	G-AlSi5Cu1Mg, G-AlSi7Mg, A242.0, A319.0, LM14, LM4, LM16	7.3	N1
		N2.3			90 - 140 HB	> 270 ≤ 440	G-AlCu4MgTi, G-AlCu4Ni2Mg2, A204.0, A771.0, LM30, LM24, ELT-204	7.3	N2
	N3	N3.1	Free-cutting copper-alloys materials with excellent machining properties				CuPb1P, CuSP, CuZn39Pb3, 2.1498, 2.1546, 2.0780, C18700, C79800, C34200	6.3	N3
		N3.2	Short-chip copper-alloys with good to moderate machining properties				CuNi3Si, CuZn40, CuZn40Al2, 2.0857, 2.0360, 2.0550, CZ109, CZ135, C28000	6.2	N3
		N3.3	Electrolytic copper and long-chip copper-alloys with moderate to poor machining properties				Cu-OFE, SF-Cu, CuNi2Be, 2.0070, 2.0090, 2.0855, C103, C10100,C12200	6.1	N4
	N4	N4.1	Thermoplastic polymers				Polyolefine, PE, PP, Styrol, PS, SAN, ABS, PMMA, Acryl, PC	8.1	
		N4.2	Thermosetting polymers				Aramid, Epoxy, Fluoropolymer, Melamine, Mehacrylate, Phenolic, Polyester	8.2	
		N4.3	Reinforced polymers or composites				GFK, CFK, GMT, LFT, SMC, Kevlar, Honeycomb, Organo	8.3	
	N5	N5.1	Graphite				CGM-1, CM-00, GM-10, GM-11, GR030, GR030PI, GR060, GR060PI,		
S	S1	S1.1	Titanium or titanium alloys		< 200 HB	≤ 660	R50250, 3.7025, T35, 2TA1, R50400, 3.7035, 2TA2,	4.1	S1
		S1.2			200 - 280 HB	> 660 ≤ 950	TA6V, Ti-6Al-4V, Ti 10.2.3, Ti5553	4.2	S1
		S1.3			280 - 360 HB	> 950 ≤ 1200		4.3	S1
	S2	S2.1	Fe-based high-temperature alloys		< 200 HB	≤ 690	A-286, Discaloy, Haynes 556, Iconel 909, Greek Ascolloy		S2
		S2.2			200 - 280 HB	> 690 ≤ 970			S2
	S3	S3.1	Ni-based high-temperature alloys		< 280 HB	≤ 940	Inconel 718, 706 Waspalloy, Udimet 720, Inconel 625	5.2	S3
		S3.2			280 - 360 HB	> 940 ≤ 1200		5.3	S3
	S4	S4.1	Co-based high-temperature alloys		< 240 HB	≤ 800	Haynes 25, Stellite 21, 31		S4
		S4.2			240 - 320 HB	> 800 ≤ 1070			S4
H	H1	H1.1	Chilled cast iron		< 440 HB		GHK-CrNi 350, GHK-470, GHK-475		
	H2	H2.1	Hardened cast iron		< 55 HRC		GHK-500, GHK-530, EN-GJN-HV550, EN-GJN-HV600, EN-GJN-HV600(XCr11),		H2
		H2.2			> 55 HRC		EN-GJN-HV600(XCr14), EN-GJN-NH600(XCr18)		H2
	H3	H3.1	Hardened steel <55HRC		< 51 HRC		1026, 1526… 1059, 1060… 1090, 1330… A2317, A2515… 3140… 4023… 4118, 4130…E50100… 50B40, 50B44… 5120, 5130… A-2, D-4, F-1, H-13, P-2… 1.1520, 1.2319, 1.2378… 100CrMo5, 38CrCoWV18 17-17, 40CRMoS4, X40CrMoVS-1…	1.7	H3
		H3.2			51 - 55 HRC			1.7	H3
	H4	H4.1	Hardened steel >55HRC		55 - 59 HRC			1.8	H4
		H4.2			> 59 HRC			1.8	H4