CRUCIBLE

DATA SHEET

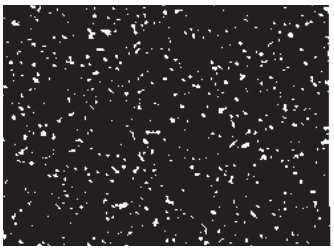
CRUCIBLE CPM® Rex® 45® (HS)*

High Speed Steel

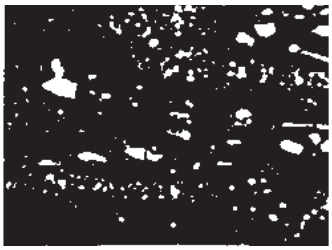
Issue #1

CPM Rex 45 is an 8% cobalt modification of M3 high speed steel made by the CPM (Crucible Particle Metallurgy) Process. It has red hardness comparable to that of M42 but offers abrasion resistance even better than that of M3. With its excellent red hardness, good wear resistance and good toughness, CPM Rex 45 is suitable for difficult machining applications or high cutting speed applications.

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

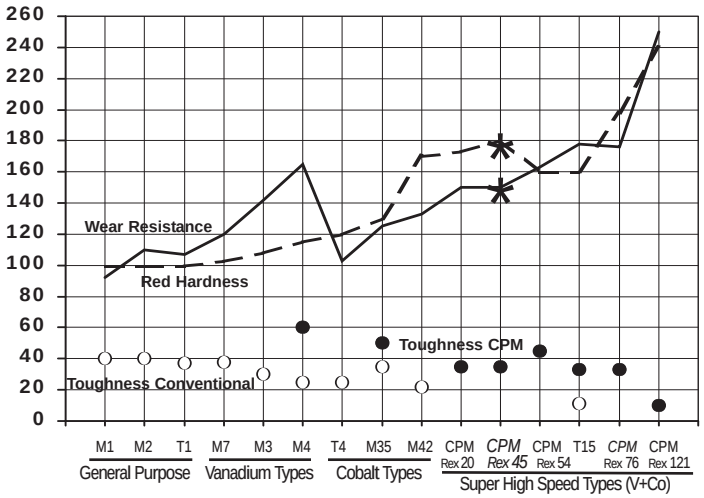


Conventional Steel

Carbon	**1.30%**
Chromium	**4.05%**
Vanadium	**3.05%**
Tungsten	**6.25%**
Molybdenum	**5.00%**
Cobalt	**8.00%**
Sulfur	**0.06 (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

Typical Applications

Gear Hobs	Milling Cutters
End Mills	Extrusion Punches
Form Tools	Shaper Cutters
Broaches	Taps

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

Physical Properties

Elastic Modulus	31 X10^6 psi	214 GPa
Specific Gravity	8.05	
Density	0.291 lbs/in^3	8.05 g/cm^3

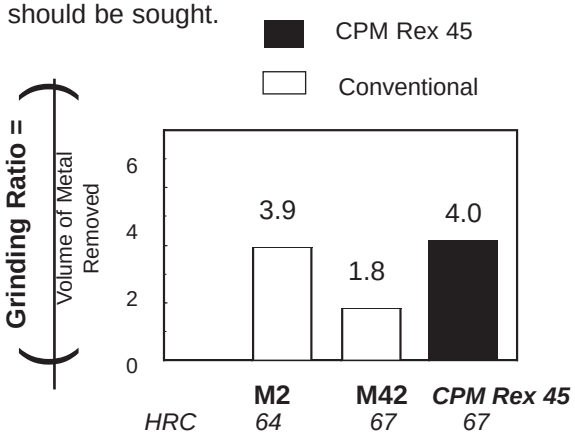
Coefficient of Thermal Expansion

°F	°C	in/in/°F	mm/mm/°C
70-750	20-400	6.3 X 10^{-6}	11.4 X 10^{-6}
70-1100	20-595	6.4 X 10^{-6}	11.5 X 10^{-6}

Machinability and Grindability

Machinability of CPMRex 45 in the annealed condition is approximately 30% of W1 Tool Steel (1%C).

Grindability of CPM Rex 45 compares favorably with regular high speed steels because of its 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.

Crucible Industries LLC

Thermal Treatments

Critical Temperature: 1500°F (815°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 255/285

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 66-68 is 2175°F (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 tempering is 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)	67	+0.002 in/in (+0.051 mm/mm)

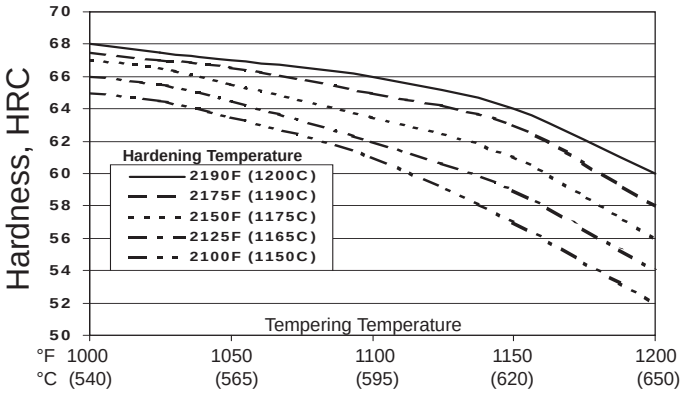
Heat Treat Response

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		66	67	67	66	65.5
1000	(540)	65	66	67	67.5	68
Optimum For Maximum Toughness and Effective Stress Relieving						
1025	(550)	64.5	65.5	66.5	67	67.5
1050	(565)	63.5	64.5	65.5	66.5	67
1100	(595)	61	62	63.5	65	66
1150	(620)	57	59	61	63	64
1200	(650)	52	54	56	58	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	3	3



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)
2175	(1190)	1025	(550)	67	15	20	702	4826
2150	(1175)	1025	(550)	66.5	18	24	712	4895
2125	(1165)	1040	(560)	65	20	27	685	4709

Surface Treatments

CPM Rex 45 can be nitrided or PVD coated if desired. If a CVD treatment is used, subsequent hardening is

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