CRUCIBLE

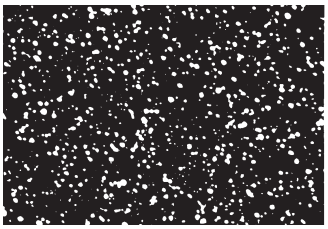
DATA SHEET

CRUCIBLE CPM® S35VN™

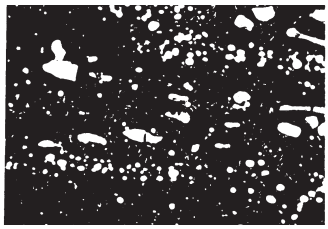
Issue #1

CPM S35VN is a martensitic stainless steel designed to offer improved toughness over CPM S30V. It is also easier to machine and polish than CPM S30V. Its chemistry has been rebalanced so that it forms some niobium carbides along with vanadium and chromium carbides. Substituting niobium carbides for some of the vanadium carbides makes CPM S35VN about 15-20% tougher than CPM S30V without any loss of wear resistance. CPM S35VN's improved toughness gives it better resistance to edge chipping. Because both vanadium and niobium carbides are harder and more effective than chromium carbides in providing wear resistance, the CPM stainless blade steels offer improved edge retention over conventional high chromium steels such as 440C and D2.

The CPM process produces very homogeneous, high quality steel characterized by superior dimensional stability, grindability, and toughness compared to steels produced by conventional melting practices.



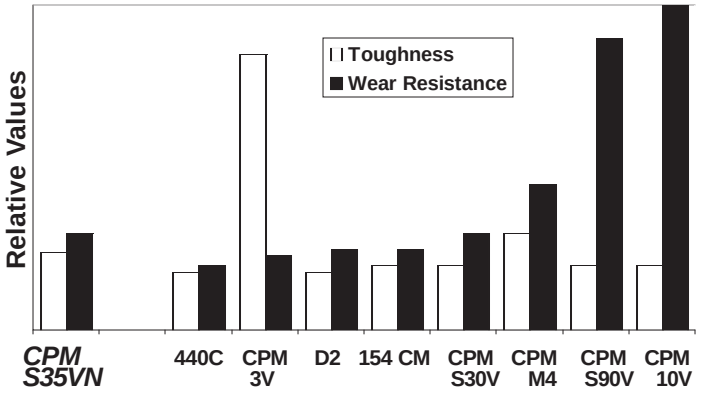
CPM Steel



Conventional Steel

Carbide Type and Volume				
	Vanadium	**Niobium**	**Chromium**	**Total**
CPM S35VN	3.0%	0.5%	10.5%	14.0%
CPM S30V	4.0%		10.5%	14.5%
440C	0%		12.0%	12.0%
154 CM	0%		17.5%	17.5%
CPM S90V	9.0%		11.0%	20.0%

Tool Steel Comparagraph



Typical Applications

Long-Wearing Specialty Cutlery
Plastic Injection and Extrusion Feed Screws and Dies
Non-Return Valve Components
Pelletizing Equipment
Wear Components for Food and Chemical Processing

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

Crucible Industries LLC

Carbon	**1.40%**
Chromium	**14.00%**
Vanadium	**3.00%**
Molybdenum	**2.00%**
Niobium	**0.50%**

Physical Properties

Elastic Modulus	32 X 10^6 psi	(221 GPa)
Density	0.27 lbs./in^3	(7.47 g/cm^3)

Thermal Conductivity

		BTU/hr-ft-°F	W/m-°K	cal/cm-s-°C
200°F	93°C	10	17.31	4.13 X 10^{-2}

Coefficient of Thermal Expansion

°F	°C	in/in/°F	mm/mm/°C
70 - 400	(20 - 200)	6.1 X10^{-6}	(11.0 X10^{-6})
70 - 600	(20 - 315)	6.4 X10^{-6}	(11.5 X10^{-6})

Mechanical Properties

Toughness (*Transverse* Charpy C-notch Testing)

Grade	Impact Energy
CPM S35VN	**12.0 ft. lbs.**
CPM S30V	10.0 ft. lbs.
154CM	2.5 ft. lbs.
440C	2.5 ft. lbs.

Although the longitudinal toughness of all four of these grades is about 25-28 ft. lbs., the *transverse* toughness of the CPM grades is four or more times that of 440C and 154CM. The higher transverse toughness results indicate that CPM S35VN and CPM S30V are much more resistant to chipping and breaking in applications which may encounter side loading. In knifemaking, the higher transverse toughness makes CPM especially good for bigger blades.

Edge Retention (CATRA Testing Relative to 440C)

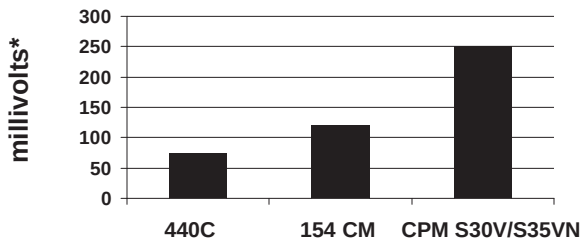
Grade	%
CPM S35VN	**145***
CPM S30V	145
154CM	120
440C	100

The CATRA (Cutlery & Allied Trades Research Association) test machine performs a standard cutting operation and measures the number of silica impregnated cards which are cut. It is considered a measure of relative wear resistance, reported in this table as compared to a 440C standard.

*Estimate based upon market feedback

Corrosion Resistance

Average Pitting Potential measurements from Polarization Curves run in 5% NaCl (Sodium Chloride) Solution at Room Temperature: (Higher voltage pitting potential indicates better corrosion resistance.)



*vs. Hg/HgO reference electrode

Thermal Treatments

Forging: 2100°F (1150°C) Do not forge below 1750°F (950°C).
Annealing: Heat to 1650°F (900°C), hold 2 hours, slow cool no faster than 25°F (15°C) per hour to 1100°F (595°C), then furnace cool or cool in still air to room temperature.
Annealed Hardness: About BHN 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.
Straightening: Best done warm 400-800°F (200-425°C)

Hardening

Preheat: Heat to 1550-1600°F (845-870°C) Equalize.

Austenitize: 1900-2000°F (1035-1095°C), hold time at temperature 15-30 minutes.

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).

Temper: Double temper at 400-750°F (200-400°C). Hold for 2 hours minimum each time. (See Table) A freezing treatment may be used between the first and second tempers. Freezing treatments help to attain maximum hardenability and must always be followed by at least one temper.
NOTE: For optimum stress relieving, CPM S35VN may be tempered at 1000-1025°F (540-550°C). Tempering in this range may result in a slight decrease in corrosion resistance.

Size Change: +0.05 to +0.10% when fully martensitic. The presence of retained austenite may reduce the net growth. When tempering at 400-750°F (200-400°C), freezing treatments may be necessary to minimize retained austenite.

Recommended Heat Treatment:

Austenitize 1950°F (1065°C). Quench to below 125°F (50°C). Double temper at 600°F (315°C) 2 hrs. minimum each temper. Cool to hand warm between tempers. A freezing treatment may be added between tempers.
Aim hardness: 58-61 HRC.

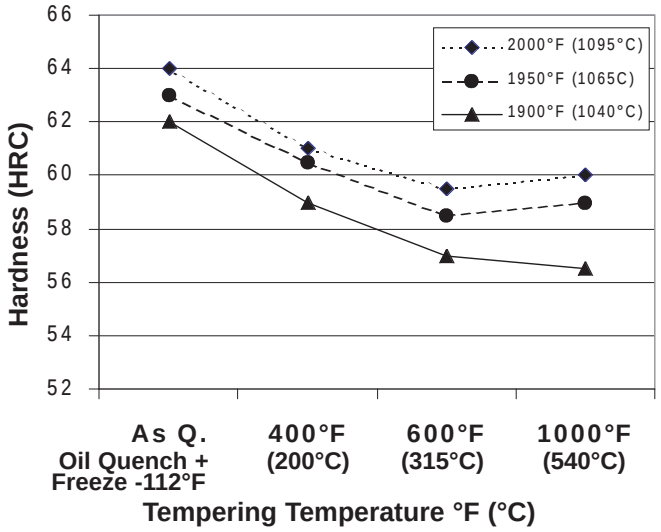
Note: Properties shown throughout this data sheet are typical values. Normal variations in chemistry, size and heat treat conditions may cause deviations from these values.

Heat Treat Response - Hardness (HRC)

	Austenitizing Temperature					
	1900°F (1040°C)		1950°F (1065°C)		2000°F (1095°C)	
Tempering Temperature	Oil	Oil + Freeze -112°F	Oil	Oil + Freeze -112°F	Oil	Oil + Freeze -112°F
As Quenched	60.5	62	62	63	63.5	64
400°F (200°C)	57.5	59	57.5	60.5	59.5	61
600°F (315°C)	57.5	57	59	58.5	59	59.5
1000°F (540°C)	57	56.5	59.5	59	58.5	60

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.

Minimum Time at Aust. Temp.	30 min.	30 min.	15 min.
Minimum Number of Tempers	2	2	2



Machinability and Grindability

In the annealed condition, CPM S35VN is much easier to machine than CPM S90V and easier to machine than CPM S30V. Similar grinding equipment and practices used for high speed steels are recommended. "SG" type alumina wheels or CBN wheels have generally given the best performance with CPM steels.

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