



NESSteel Inc.

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High Carbon/Chrome Steel AISI D-2

D-2 is an air-hardening, high carbon/chromium steel with great hardness and resistance to abrasion D-2 is also practically free of change in size or shape after proper heat treatment. Typical analysis is shown in the chart below:

Carbon	Silicon	Manganese	Chromium	Molybdenum	Vanadium
1.50%	0.3%	0.50%	12.00%	0.80%	0.90%

D-2 is used in applications requiring sharp cutting edges, wear and pressure resistance. Typical applications are

- Taps
- Drawing Dies
- Forming/Blanking Dies
- Trimming Dies
- Coining Dies
- Gages
- Master Tools
- Thread Rolling Dies

Heat Treatment

Forging:

- Preheat slowly to 1300°F - 1400° F until piece is thoroughly heated through, then increase heat to 1850°F - 1925°F.
- DO NOT hot work D-2 below 1700°F - reheat as necessary.
- After finish forging, allow D-2 to equalize to approximately 1400°F - 1500°F and then cool slowly in ashes, lime, etc.
- Anneal as soon as possible.

Annealing

- Surface protection - Anneal in controlled atmosphere furnace or pack in an inert material.
- Slowly heat D-2 to 1550° - 1600°
- Allow to cool at rate of 20°F per hour to 1000°F.
- Remove from furnace at 600°F, and allow to air cool.
- Annealed hardness ranges between 210 - 240 Brinell.

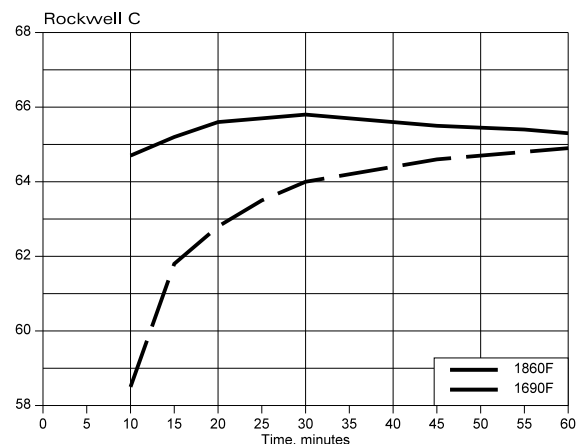
Stress Relieving

- Hold tool at 1200°F - 1300°F for 1 - 2 hours, cool slowly in furnace to 900°F, then air cool to eliminate distortion in hardening.

Hardening:

- Pack in inert mat'l or use controlled atmosphere furnace/
- Pre-heat slowly to 1200°F - 1250°F, and ensure equal temperature throughout the piece.
- Increase heat more rapidly to 1825°F-1875°F.
- Hold steel at temperature for one hour per inch of maximum thickness.
- Remove the piece from the furnace (or the container, if packed), allow to cool in still air or mild dry air blast to 150°F. Temper at once.
- For extremely large pieces, oil quenching may be used to achieve higher hardness and wear resistance. Quench at 1800°F, hold in oil bath until piece reaches 1000°F - 1200°F, remove and allow to cool in air. Oil temperature should be 150°F.

Holding Time Effect



Tempering

- Temper immediately when piece reaches 150°F or when comfortably hand-held.
- Tempering Temperatures vary by tool usage:
 - 350°F- maximum compressive strength
 - 400°F- maximum hardness and wear resistance
 - 550°F- good toughness/hardness balance
 - 900-950°F- good toughness, no size change
- Heat slowly to temperature, hold tools at heat for 2 hours per inch of maximum thickness.

Tempering, continued

- Avoid tempering temperature range of 600 - 750°F because of decreased ductility.

Tempering Temperature,	Rockwell C
300	63
400	61
500	59.5
600	59
700	59
800	59.5
900	59
1000	59

Air quenched from 1850°F for 2 hours

Physical & Mechanical Properties (approx)

- Density, lb per cu in: .2778
- Specific gravity 7.69
- Critical points:
Heating (Ac) 100°/hr - begins 1490°F; ends 1525°F
Cooling (Ar) 50°/hr - begins 1440°F; ends 1415°F

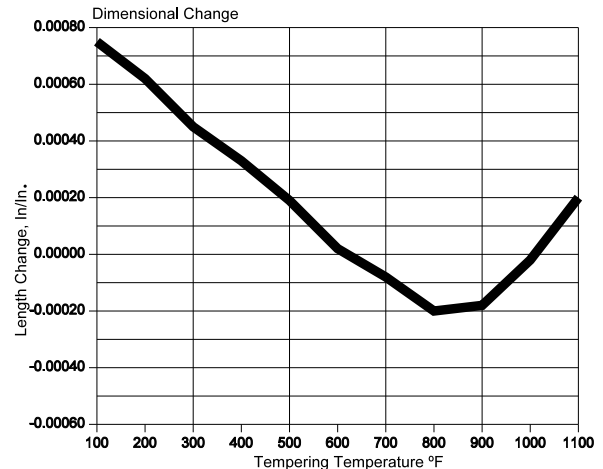
Sub-Zero Treatment

- Chilling to -60°F after cooling from hardening temperature results in very high hardness.
- Dimensions expand approximately 0.002 inches.
- Tempering at 300°F or 400°F result in Rc 65 or 63.

Mean Thermal Coefficient of Expansion

Range °F	Coefficient in./in./°F	Range °F	Coefficient in./in./°F
70-200	5.77 x 10 ⁻⁶	70-900	6.86
70-300	6.09	70-1000	6.99
70-400	6.36	70-1100	7.09
70-500	6.40	70-1200	7.17
70-600	6.51	70-1300	7.24
70-700	6.75	70-1400	7.29
70-800	6.85	70-1499	7.41

Dimensional Changes on Hardening, in/in.



IZOD Impact Properties

- Test samples prepared from 1/2 inch square annealed bars.
- Samples were tempered for 20 minutes at 1850°F and air-cooled.
- Samples were wet-ground to .394 inch square, and were tested in a 120 ft-lb machine. Each value is an average of 4 individual tests.

Tempering Temperature, °F	Energy Absorbed, Ft-lb	Hardness, Rockwell C
None	24	63.5
300	40	62
400	66	60.5
500	66	58.5
600	66	57.5
700	71	57
800	88	56.5
900	70	56.5
1000	52	57
1100	71	51.5
1200	89	43.5

Compression Properties

Tempering Temperature, °F	Compressive Strength, psi	Hardness, Rc
300	504,000	625
900 + 900	506,500	585
Tempering Temperature, °F	Compressive Strength, psi	Hardness, Rc
300	558,500	63
900 + 900	521,000	60

Samples were .505 inch diameter, preheated at 1100°F, oil-quenched from 1450°F, tempered 2 hours to indicated temperatures. Samples were compressed in 100,000 lb capacity test machine.

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