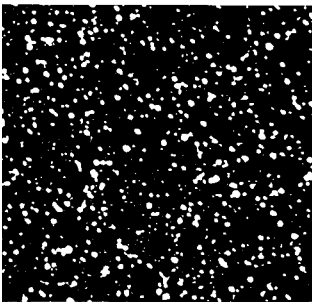
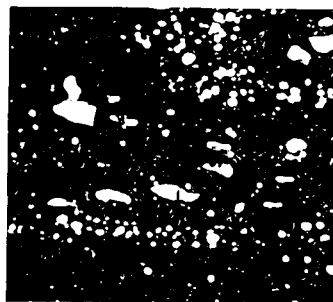


CRUCIBLE

PM M2 is an improved quality tool steel compared to conventionally produced material. The powder metallurgy process results in a homogeneous microstructure exhibiting a uniform distribution of fine carbides with essentially no carbide segregation. PM M2 tools will have a finer grain size, much better toughness, and superior grindability in the heat treated condition compared to those made from conventional M2. The higher carbon content (1.00% vs. 0.85%) of PM M2 permits higher attainable hardness. It also offers improved hardenability and gives better heat treat response in larger tool sections. PM M2's other general characteristics and physical properties are similar to conventionally produced M2.

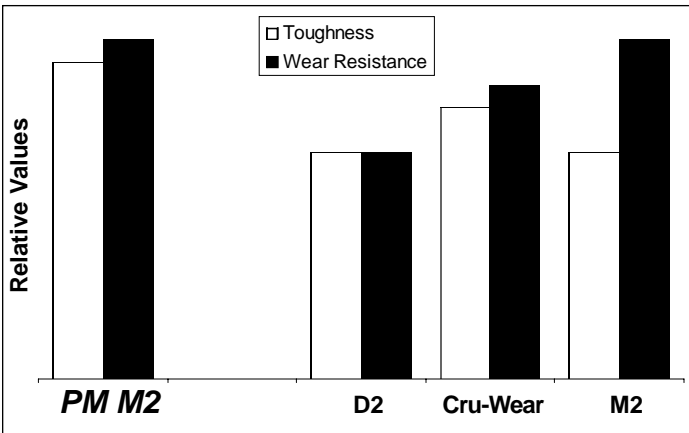


PM Steel



Conventional Steel

Tool Steel Comparagraph



Typical Applications

- Roto Form Tools
- Broaches
- Threading Tools
- Form Tools
- Planer Tools
- Punches (Hot and Cold)
- Lathe Tools

Note: These are some typical applications. Your specific application should not be undertaken without independent study and evaluation for suitability.

Crucible...

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DATA SHEET

CRUCIBLE PM M2

Issue #1

Carbon	1.00%
Chromium	4.15%
Vanadium	1.95%
Tungsten	6.40%
Molybdenum	5.00%

Physical Properties

Elastic Modulus	30 X 10 ⁶ psi	(207 GPa)
Density	0.294 lbs./in ³	(8.14 g/cm ³)
Coefficient of Thermal Expansion	in/in/°F mm/mm/°C	
70-500°F (20-260°C)	6.40X10 ⁻⁶	(11.5X10 ⁻⁶)
70-800°F (20-425°C)	6.58X10 ⁻⁶	(11.8X10 ⁻⁶)
70-1000°F (20-540°C)	6.72X10 ⁻⁶	(12.1X10 ⁻⁶)

Mechanical Properties

Impact Toughness

The PM microstructure gives PM M2 its improved impact toughness compared to conventional M2.

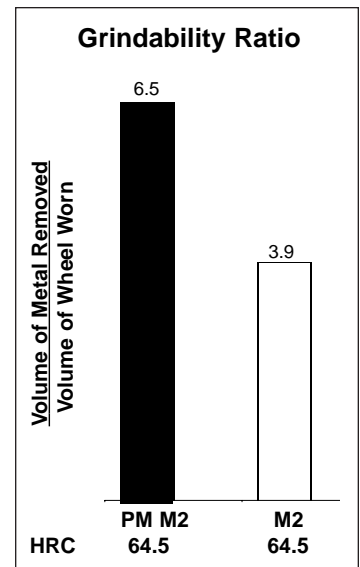
	Heat Treatment ⁽¹⁾			Impact Toughness ⁽²⁾ ft.-lb. (J)
	Austenitizing Temperature	Tempering Temperature	HRC	
M2	2175°F (1190°C)	1025°F (550°C)	64	17 (23)
PM M2	2175°F (1190°C)	1025°F (550°C)	64	30 (41)
M2	2150°F (1175°C)	1050°F (565°C)	63	19 (26)
PM M2	2150°F (1175°C)	1025°F (565°C)	63	27 (37)
PM M2	2150°F (1175°C)	1050°F (565°C)	62	24 (33)
M2	2100°F (1150°C)	1075°F (580°C)	61	21 (28)
PM M2	2100°F (1150°C)	1075°F (580°C)	61	26 (35)

(1) Heat Treatment: Austenitized as indicated and tempered to hardness.

(2) Charpy C-Notch Impact Test

Grindability

PM M2 is much easier to grind than conventional M2. The improved grindability is related to the fine and more uniformly distributed primary carbides resulting from the powder metallurgy process. Some benefits derived from the superior grinding characteristics are: better surface finish, higher removal rates, minimal grinding damage, and reduced wheel wear rates.



Thermal Treatments

Annealing: Heat to 1600°F (870°C), hold 2 hours, slow cool no faster than 25°F (15°C) per hour to 1000°F (535°C), then furnace cool or cool in still air to room temperature.

Annealed Hardness: About BHN 217/255

Stress Relieving

Annealed Parts: Heat to 1100-1300°F (595-705°C), hold 2 hours, then furnace cool or cool in still air.

Hardened Parts: Heat to 25-50°F (15-30°C) below original tempering temperature, hold 2 hours, then furnace cool or cool in still air.

Hardening

Critical Temperature: 1525°F (830°C)

Preheat: Heat to 1500-1550°F (815-845°C) Equalize.

Austenitize: 1975-2225°F (1150-1220°C), hold time at temperature 5-30 minutes (see chart).

Quench: Air or positive pressure quench (2 bar minimum) to below 125°F (50°C), or salt or interrupted oil quench to about 1000°F (540°C), then air cool to below 125°F (50°C). Salt bath treatment, if practical, will ensure the maximum attainable toughness for a given hardening treatment. Temper immediately.

Temper: Two to three times at 1000°F (540°C) or higher. 2 hours minimum each time. Air cool to room temperature in between tempers.

Size Change: +0.0015 to +0.002 in/in.

Recommended Heat Treatment: For the best combination of toughness and wear resistance, austenitize at 2125°F (1165°C), hold 15 minutes, and quench. Temper 3 times at 1025°F (550°C).

Aim hardness: HRC 63/65

Higher austenitizing temperatures may be used to obtain higher hardness.

Note: Properties shown throughout this data sheet are typical values. Normal variations in chemistry, size and heat treat conditions may cause deviations from these values. For additional data or metallurgical engineering assistance, consult your local Crucible Service Center.

Service Center Locations

Location	Phone	Toll Free	FAX
Auburn, MA	508-832-5353	800-365-1101	508-832-2217
Charlotte, NC	704-372-3073	800-365-1160	704-342-0985
Chicago, IL	630-378-0093	800-365-1151	630-378-1965
Cincinnati, OH	513-771-1310	800-365-1163	513-771-0119
Cleveland, OH	330-562-3131	800-365-1132	330-562-7818
Columbus, OH	614-262-4959	800-365-1131	614-262-7850
Dallas, TX	817-649-2800	800-365-1168	817-633-8142
Detroit, MI	248-528-0332	800-365-1133	248-528-1977
Grand Rapids, MI	616-554-9699	800-365-1137	616-554-9328
Huntsville, AL	256-772-0201	800-365-1161	256-772-3361
Indianapolis, IN	317-638-4501	800-365-1146	317-634-7375
Los Angeles, CA	714-632-1131	800-365-1179	714-632-1181



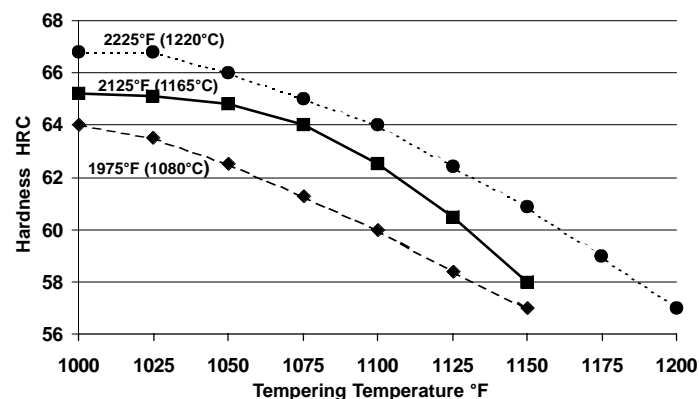
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Heat Treat Response

Hardness HRC

Tempering Temperature	Austenitizing Temperature		
	1975°F (1080°C)	2125°F (1165°C)	2225°F (1220°C)
Minimum time at Austenitizing Temp.	30 min.	15 min.	5 min.
Oil Quenched			
1000°F (540°C)	64	65	67
Optimum for Maximum Toughness and Effective Stress Relieving			
1025°F (550°C)	63.5	65	67
1050°F (565°C)	62.5	65	66
1075°F (580°C)	61.5	64	65
1100°F (595°C)	60	62.5	64
1125°F (605°C)	58.5	60.5	62.5
1150°F (620°C)	57	58	61
1175°F (635°C)	—	—	59
1200°F (650°C)	—	—	57
Minimum number of Tempers	2	3	3

Results may vary with hardening method and section size. Salt or oil quenching will give maximum response. Vacuum or atmosphere cooling may result in up to 1-2 HRC points lower.



Surface Treatments

Because of its high tempering temperatures (>1000°F) PM M2 is suitable for nitriding, PVD coating or similar surface treatments. CVD coating processes may result in non-predictable dimensional changes.

Location	Phone	Toll Free	FAX
Meadville, PA	814-337-8804	800-365-0530	814-337-8808
Milwaukee, WI	262-781-6710	800-242-0948	262-781-6743
Minneapolis, MN	612-331-6320	800-365-1153	612-331-4137
St. Louis, MO	636-272-7220	877-201-4049	636-978-9559
Canada			
Wallaceburg, ONT	519-627-2245	800-265-5293	519-627-2247
Mexico (SISA)			
Monterrey, N.L.	52-818-351-7220		52-818-351-2981
Naucalpan, E de M	52-555-576-4011		52-555-360-1865

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