CRUCIBLE

DATA SHEET

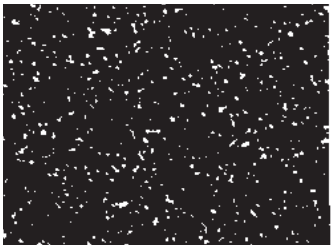
CRUCIBLE CPM® Rex® 76® (HS)*

High Speed Steel (AISI M48)

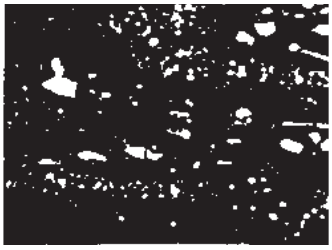
Issue #1

CPM Rex 76 is a super high speed steel made by the CPM (Crucible Particle Metallurgy) Process. It is heat treatable to HRC 68-70. Its high carbon, vanadium and cobalt contents provide abrasion resistance comparable to that of T15 and red hardness superior to that of M42. With its high hardness, fine grain size and uniform carbide distribution, CPM Rex 76 is an outstanding choice for special purpose cutting tools requiring high red hardness, high abrasion resistance, and good toughness.

The CPM process results in a homogeneous microstructure with a finer, more uniform carbide distribution imparting superior dimensional stability, grindability and toughness when compared to steels produced by conventional processes. The CPM process also allows the design of more highly alloyed grades which cannot be produced by conventional steelmaking.



CPM Steel

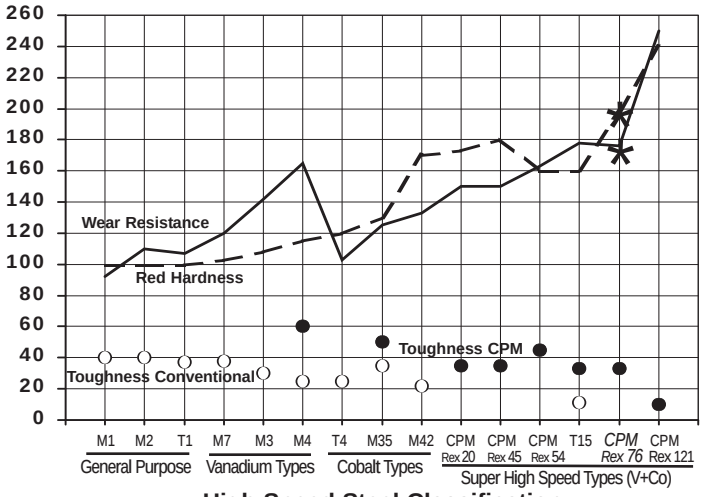


Conventional Steel

Carbon	**1.50%**
Chromium	**3.75%**
Vanadium	**3.10%**
Tungsten	**9.75%**
Molybdenum	**5.25%**
Cobalt	**8.50%**
Sulfur	**0.07 (0.22%)***

**Sulfur is added to improve the machinability of larger diameter rounds (e.g. 2-9/16" and over). The higher sulfur content benefits the toolmaker by increasing the ease of manufacture, and benefits the tool user by increasing the ease of resharpening. The CPM process permits the use of sulfur without affecting the tool's performance.*

High Speed Steel Comparagraph



High Speed Steel Classification

Physical Properties

Elastic Modulus	31 X10^6 psi	214 GPa
Specific Gravity	8.26	
Density	0.298 lbs/in^3	8.255 g/cm^3

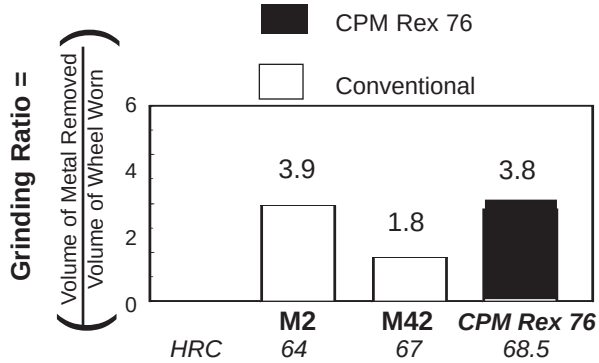
Coefficient of Thermal Expansion

°F	°C	in/in/°F	mm/mm/°C
70-200	20-95	5.92 X 10^{-6}	10.66 X 10^{-6}
70-400	20-200	6.00 X 10^{-6}	10.80 X 10^{-6}
70-600	20-315	6.15 X 10^{-6}	11.07 X 10^{-6}
70-800	20-425	6.33 X 10^{-6}	11.39 X 10^{-6}
70-1000	20-540	6.52 X 10^{-6}	11.74 X 10^{-6}
70-1200	20-650	6.75 X 10^{-6}	12.15 X 10^{-6}

Machinability and Grindability

Machinability in the annealed condition is approximately 15% of W1 Tool Steel (1%C).

Grindability of CPM Rex 76 compares favorably with regular high speed steels because of the fine, uniformly distributed carbides. Conventional grinding wheels designed for high speed steels can be used. In special cases, the advice of a grinding wheel manufacturer should be sought.



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.

Typical Applications

End Mills	Form Tools	Shaper Cutters
Gear Hobs	Broaches	Spade Drills
Tool Bits	Milling Cutters	Special Taps

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

Crucible Industries LLC

Thermal Treatments

Critical Temperature: 1535°F (835°C)

Forging: 2000-2100°F (1095-1150°C). Do not forge below 1700°F (925°C). Slow cool after forging.

Annealing

Heat to 1600°F (870°C), hold 2 hours, slow cool no faster than 25°F (15°C) per hour to 1000°F (540°C), then furnace cool or cool in still air to room temperature.
Annealed Hardness: Approx. BHN 285/311

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°F (15°C) below original tempering temperature, or 1000°F (540°C) minimum, hold 2 hours, then furnace cool or cool in still air.

Hardening (Salt or High Pressure Vacuum preferred)

Pre-heat: Heat to 1500-1550°F (815-845°C), hold long enough to soak through. For vacuum heat treating, an additional pre-heat at 1850-1900°F (1010-1040°C) is recommended to minimize hold time needed at austenitizing temperature.
Austenitize: 2100-2190° F (1150-1200°C)
Standard recommendation to achieve HRC 67-69 is 2150-2175°F (1175-1190°C).

Quench: Quench rapidly to below 1100°F (595°C), equalize, then air cool to hand warm, below 125°F (50°C). Salt or interrupted oil quenching usually gives the best heat treat response for high speed steels. A fast quench rate from hardening temperature to below 1100°F (595°C) is critical to achieve optimum heat treat response.

Temper: 1000°F (540°C) minimum. Triple or quadruple tempering required, hold 2 hr. minimum at temperature. Cool to room temperature between tempers.

Straightening: Best done warm 400°F minimum (205°C). Straightening after salt quenching and before cooling to below 400°F (205°C) is preferred.

Size Change During Hardening

Hardening Temp.	Tempering Temp.	HRC	Longitudinal Size Change
2175°F (1190°C)	1025°F (550°C)	68.5	+0.22%

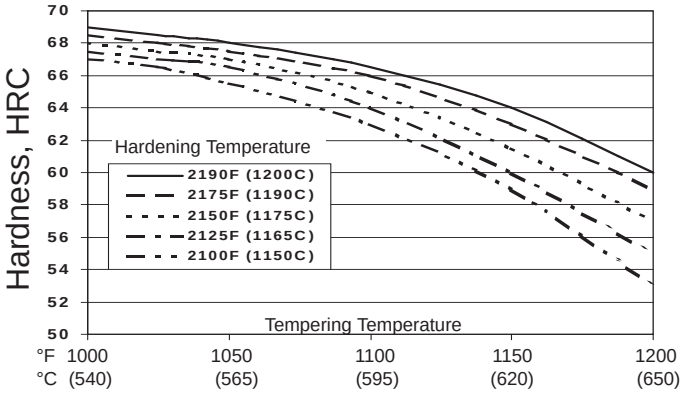
Heat Treat Response

Hardness (HRC) - Oil or Salt Quench (Note A)

Tempering Temperature °F	(°C)	2100°F (1150°C)	2125°F (1165°C)	2150°F (1175°C)	2175°F (1190°C)	2190°F (1200°C)
As-Quenched		68	68	67	66.5	66.5
1000	(540)	67	67.5	68	68.5	69
Optimum For Maximum Toughness and Effective Stress Relieving						
1025	(550)	66.5	67	67.5	68	68.5
1050	(565)	65.5	66.5	67	67.5	68
1100	(595)	63	64	65	66	66.5
1150	(620)	59	60	61.5	63	64
1200	(650)	53	55	57	59	60

NOTE A: RESULTS MAY VARY WITH HARDENING METHOD AND SECTION SIZE. SALT OR OIL QUENCHING WILL GIVE MAXIMUM RESPONSE. VACUUM OR ATMOSPHERE COOLING MAY RESULT IN ≅1 POINT HRC LOWER.

Minimum time at Austenitizing temp.	10 minutes	10 minutes	5 minutes	5 minutes	3 minutes
Minimum number of tempers	3	3	3	4	4



Toughness: Lower hardening temperatures (underhardening) provide finer grain size and increased toughness.

Hardening Temp. °F	(°C)	Tempering Temp. °F	(°C)	Hardness HRC	Charpy Impact C-Notch ft.lb.	(J)	Bend Fracture Strength ksi	(MPa)
2190	(1200)	975	(525)	70	6	8	333	2296
2175	(1190)	1000	(540)	68.5	10	14	531	3661
2175	(1190)	1025	(550)	68	10	14	593	4088
2125	(1165)	1025	(565)	67	15	20	633	4365

Surface Treatments

CPM Rex 76 can be nitrided or PVD coated if desired. If a CVD treatment is used, subsequent hardening is required and may result in undesirable distortion.

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