Z-9 PM Data Sheet
Tooling Alloys

AFCI and ZAPP are certified according to ISO 9001 standard

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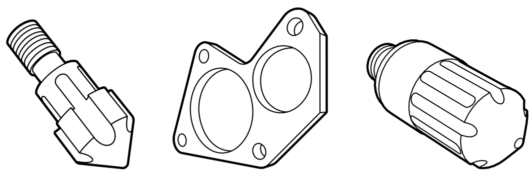


Chemical compositions

Carbon	1.80 %
Chromium	5.25 %
Vanadium	9.00 %
Molybdenum	1.30 %
Manganese	0.30 %
Silicon	0.50 %

Description

Z-9 PM is the low vanadium and carbon version of Z-10 PM tool steel. This difference in composition results in significantly enhanced toughness and thermal fatigue properties. Although it has reduced attainable hardness, the grade retains superior wear resistance compared to most standard tool steel grades. The unique combination of properties make it suitable for select cold and warm- work tooling applications that involve heavy abrasion along with high risk of chipping and cracking. It is typically used at hardness less than HRc 58, and Z-9 PM should be considered for use if higher hardness is deemed necessary. The powder metallurgy processing utilized provides well known benefits including more consistent machinability, grindability, heat treat response, and dimensional stability when compared to conventionally produced, high alloy grades.

Typical applications

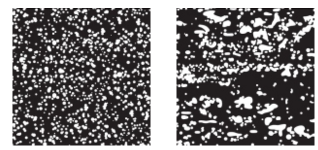
- plasticizing components
- extrusion tooling
- rolling mill rolls
- shear blades
- granulator and pelletizer blades
- forming rolls
- punches and dies

Thermal processing

Annealing

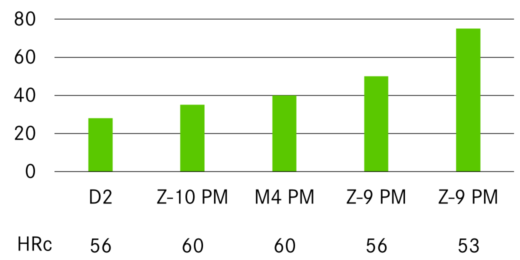
Heat uniformly in a protective atmosphere (or vacuum) to 1,650°F (900°C) and soak for 2 hours. Slow cool 30°F (15°C) per hour until 1,000°F (540°C). Parts can then be cooled in air or furnace as desired. Hardness expected is BHN 223-255.

Powder metallurgical and conventional microstructure

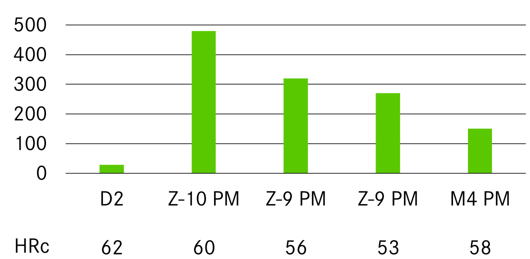


The uniform distribution of carbides in the powder metallurgical structure compared to conventional tool steels with big carbides and carbide clusters.

Relative toughness



Relative wear resistance



Physical properties

Modulus of elasticity E [psi x 10^6]	32
Density [lb/in³]	0.269

Coefficient of thermal expansion [in/in/ °F]
Over a temperature range of

70 - 400°F	6.21 x 10^{-6}
70 - 800°F	6.45 x 10^{-6}
70 – 1,200°F	6.59 x 10^{-6}

Stress relieving (soft)

Heat uniformly to 1,100-1,300°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 1,550-1,600°F (845-870°C) until temperature is equalized. Additional preheat steps including 1,250-1,300°F (680-700°C) and 1,850-1,900°F (1,010-1,040°C) are suggested when using programmed control during vacuum processing.

Austenitizing

Temperatures in the range of 1,950°F (1,040°C) to 2,100°F (1,150°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 1,900°F (1,040°C) to 1,300°F (700°C) is critical to the development of optimum structure and properties. Part temperature can then be equalized at 1,000-1,100°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.

Stress relieving (hard)

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

Critical temperature

1,590°F (865°C).

Size change during hardening

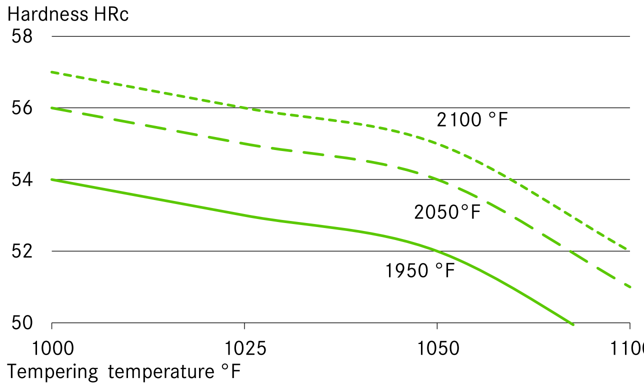
+.0002 in/in (at HRc 55)

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.

Tempering diagram



Heat treatment instrucitons

1st preheat	1,250-1,300°F
2nd preheat	1,550-1,600°F
Hardening	as specified in table
Tempering	2+2+2 hours at 1,000°F minimum

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

Required hardness HRc	Austenit-izing soak temp °F	Austenit-izing soak time [min]*	Tempering tempera-ture[°F]**
48-50 (max toughness)	1,950	30	1,075
50-52	1,950	30	1,050
52-54	1,950	30	1,025
54-56	2,050	20	1,025
55-57 (max wear)	2,100	15	1,025

* 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 1,000°F should not be used

Tempering

Tempering should be performed immediately after quenching. Temperatures in the range of 1,000°F (540°C) to 1,100°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 2,100°F (1,150°F) and over. Tempering temperatures of less than 1,000°F (540°C) should not be used and care must be taken to cool parts fully to room temperature (hand warm) between each temper.

Straightening

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