CRUCIBLE

DATA SHEET

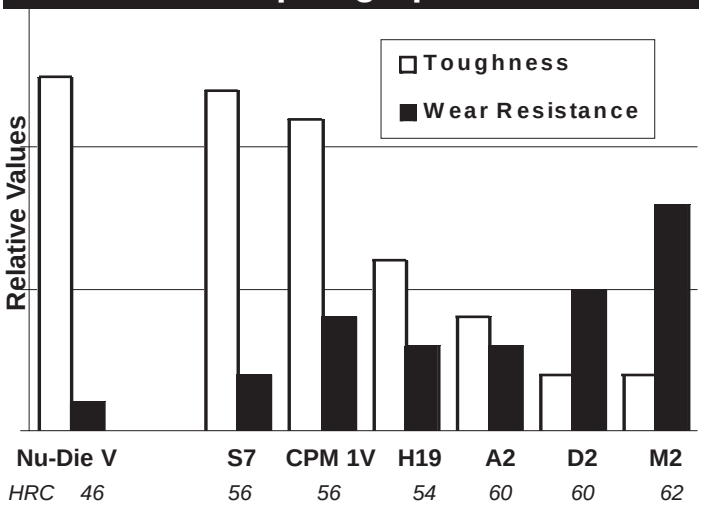
Nu-Die® V (AISI H13)

Issue #1

Nu-Die® V (AISI H13) has been the most popular, and perhaps the most versatile hot work tool steel available for many years. It provides a good balance of toughness, heat check resistance and temper resistance, along with moderate wear resistance. It is air hardenable and is used in most applications in the heat treated condition at HRC 44-52. The normal tempering temperatures for Nu-Die V are quite high (>1000°F, 540°C), allowing it to retain its heat treated hardness and strength while in service at elevated temperatures. Nu-Die V may be used for tool temperatures up to about 1000°F (540°C) with brief exposures up to 1100°F (595°C), making it ideal for forging dies, hot extrusion tooling, and die casting dies. Crucible offers two premium versions, Nu-Die XL and Nu-Die ESR, for applications requiring critical polishability, improved heat check resistance and better transverse toughness.

Carbon	**0.40%**
Silcon	**1.00%**
Chromium	**5.20%**
Molybdenum	**1.30%**
Vanadium	**0.95%**

Tool Steel Comparagraph



Typical Applications

Extrusion Tooling	Forging Dies
Die Casting Dies	Die Inserts
Bolsters	Dummy Blocks
Shot Sleeves/Plungers	Mandrels
Core Pins	Ejector Pins

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

Physical Properties

Elastic Modulus	30 X 10^6 psi	(207 GPa)
Density	0.280 lbs./in^3	(7.75 g/cm^3)

Thermal Conductivity

	BTU/hr-ft-°F	W/m-°K	cal/cm-s-°C
at 200°F (95°C)	15	26.0	0.062
at 600°F (315°C)	16	27.7	0.066

Coefficient of Thermal Expansion

	in/in/°F	mm/mm/°C
70-200°F (20-95°C)	6.1 X10^{-6}	(11.0 X10^{-6})
70-400°F (20-205°C)	6.4 X10^{-6}	(11.5 X10^{-6})
70-800°F (20-425°C)	6.8 X10^{-6}	(12.2 X10^{-6})
70-1000°F (20-540°C)	7.0 X10^{-6}	(12.6 X10^{-6})
70-1200°F (20-650°C)	7.3 X10^{-6}	(13.1 X10^{-6})

Mechanical Properties

The practice of pre-heating Nu-Die V tooling prior to elevated temperture service will greatly improve its toughness as shown by the following high temperature Charpy V-Notch test data:

Effect of Elevated Temperature on Impact Toughness:

Austenitized 1850°F (1010°C) Air Cool. Double tempered to hardness indicated, i.e. original HRC at Room Temperature. Charpy V-Notch specimens subsequently heated to test temperature as shown.

Original Hardness at R.T. HRC	Impact Toughness in ft-lbs. *(J)* Charpy V-Notch Test Temperature				
	R.T. *(21°C)*	500°F *(260°C)*	1000°F *(540°C)*	1050°F *(565°C)*	1100°F *(595°C)*
52	10 *(14)*	22 *(30)*	25 *(34)*	25 *(34)*	---
47	18 *(24)*	30 *(41)*	33 *(45)*	---	32 *(43)*
43	18 *(24)*	38 *(51)*	44 *(60)*	---	42 *(57)*

Machinability

The machinability of Nu-Die V in the annealed condition is about 70% of W1 tool steel.

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Thermal Treatments

Annealing: Heat to 1600°F (870°C), hold 2 hours, slow cool 25°F (15°C) per hour to 1200°F (650°C) then air cool. OR heat to 1600°F (870°C), hold 2 hrs., cool to 1400°F (760°C) hold 6 hrs. then air cool.

Annealed Hardness: About BHN 192/235

Stress Relieving

Annealed Parts: Heat to 1200-1250°F (650-675°C), hold 2 hours, then cool in still air to room temperature.

Hardened Parts: Heat to 25-50°F (15-25°C) below the original tempering temperature, hold 2 hours, then cool in still air to room temperature.

Hardening

Critical Temperature: 1560°F (850°C)
Preheat: Heat to 1100-1250°F (595-675°C), equalize, then to 1450-1550°F (790-845°C), equalize.
Austenitize: 1825-1875°F (995-1025°C), Hold time at temperature 30-45 minutes. *Hardening from the high end of the range will provide better resistance to softening but with a slight decrease in toughness.*
Quench: Air or positive pressure quench (2 bar minimum), salt or interrupted oil to below 150°F (65°C)
A minimum quench rate of about 50°F (25°C) per minute from 1800°F (980°C) down to below 1200°F (650°C) is recommended to achieve maximum impact toughness.
Temper: 1000-1200°F (540-650°C). Temper Twice. Temper 2 hours minimum each time or at least 1 hour per inch (25mm) of thickness. Air cool to room temperature.

Dimensional Change: Average dimensional change for normally heat treated Nu-Die V is about +0.06% (= a growth of 0.0006 in/in) when tempered in the range 1000-1150°F (540-620°C). Variations in the heat treating process will affect actual results.

Surface Treatments

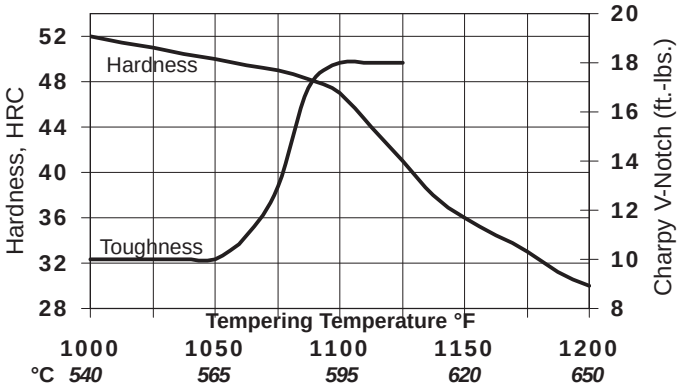
Nu-Die V may be nitrided or PVD coated. Because of its high tempering temperatures (>1000°F, >540°C), it will retain its hardness after such processes. As for most tool steels, higher temperature surface treatments, such as CVD, may result in dimensional distortion.

Heat Treat Response

Hardness and Impact Toughness Data

Austenitized 1850°F (1010°C) Air Cool, Double Tempered

Tempering Temperature	HRC	Charpy V-Notch(*) Ft. lbs.	Joules
1000°F (540°C)	**51-53**	**10**	**14**
1050°F (565°C)	**49-51**	**10**	**14**
1100°F (595°C)	**46-48**	**18**	**24**
1125°F (605°C)	**40-42**	**18**	**24**
1150°F (620°C)	**35-37**	**---**	**---**
1200°F (650°C)	**28-32**	**---**	**---**



(*) Longitudinal Toughness Measurements

Welding

Use H13, H11 or other hot work tool steel filler material.
Annealed Material: Preheat 800-1000°F (425-540°C). Maintain the temperature of the workpiece above 700°F (370°C) during welding. Reanneal after welding or temper at 1400°F (760°C) for 6 hours.
Hardened Material: Preheat 800-1000°F (425-540°C). Maintain the temperature of the workpiece above 700°F (370°C) during welding. Cool to hand warm, below 150°F (65°C), after welding. Retemper at 25-50°F (15-25°C) below original tempering temperature or 1000°F (540°C) minimum.

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.

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