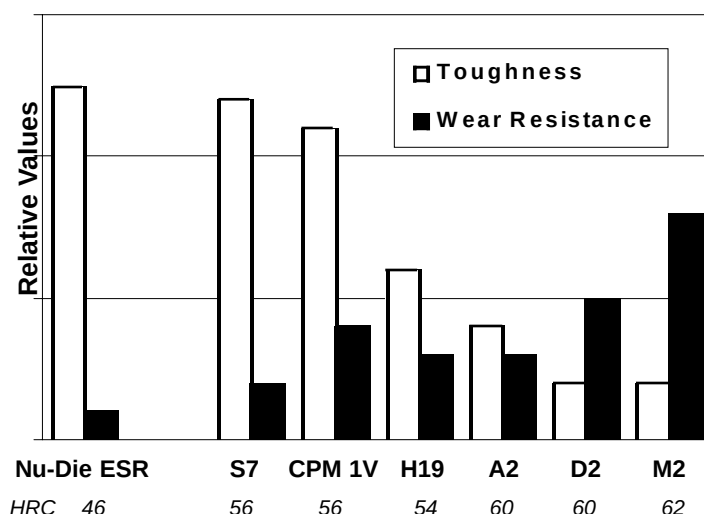


# CRUCIBLE

Nu-Die ESR (AISI H13) is a remelted version of H13 tool steel. It offers better transverse toughness than standard H13, reducing the susceptibility to breaking or cracking. Nu-Die ESR is double melted to improve its microstructural uniformity and microcleanliness, making it an excellent choice for critical polishability and more resistant to thermal fatigue. Nu-Die ESR can be used in any application where standard H13\* is used. Crucible stocks Nu-Die ESR primarily in round bar in the annealed condition.

*\*H13 is a versatile, air-hardenable hot work tool steel providing moderate wear resistance along with good toughness, good heat check resistance, and high temperature strength up to 1000°F (540°C), with brief exposures up to 1100°F (595°C).*

## Tool Steel Comparagraph



## Typical Applications

|                       |                   |
|-----------------------|-------------------|
| Forging Dies          | Extrusion Tooling |
| Bearer Rolls          | Hot Upset Dies    |
| Plastic Molds         | Fuel Injectors    |
| Core Pins             | Ejector Pins      |
| Mandrels              | Bolsters          |
| Die Casting Dies      | Die Inserts       |
| Shot Sleeves/Plungers | Dummy Blocks      |

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

# Crucible...

## The Tool Steel Pros®

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## DATA SHEET

### Nu-Die ESR (AISI H13)

Issue #1

|            |         |
|------------|---------|
| Carbon     | 0.40%   |
| Silicon    | 1.00%   |
| Chromium   | 5.20%   |
| Molybdenum | 1.30%   |
| Vanadium   | 0.95%   |
| Sulfur     | <0.005% |

## Physical Properties

|                             |                            |                           |             |
|-----------------------------|----------------------------|---------------------------|-------------|
| <b>Elastic Modulus</b>      | 30 X 10 <sup>6</sup> psi   | (207 GPa)                 |             |
| <b>Density</b>              | 0.280 lbs./in <sup>3</sup> | (7.75 g/cm <sup>3</sup> ) |             |
| <b>Thermal Conductivity</b> |                            |                           |             |
|                             | 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 X 10 <sup>-6</sup> | (11.0 X 10 <sup>-6</sup> ) |
| 70-400° F (20-205° C)  | 6.4 X 10 <sup>-6</sup> | (11.5 X 10 <sup>-6</sup> ) |
| 70-800° F (20-425° C)  | 6.8 X 10 <sup>-6</sup> | (12.2 X 10 <sup>-6</sup> ) |
| 70-1000° F (20-540° C) | 7.0 X 10 <sup>-6</sup> | (12.6 X 10 <sup>-6</sup> ) |
| 70-1200° F (20-650° C) | 7.3 X 10 <sup>-6</sup> | (13.1 X 10 <sup>-6</sup> ) |

## Mechanical Properties

The practice of pre-heating Nu-Die ESR tooling prior to elevated temperature 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<br>Hardness<br>at R.T.<br>HRC | Impact Toughness in ft-lbs. (J)<br>Charpy V-Notch Test Temperature |                  |                   |                   |                   |
|----------------------------------------|--------------------------------------------------------------------|------------------|-------------------|-------------------|-------------------|
|                                        | R.T.<br>(21°C)                                                     | 500°F<br>(260°C) | 1000°F<br>(540°C) | 1050°F<br>(565°C) | 1100°F<br>(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 ESR in the annealed condition is about 70% of W1 tool steel.

## 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 ESR 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 ESR 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.

## Service Center Locations

| Location         | Phone        | Toll Free     | FAX          |
|------------------|--------------|---------------|--------------|
| Auburn, MA       | 508-832-5353 | 800-365-1101  | 508-832-2217 |
| Charlotte, NC    | 704-372-3073 | 800-365-1160  | 704-342-0985 |
| Chicago, IL      | 630-378-0093 | 800-365-1151  | 630-378-1965 |
| Cincinnati, OH   | 513-771-1310 | 800-365-1163  | 513-771-0119 |
| Cleveland, OH    | 330-562-3131 | 800-365-1132  | 330-562-7818 |
| Columbus, OH     | 614-262-4959 | 800-365-1131  | 614-262-7850 |
| Dallas, TX       | 817-649-2800 | 800-365-1168  | 817-633-8142 |
| Detroit, MI      | 248-528-0332 | 800-365-1133  | 248-528-1977 |
| Grand Rapids, MI | 616-554-9699 | 800-365-1137  | 616-554-9328 |
| Huntsville, AL   | 256-772-0201 | 800-365-1161  | 256-772-3361 |
| Indianapolis, IN | 317-638-4501 | 800-365-1146  | 317-634-7375 |
| Los Angeles, CA  | 714-632-1131 | 800-365-11797 | 714-632-1181 |

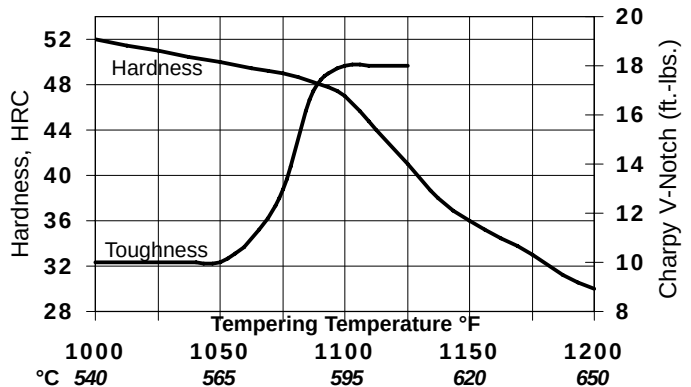


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## Heat Treat Response

### 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. For additional data or metallurgical engineering assistance, consult your local Crucible Service Center.*

| Location             | Phone           | Toll Free    | FAX                    |
|----------------------|-----------------|--------------|------------------------|
| Meadville, PA        | 814-337-8804    | 800-365-0530 | 814-337-8808           |
| Milwaukee, WI        | 262-781-6710    | 800-242-0948 | 262-781-6743           |
| Minneapolis, MN      | 612-331-6320    | 800-365-1153 | 612-331-4137           |
| St. Louis, MO        | 636-272-7220    | 877-201-4049 | 636-978-9559           |
| <b>Canada</b>        |                 |              |                        |
| Wallaceburg, ONT     | 519-627-2245    | 800-265-5293 | 519-627-2247           |
|                      |                 |              | Toll Free 888-701-4287 |
| <b>Mexico (SISA)</b> |                 |              |                        |
| Monterrey, N.L.      | 52-81-8351-7220 |              | 52-81-8351-2981        |
| Naucalpan, E de M    | 52-55-5576-4011 |              | 52-55-5360-1865        |

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