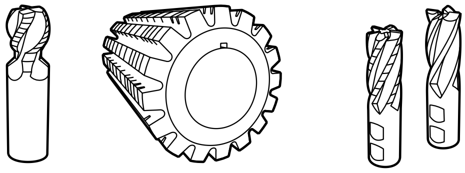
TOOLING ALLOYS
DATA SHEET Z-MAX PM

LINDQUIST STEELS
TOOL STEEL SPECIALISTS



CHEMICAL COMPOSITION

Carbon	2.00 %
Chromium	4.00 %
Vanadium	5.00 %
Tungsten	10.00 %
Molybdenum	5.00 %
Cobalt	9.00 %

DESCRIPTION

Z-Max PM is an ultra high performance HSS produced by powder metallurgy methods that can be heat treated to a maximum attainable hardness of HRc 68-70. It offers maximized levels of wear resistance, red hardness, attainable hardness, and compressive strength compared to other cobalt HSS grades. It is suitable for use in various heavy duty cutting tool applications involving difficult to machine materials as well as selected cold work applications when underhardened to optimize toughness. It can be considered as a possible alternative to carbide when toughness is a concern. The particle metallurgy processing also provides improved machinability, grindability, heat treat response, and dimensional stability when compared to similar grades produced by conventional methods.

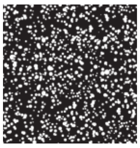
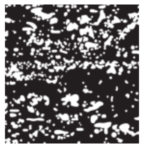
TYPICAL APPLICATIONS

_ form tools
_ gear tools
_ broaches
_ misc. cutting tools
_ precision wear parts
_ powder compaction tooling
_ roll forming tools
_ punches and dies

PHYSICAL PROPERTIES

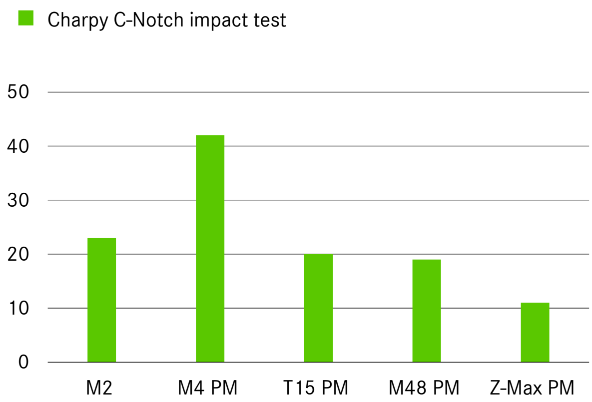
Modulus of elasticity E [psi/10⁶]	31
Density [lb/in³]	0.292
Thermal conductivity at 72°F [BTU/hr-ft-°F]	TBD
Coefficient of thermal expansion 100 - 1000 °F [in/in/°F]	TBD

POWDER METALLURGICAL AND CONVENTIONAL MICROSTRUCTURE

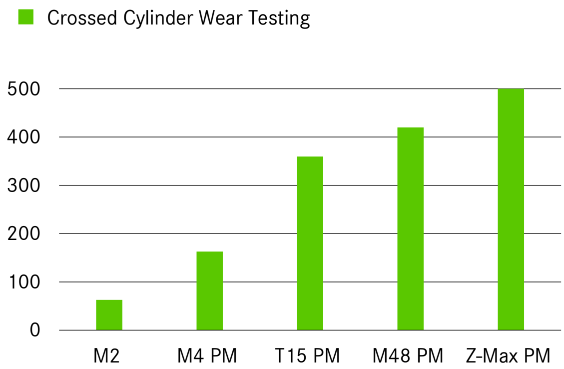



The uniform distribution of carbides in the powder- metallurgical structure compared to conventional tool steels with big carbides and carbide clusters.

RELATIVE TOUGHNESS (ESTIMATED)



WEAR RESISTANCE (ESTIMATED)



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 245-275.

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.

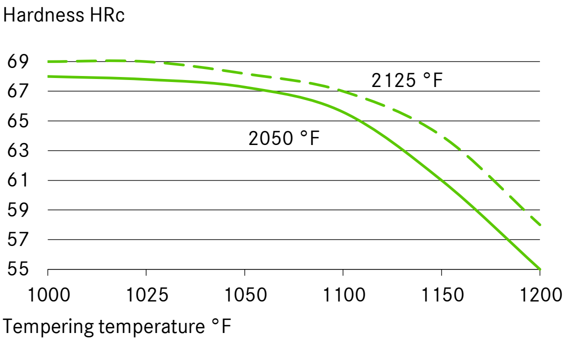
PREHEAT
Heat to 1550-1600°F (845-870°C) until temperature is equalized. Additional preheat steps including 1250-1300°F (680-700°C) and 1850-1900°F (1010-1040°C) are suggested when using programmed control during vacuum processing.

AUSTENITIZING
Temperatures in the range of 2050°F (1120°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 and temper curves 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. Triple tempering is essential with a fourth temper recommended when using high end hardness. 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.

TEMPERING DIAGRAM



HEAT TREATMENT INTRUCTIONS

1st preheating	1250–1300 °F
2nd preheating	1550–1600 °F
Hardening	as specified in table
Tempering	2+2+2+2 hours at 1000°F minimum

Quenching after hardening in hot bath at approx. 550°C or in vacuum at least at 5 bar overpressure.

Required hardness HRc ± 1	Austenit-izing soak temp. [°F]	Austenit-izing soak time [min]*	Tempering tempera-ture[°F]**
63-65	2050	20	1050
65-67	2100	15	1050
67-69	2150	12	1025
68-70	2175	10	1025
69-71	2190	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.

STRESS RELIEVING (HARD)

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

CRITICAL TEMPERATURE

1550°F (845°C).

SIZE CHANGE DURING HARDENING

+.0025in/in (at HRc 67.5)

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. 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.

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