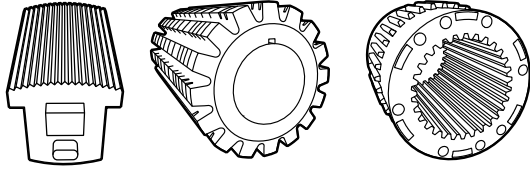


# TOOLING ALLOYS

## DATA SHEET Z-M4 PM™



### CHEMICAL COMPOSITION

Carbon	1.42 %
Chromium	4.00 %
Vanadium	4.00 %
Molybdenum	5.25 %
Tungsten	5.50 %
Manganese	0.30 %
Silicon	0.55 %

### DESCRIPTION

Z-M4 PM™ is a tungsten-molybdenum-vanadium high speed steel produced by powder metallurgy methods. It offers an excellent combination of wear resistance, red hardness, and toughness properties which can provide superior tool performance in a broad range of cutting tool and cold work tooling applications. It is an excellent upgrade over standard M2 high speed and D2 tool steel. The particle metallurgy processing also provides improved machinability, grindability, heat treat response, and dimensional stability when compared to similar grades produced by conventional methods.

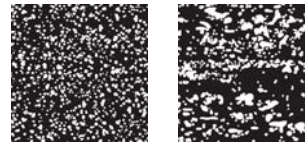
### TYPICAL APPLICATIONS

- \_ cutting tools
- \_ punches and dies
- \_ fine blanking tools
- \_ shears, rotary shears
- \_ PM compaction tooling
- \_ cold extrusion dies
- \_ broaches
- \_ reamers
- \_ milling tools

### PHYSICAL PROPERTIES

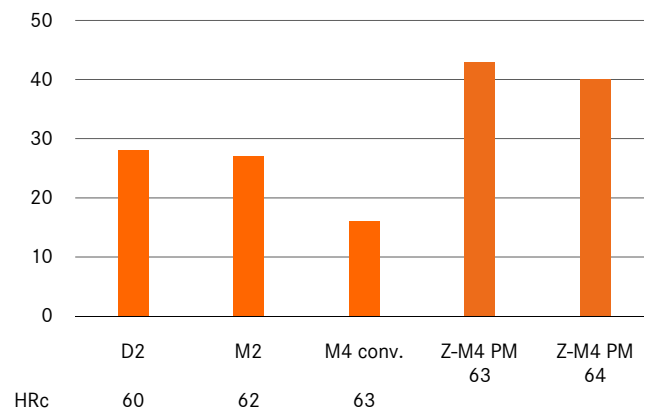
Modulus of elasticity E [psi x 10 <sup>6</sup> ]	31
Density [lb/in <sup>3</sup> ]	0.288
Thermal conductivity at 72 °F [BTU/hr-ft-°F]	10.98
Coefficient of thermal expansion over temperature range of 100 - 1000 °F [in/in/ °F]	6.72 x 10 <sup>-6</sup>

### POWDER METALLURGICAL AND CONVENTIONAL MICROSTRUCTURE

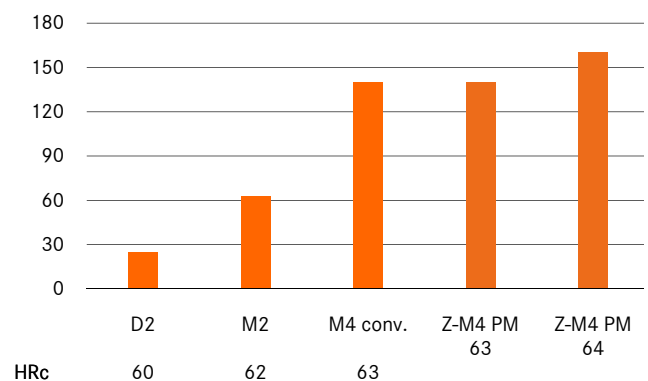


The uniform distribution of carbides in the powder-metallurgical structure compared to conventional tool steels with big carbides and carbide clusters.

### RELATIVE TOUGHNESS



### RELATIVE WEAR RESISTANCE



## THERMAL PROCESSING

### ANNEALING

Heat uniformly in a protective atmosphere (or vacuum) to 1600°F (870°C) and soak for 2 hours. Slow cool 30°F (15°C) per hour until 1000°F (540°C). Parts can then be cooled in air or furnace as desired. Hardness expected is BHN 225-255.

### STRESS RELIEVING (SOFT)

Heat uniformly to 1100-1300°F (595-700°C), soak for 2 hours, and cool in air or furnace.

### HARDENING

Vacuum, salt, or protective atmosphere methods are generally used. Care must be taken to prevent decarburization.

**PREHEAT:** Heat to 1550-1600°F (845-870°C) until temperature is equalized. Additional preheat steps including 1250-1300°F (680-700°C) and 1850-1900°F (1010-1040°C) are suggested when using programmed control during vacuum processing.

**AUSTENITIZING:** Temperatures in the range of 1900°F (1040°C) to 2175°F (1190°C) are commonly used with the specific temperature and soak time determined by the hardness required. Higher hardening temperatures will provide maximum wear resistance and hardness while temperatures lower in the range will provide increased toughness. Refer to chart for further information.

**QUENCHING:** Methods include use of high pressure gas (minimum 5 bar preferred), salt bath, or oil. Quench rate through the temperature range of 1900°F (1040°C) to 1300°F (700°C) is critical to the development of optimum structure and properties. Part temperature can then be equalized at 1000-1100°F (540-595°C) after which cooling can continue to below 150°F (66°C) or “hand warm”. Step quenching in this manner will help to minimize distortion in larger section sizes.

### TEMPERING

Tempering should be performed immediately after quenching. Temperatures in the range of 1000°F (540°C) to 1100°F (595°C) are generally used depending on the hardness required. Heat uniformly to the selected temperature and soak for 2 hours. Double tempering is absolutely necessary while triple tempering is highly recommended when hardening at 2100°F (1150°F) and over. Tempering temperatures of less than 1000°F (540°C) should not be used, and care must be taken to cool parts fully to room temperature between each temper.

### STRESS RELIEVING (HARD)

Heat to 25°F (15°C) less than the temperature of the last temper and soak for 1 hour.

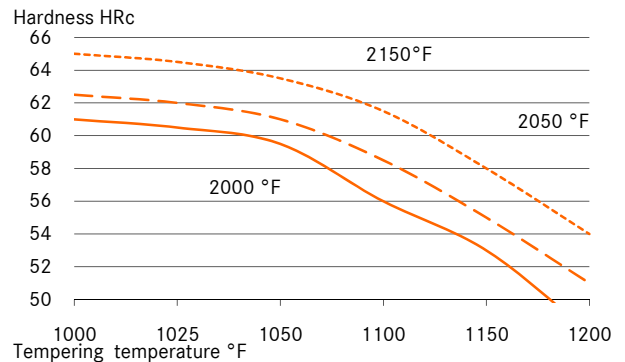
## CRITICAL TEMPERATURE

1545°F (840°C).

## SIZE CHANGE DURING HARDENING

+0.0015 in/in (at HRC 64)

## TEMPERING DIAGRAM



## HEAT TREATMENT INSTRUCTIONS

1st preheating	1250-1300 °F
2nd preheating	1550-1600 °F
Hardening	as specified in table
Tempering	2+2+2 hours at 1025 °F

Preferred quench method is high pressure inert gas (minimum 5 bar) or molten salt at 1025°F.

Required hardness HRC	Austenitizing soak temp [°F]	Austenitizing soak time [min]*	Tempering temperature [°F]**
58-60	2000	25	1025
60-62	2050	20	1025
62-64	2100	15	1025
63-65	2150	10	1025
64-66	2175	5	1025

\* Process variation and part section size can affect results. Soak times should be based on actual part temperatures. Use of load thermocouples is highly recommended during batch processing.

\*\* An increase in tempering temperature by 25°F can be used to reduce hardness 1 to 2 points HRC. Tempering temperatures less than 1000°F should not be used.

## STRAIGHTENING

Should be done warm (or during quench) using temperatures in the range of 400°F (200°C) to 800°F (430°C).

## SURFACE TREATMENT

This grade is an excellent substrate material for use with the various commercially available PVD coating processes. Conventional nitriding (.001” maximum depth) and steam tempering can also be used. Coating vendors should be consulted to select the optimum process for a given application.

Care must be exercised during CVD and other surface treatment processes that can alter the original heat treatment of the tool.

## MACHINING DATA

### TURNING

Cutting parameter	Turning with cemented carbide		HSS
	medium turning	finish turning	
Cutting speed (V <sub>c</sub> ) m/min.	70-90	90-130	12-15
Feed (f) mm/U	0.2-0.4	0.05-0.2	0.05-0.3
Cutting depth (a <sub>p</sub> ) mm	2-4	0.05-2	0.5-3
Tools according ISO	P 10-P 20*	P 10*	-

\* Use wear resistant coated cemented carbide, e. g. Coromant 4015 or Seco TP 100.

### MILLING

#### FACE- AND EDGEMILLING

Cutting parameter	Milling with cemented carbide		HSS
	medium turning	finish turning	
Cutting speed (V <sub>c</sub> ) m/min.	70-90	90-130	15
Feed (f) mm/U	0.2-0.3	0.1-0.2	0.1
Cutting depth (a <sub>p</sub> ) mm	2-4	1-2	1-2
Tools according ISO	K 15*	K 15*	-

\* Use wear resistant coated cemented carbide, e. g. Coromant 4015 or Seco TP 100.

#### END MILLING

Cutting parameter	Solid carbide	Milling cutter w. indexable tips	Coated HSS
	Cutting speed (V <sub>c</sub> ) m/min.	20-35	50-80
Feed (f) mm/U	0.01-0.20**	0.06-0.20**	0.01-0.30**
Tools according ISO	K 20	P 25***	-

\* for TiCN-coated end mills made of HSS V<sub>c</sub> ~ 25-30 m/min.  
 \*\* depends on radial depth of cut and on milling cutter - diameter  
 \*\*\* Use wear resistant coated cemented carbide, e. g. Coromant 3015 or SECO T15M.

### DRILLING

#### SPIRAL DRILL MADE OF HSS

Driller-∅ mm	Cutting speed (V <sub>c</sub> ) m/min.	Feed (f) mm/U
0 - 5	5 - 8*	0.05-0.15
5 - 10	5 - 8*	0.15-0.25
10 - 15	5 - 8*	0.25-0.35
15 - 20	8 - 8*	0.35-0.40

\* for TiCN-coated end mills made of HSS V<sub>c</sub> ~ 25-30 m/min.

#### CARBIDE METAL DRILLER

Cutting parameter	Drill type insert drill	Solid carbide tip	Coolant bore driller with carbide tip*
	Cutting speed (V <sub>c</sub> ) m/min.	80-110	40
Feed (f) mm/U	0.08-0.14**	0.10-0.15**	0.10-0.20**

\* driller with coolant bores and a soldered on carbide tip  
 \*\* depends on driller-diameter

### GRINDING

Grinding method	soft annealed	hardened
	Surface grinding, straight grinding wheels	A 13 HV
Surface grinding	A 24 GV	3SG 36 HVS**
Cylindrical grinding	A 60JV	B 126 R75 B3* 3SG 60 KVS** A 60 IV
Internal grinding	A 46 JV	B 126 R75 B3* 3SG 80 KVS** A 60 HV
Profile grinding	A 100 LV	B 126 R100 B6* 5SG 80 KVS** A 120 JV

\* for these applications we recommend CBN-wheels  
 \*\* grinding wheel from the company Norton Co.

### ZAPP MATERIALS ENGINEERING

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