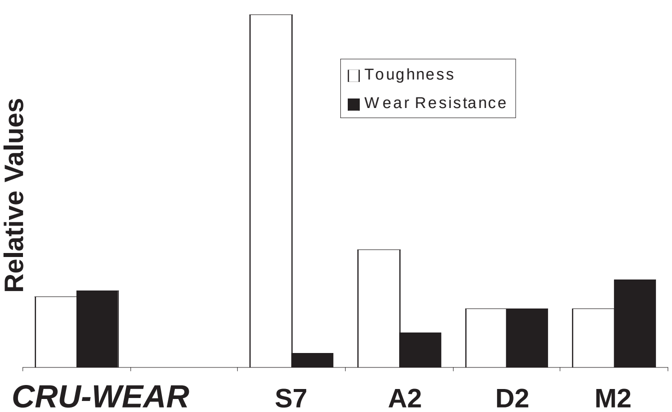
CRUCIBLE

CRU-WEAR is an air-hardening tool steel, heat treatable to HRC 60-65. Designed as an upgrade to D2, it offers better wear resistance, greater toughness and higher attainable hardness. Compared to the chemistry of D2, (D2 = 1.55% carbon, 11.5% chromium, 0.8% vanadium, and 0.9% molybdenum), CRU-WEAR has less carbon and less chromium, but more vanadium and tungsten. Both D2 and CRU-WEAR contain carbides for wear resistance, but CRU-WEAR has more vanadium carbides than D2. Vanadium carbides are harder than chromium carbides and are much more effective in providing wear resistance. Because CRU-WEAR contains less carbon than D2, its overall carbide volume is lower, making it tougher than D2. (Note: Although CRU-WEAR contains fewer total carbides, it has more of the type of carbides that are most effective for wear resistance.) CRU-WEAR's higher attainable hardness results from the fact that it contains sufficient tungsten and molybdenum to cause a secondary hardening response, (up to HRC 65), which does not occur in D2. Finally, CRU-WEAR tempers at a higher range (900-1050°F) than D2 (400-600°F), so it is more compatible with a wide variety of surface treatments.

Tool Steel Comparagraph



Typical Applications

- Stamping or Forming Tools
- Rolls
- Thread Rolling Dies
- Lamination Dies
- Industrial Knives and Slitters
- Fineblanking Tools
- Wear Parts
- Plastic Injection Feeder Screws and Tips
- Punches and Dies
- Blanking Dies
- Coining Dies
- Trim Dies
- Shear Blades
- Scrap Choppers
- Tire Shredders

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

DATA SHEET

CRU-WEAR®

Issue #1

Carbon	**1.1%**
Chromium	**7.5%**
Vanadium	**2.4%**
Tungsten	**1.15%**
Molybdenum	**1.6%**

Physical Properties

Elastic Modulus	30 X 10^6 psi	(207 GPa)
Density	0.28 lbs./in^3	(7.8 g/cm^3)

Thermal Conductivity

	BTU/hr-ft-°F	W/m-°K	cal/cm-s-°C
at 200°F (95°C)	13.6	23.5	0.056

Coefficient of Thermal Expansion

	in/in/°F	mm/mm/°C
70-600°F (20-325°C)	6.2X10^{-6}	(11.2X10^{-6})

Mechanical Properties

Wear Resistance

CRU-WEAR offers better wear resistance than AISI D2, approaching that of AISI M2.

Impact Toughness

CRU-WEAR has greater toughness than AISI D2, approaching that of AISI A2.
NOTE: Lowering the hardening temperature reduces the grain size and increases toughness.

	Heat Treatment(1) Austenitizing Temperature	HRC	Impact Toughness(2) ft.-lb.	(J)	Wear Resistance(3) Adhesive
Cru-Wear	**1950°F (1065°C)**	**62**	**30**	**(40)**	**5-6**
S7	**1750°F (955°C)**	**57**	**125**	**(165)**	**1**
A2	**1750°F (955°C)**	**60**	**40**	**(53)**	**2-3**
D2	**1850°F (1010°C)**	**60**	**21**	**(28)**	**3-4**
M2	**2050°F (1025°C)**	**62**	**20**	**(27)**	**8-10**

(1) Heat Treatment: Austenitized as indicated and tempered to hardness.
(2) Charpy C-Notch Impact Test
(3) Crossed cylinder adhesive wear test (higher number = better wear resistance)

Machinability

Machinability of CRU-WEAR in the annealed condition is similar to D2 but grindability will be slightly better. Similar grinding equipment and practices are acceptable. "SG" type alumina wheels or CBN wheels have generally given the best performance.

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Thermal Treatments

Annealing: Heat to 1550-1650°F (840-900°C), hold 2 hours, slow cool 50°F (25°C) per hour to 1200°F (650°C).

Annealed Hardness: About BHN 225/255

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

Hardening

It is customary to use two furnaces: one furnace to pre-heat and the second furnace to austenitize. This ensures that the transition from the pre-heat temperature to the austenitizing temperature occcurs fairly rapidly.

Preheat: Heat to 1550-1600°F (840-870°C) Equalize.

Austenitize: 1850-2050°F (1010-1120°C), Hold time at temperature 20-45 minutes.

Quench: Air or positive pressure quench (2 bar minimum) to below 125°F (50°C) Salt bath treatment, if practical will ensure the maximum attainable toughness for a given hardening treatment.

Temper: 900-1050°F (480-565°C).

Double tempering is mandatory, and triple tempering is recommended. Cool to room temperature in between tempers. Temper 2 hours minimum each time or at least 1 hour per inch (25mm) of thickness for sections over 2" (50mm) thick.

Size Change: Approx. +0.15%

Recommended Heat Treatment: For the best combination of toughness and wear resistance, austenitize at 1950°F (1065°C). Temper 3 times at 1000°F (540°C).

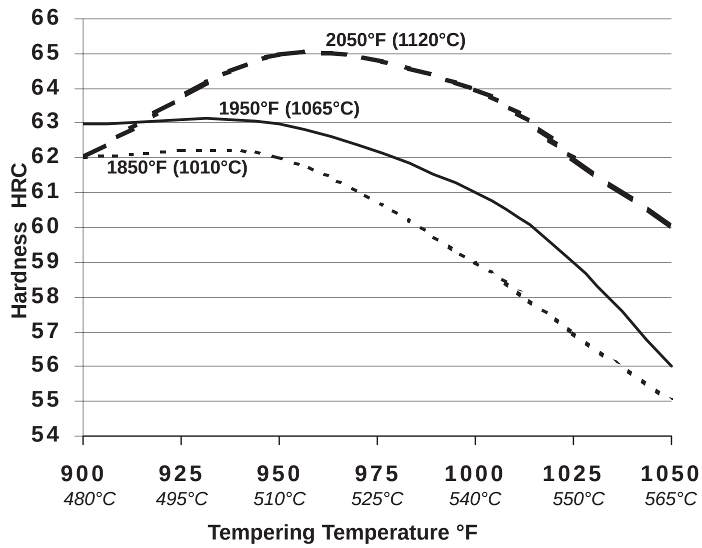
Aim hardness: HRC 62 Higher austenitizing temperatures can be used to obtain higher hardness, at a slight decrease in impact resistance. The lower austenitizing temperatures provide the best impact toughness.

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

Tempering Temperature	Hardness HRC Austenitizing Temperature 1850°F (1010°C)	1950°F (1065°C)	2050°F (1120°C)
Minimum Time at Austenitizing Temp.	45 minutes	30 minutes	20 minutes
As Quenched	63-65	63-65	62-64
900°F (480°C)	61-63	62-64	61-63
950°F (510°C)	61-63	62-64	64-66
1000°F (540°C)	57-59	60-62	63-65
1025°F (550°C)	56-58	58-60	61-63
1050°F (565°C)	54-56	55-57	59-61

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 (900-1050°F) CRU-WEAR is suitable for nitriding, PVD coating or similar surface treatments. It will retain its hardness after such processes, making it a more suitable substrate than D2. NOTE: CVD coating processes are generally performed at temperatures which exceed the critical temperature and may result in non-predictable dimensional distortion.

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