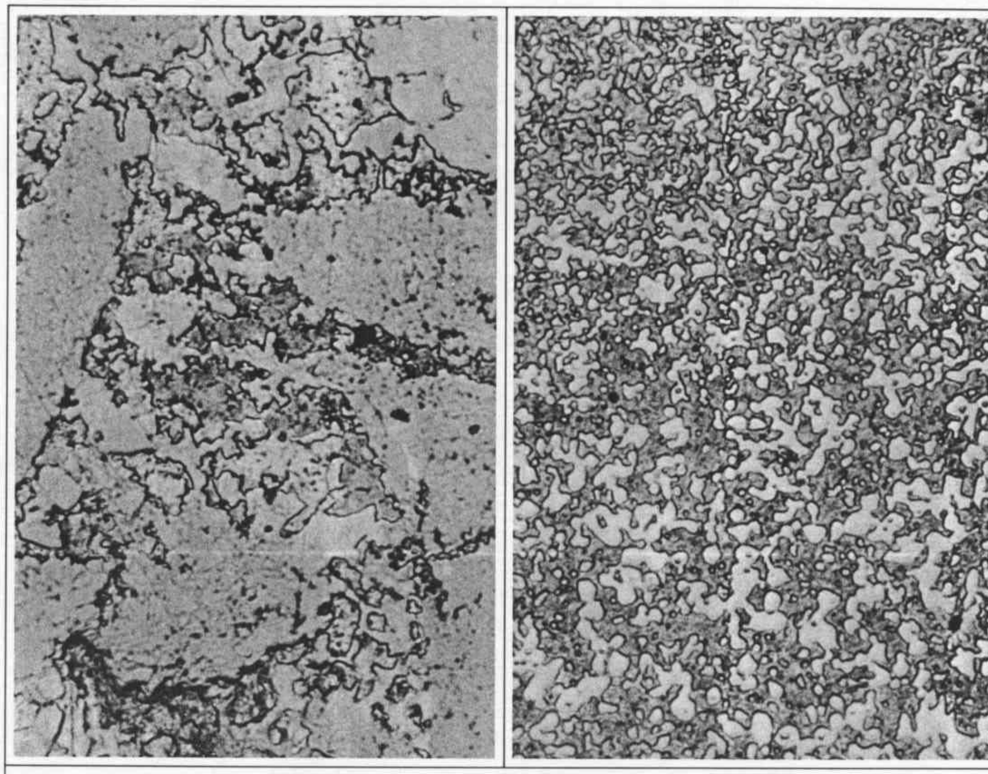
Crucible Corrosion Resistant Alloys/MPL-1

Crucible Compaction Metals' line of 100% dense P/M based materials now includes MPL-1. Its excellent wear/abrasion resistance characteristics are derived from being compositionally based in Crucible's well-known CPM-10V. Careful chemistry control and thermo-mechanical processing allow for the superior corrosion resistance of MPL-1. Many demanding application problems are being solved including:

- Plastic extrusion injection equipment.
- Sliding ring valves/assemblies.
- Replacement/repair processing components.

Figure 1. (Both 800x magnification)



Typical centrifugally cast alloy versus Quenched and tempered MPL-1 from powder.

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Introduction

Crucible MPL-1 is a unique wear/corrosion resistant alloy made by the Crucible Particle Metallurgy Process. It combines a tool steel base with added carbon and vanadium for outstanding wear resistance and chromium and molybdenum for superior corrosion resistance.

MPL-1 powder is normally HIP'd or extruded to 100% density prior to machining and heat treatment. The diffusion bonding that occurs during HIP or extrusion creates a very homogeneous material structure. As a result, the segregation and subsequent stress crack sensitivity seen in centrifugally cast alloys are eliminated. (See Figure 1)

Our combination of fine homogeneous microstructure along with great wear/corrosion properties permits MPL-1 to be applied in problem areas where "standard" alloys have insufficient wear or corrosion resistance.

Typical Applications

Pump liners, valve components, wear plates, and tubular products for the energy industry.

Alloy steel clad barrels, barrel liners for rework as well as screws, tips and valves for the plastics industry.

MPL-1 Wear/Corrosion Resistant Alloy Steel

Carbon	3.75%
Manganese	0.50%
Silicon	0.90%
Chromium	24.00%
Vanadium	9.00%
Molybdenum	3.00%
Sulphur + Phosphorus	0.03%

Note: Temperatures shown throughout this data sheet are alloy temperatures.

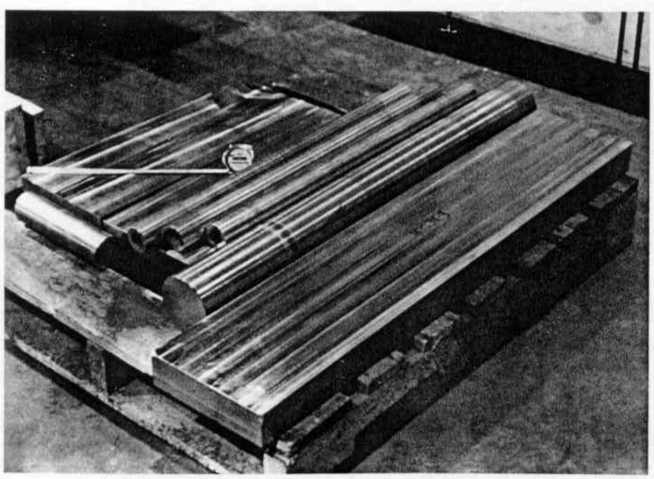
HRC Hardness

Air cooled from austenitizing temperature shown and double tempered, 2 + 2 hours. (see note below)

	1975°F	2150°F*	2200°F**
As Quenched	47	66	65
1000°F	46	67	64
1025°F	45	64	63
1050°F	45	63	62
1100°F	45	58	—

* Triple Tempering Recommended
** 10 minute austenitizing, all others 40 minutes

Note: Hardnesses shown are for salt bath heat treating of ½-inch thick specimens. As-quenched and tempered hardnesses may vary ½-1 HRC depending upon method of heat treating and section size.



Critical Temperatures

Annealing

Heat uniformly at 1600 to 1650°F, hold for two hours, and furnace cool to 1000°F at a rate of 30°F or less per hour. Then air cooling may be used. The typical annealed hardness is HR_c 42.

Stress Relieving

After severe machining operations, stress relieve by heating at 1100 to 1350°F, equalizing and air cooling.

Hardening

Preheat at 1500 to 1550°F. Transfer to a furnace at 2150°F.

To ensure adequate solutioning of the alloy carbides and proper response to tempering, a minimum soak time of 10 minutes at temperature is recommended. These times should be adjusted accordingly for large or very thin section sizes.

If controlled atmosphere or vacuum heat treating is employed, it may be desirable to increase the hardening temperature 25°F above the recommended temperature to ensure thorough solutioning of the alloy carbides.

Quenching

Both air and oil quenching are used in treating MPL-1. Interrupted oil quenching is recommended for sections 3 inches thick or greater where maximum hardness is required.

If controlled atmosphere or vacuum heat treating is employed, care should be taken to assure that an adequate quench rate is achieved to obtain the desired tempering response at the recommended tempering temperatures.

Tempering

Temper immediately after parts have cooled to below 125°F or can be comfortably held in bare hands. Double tempering is mandatory and triple tempering is strongly recommended. As with high alloy tool steels, it is important that the parts are cooled to room temperature between tempers.

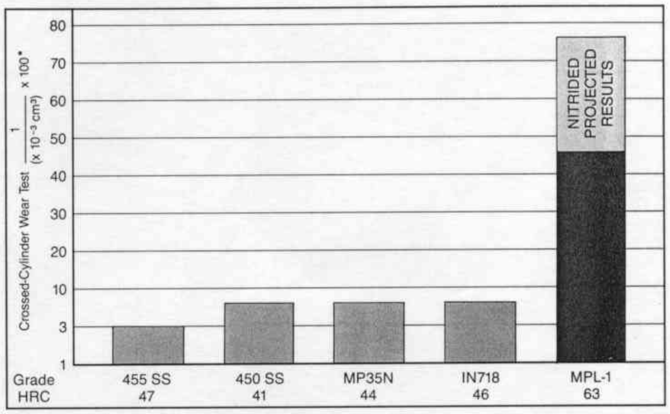
The usual tempering range is 975 to 1025°F, as illustrated in the hardness table above. Temperatures below 975°F may be considered for improved corrosion resistance.

Key Properties for Wear/Corrosion Resistant Alloys

Wear Resistance of Corrosion Alloys

Alloy	Hardness (HRC)	Volume Loss ($x 10^{-3} cm^3$)
MPL-1	63	0.67
IN718	45	38.26
MP35N	43	39.08
450 SS	40	40.80
455 SS	46	100.85

Wear Resistance

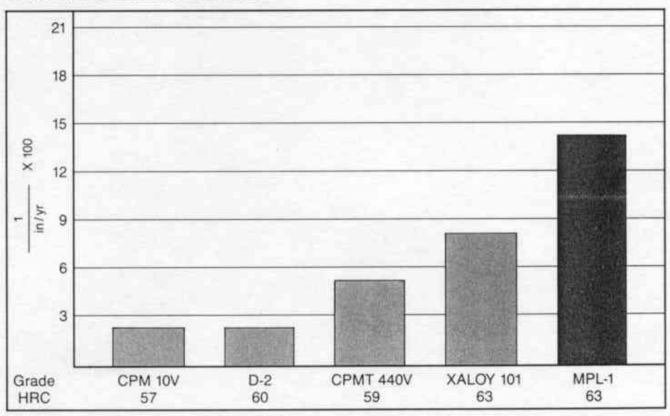


*Reciprocal of the wear rate as volume loss, in a crossed cylinder wear test in contact with rotating tungsten carbide cylinder.

Corrosion Resistance of Wear Alloys

Alloy	Hardness (HRC)	Corrosion Resistance (inches/year)
MPL-1	63	7.08
XALOY 101	60	12.50
CPM T440V	58	21.80
D-2	59	42.70
CPM 10V	62	45.65

Corrosion Resistance in HCl



*Reciprocal of the wear rate as volume loss, in a crossed cylinder wear test in contact with rotating tungsten carbide cylinder.

Nitriding

MPL-1 can be nitrided for even greater wear resistance. A gas nitriding cycle similar to 10V may be employed, or ion nitriding can be used to produce a case depth of .008 inches.

Size Change on Heat Treatment

Austenitizing Temperature	Tempering Temperature	Hardness HRC	Longitudinal Size Change from Annealed Condition (in./in.)
1950°F	1000 / 1025°F	45	+0.0004
2150°F	1000 / 1025°F	63	+0.0004

Physical Properties of MPL-1

MPL-1	75°F	600°F
Ultimate Tensile Strength, psi	223,000	228,000
0.2 Yield Strength, psi	205,000	190,000
Hardness, HRc	59	—
Specific Gravity	7.35	—
Density, lb/in³	0.268	—
Specific Heat, BTU/lb - °F	0.116	0.144
Thermal Conductivity BTU-ft/h-ft² - °F	8.1	10.5
Poisson's Ratio	0.310	0.284
Coefficient of Thermal Expansion, in/in/°F x 10^{-6}	200°F / 400°F / 600°F 4.96 / 5.57 / 5.90	
Modulus of Elasticity in tension, psi x 10^6	31.7	—

Note: Properties shown throughout this data sheet are typical values. Normal variations in chemistry, size and conditions of heat treatment may cause deviations from these values. For additional data and metallurgical engineering assistance, call us at 412/923-2670.

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