

CRUCIBLE 17Cr-4Ni SUPER-X® Data Sheet

Issue #1

CRUCIBLE 17Cr-4Ni SUPER-X is a version of 17Cr-4Ni which has been modified to substantially improve machinability and other properties. Patented 17Cr-4Ni SUPER-X meets industry specifications for 17Cr-4Ni. The machinability improvement, of up to 45% over conventional solution-treated (Condition A) 17Cr-4Ni material, has been achieved by close control of the chemical composition within the standard range.

CRUCIBLE 17Cr-4Ni SUPER-X shows a significant improvement in ductility in all conditions, especially the solution-treated condition. In addition, the steel is markedly tougher than conventional 17Cr-4Ni as measured by Charpy impact tests.

CRUCIBLE 17Cr-4Ni SUPER-X is a precipitation-hardening stainless steel which is capable of high strength and hardness levels after a relatively simple heat-treatment. This grade is martensitic and magnetic in both the solution-treated and precipitation-hardened conditions. It has high resistance to crack propagation, and its corrosion resistance is normally superior to the regular martensitic chromium-type of stainless steel. Because of the single low-temperature (900 to 1150°F) precipitation-hardening heat treatment of this grade, scaling and distortion are virtually eliminated. This enables material to be finish machined to close tolerances prior to heat treatment.

Specifications

CRUCIBLE 17Cr-4Ni SUPER-X meets the following specifications:

AMS 5643	QQ-S-763
MIL-S-862	ASTM A-564
UNS S 17400	NACE MR-01-75

Note: Temperatures shown throughout this data sheet are metal temperatures.

Typical Composition

Carbon	0.02%
Chromium	15.25%
Nickel	4.80%
Silicon	0.50%
Copper	3.50%
Manganese	0.60%
Phosphorus	0.025%
Columbian plus	
Tantalum	0.20%
Sulfur	0.02%
Nitrogen	0.015%
Iron	Balance

Typical Applications

Valves	Bolts
Motor shafts	Fasteners
Propeller shafts	Instrument parts
Pump parts	Forgings
Ball bearings	Aircraft parts
Gears	Load cells
Turbine blades	

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

Machining

CRUCIBLE 17Cr-4Ni SUPER-X machines better than conventional 17Cr-4Ni, particularly in the solution-treated condition, as shown in Figures 1 and 2.

CRUCIBLE 17Cr-4Ni SUPER-X can be readily machined in both the solution-treated (Condition A) and the precipitation hardened conditions. Suggested machining parameters are given on page 2. One of the advantages of this grade is that it can be machined to close tolerances in Condition A prior to the precipitation hardening treatment. The low-hardening temperatures of CRUCIBLE 17Cr-4Ni SUPER-X cause only a thin discoloration film and a dimensional contraction of 0.0004 to 0.0006" per inch.



Machining Data

Solution-Treated (Condition A)

Operation	Tool Width or Depth of Cut (in)	CRUCIBLE 17Cr-4Ni SUPER-X High Speed Tooling		Carbide Tooling	
		Speed (fpm)	Feed* (in/rev)	Speed (fpm)	Feed* (in/rev)
Turning single point	0.050	110	0.0055	240	0.010
	0.250	100	0.0050	240	0.020
	0.500	95	0.0045	210	0.025
Forming	1/2 wide	110	0.0015	215	0.0022
	1 wide	100	0.0012	205	0.0022
	1½ wide	100	0.0012	205	0.0020
	2 wide	95	0.0010	190	0.0015
Cutoff	1/16 wide	95	0.0015	190	0.0020
	1/8 wide	95	0.0015	190	0.0020
	3/16 wide	100	0.0015	205	0.0022
	1/4 wide	100	0.0020	205	0.0030
Drilling	1/16 dia.	60	0.0015		
	1/8 dia.	60	0.0020		
	1/4 dia.	60	0.0030		
	1/2 dia.	60	0.0035		
	3/4 dia.	65	0.0040		
	1 dia.	65	0.0050		
Threading†		10-20			
Tapping†		10-20			

†Use the higher speeds for the finer threads.

*In certain machining operations, increased feeds may enhance the chip characteristics of 17Cr-4Ni SUPER-X.

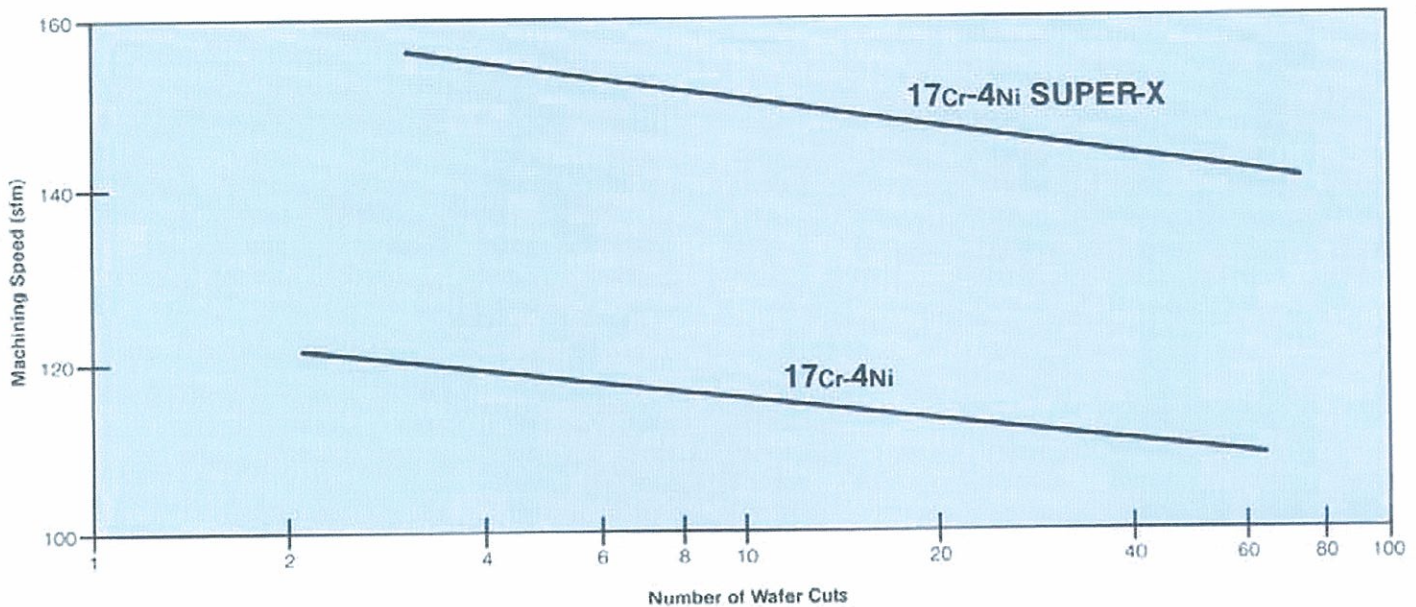


Figure 1. Tool Life Test as Solution-Treated (Condition A)

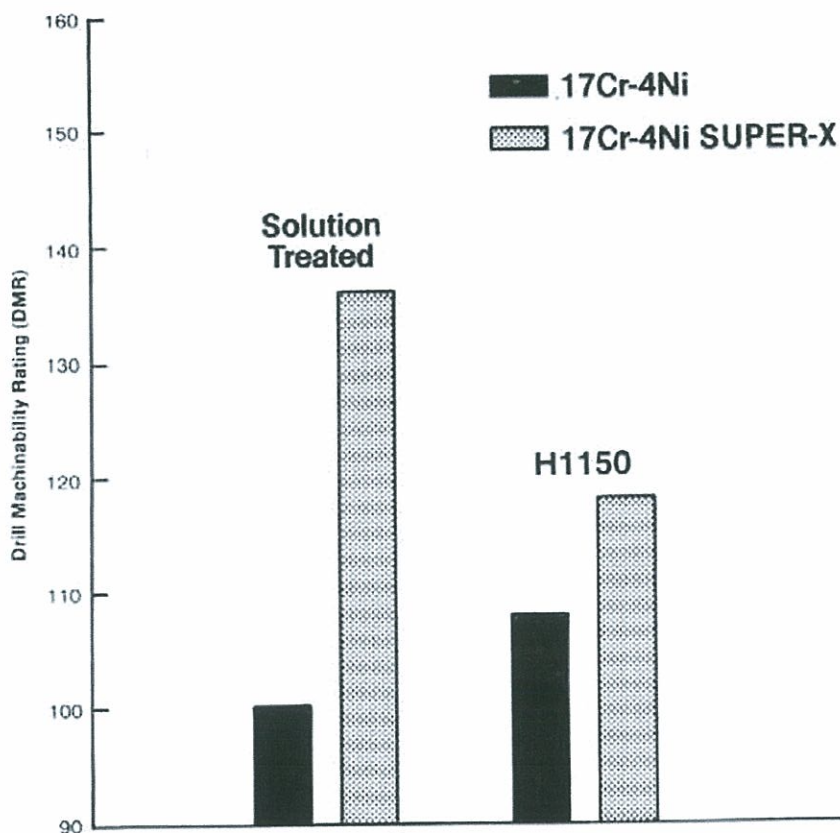


Figure 2. Drill Machinability Tests

$$\text{DMR} = \frac{\text{Total Drill Time (Standard)}}{\text{Total Drill Time of Test}} \times 100$$
. Where standard was 17Cr-4Ni solution-treated.

Corrosion Resistance

CRUCIBLE 17Cr-4Ni SUPER-X exhibits excellent corrosion resistance when exposed to a wide variety of corrosive media. It has the best corrosion resistance of the martensitic stainless steels and compares favorably to Type 304.

CRUCIBLE 17Cr-4Ni SUPER-X is highly resistant to stress-corrosion cracking when hardened at temperatures of 1000°F and higher. This is important for applications where parts have a high level of internal tension stress due to cold deformation after hardening or to weld-

ing without subsequent stress relieving. Environments that contain hydrogen sulfide or high concentrations of chlorides can also cause stress-corrosion cracking.

Results of sulfide stress cracking tests (NACE Standard Test Method TM-01-77) show that under a given applied stress, H-1150M aged materials are more resistant to stress-corrosion cracking than double H-1150 aged materials. In the H-1150M aged condition, the threshold stress level for 17Cr-4Ni SUPER-X is 25% greater as shown in Figure 3.

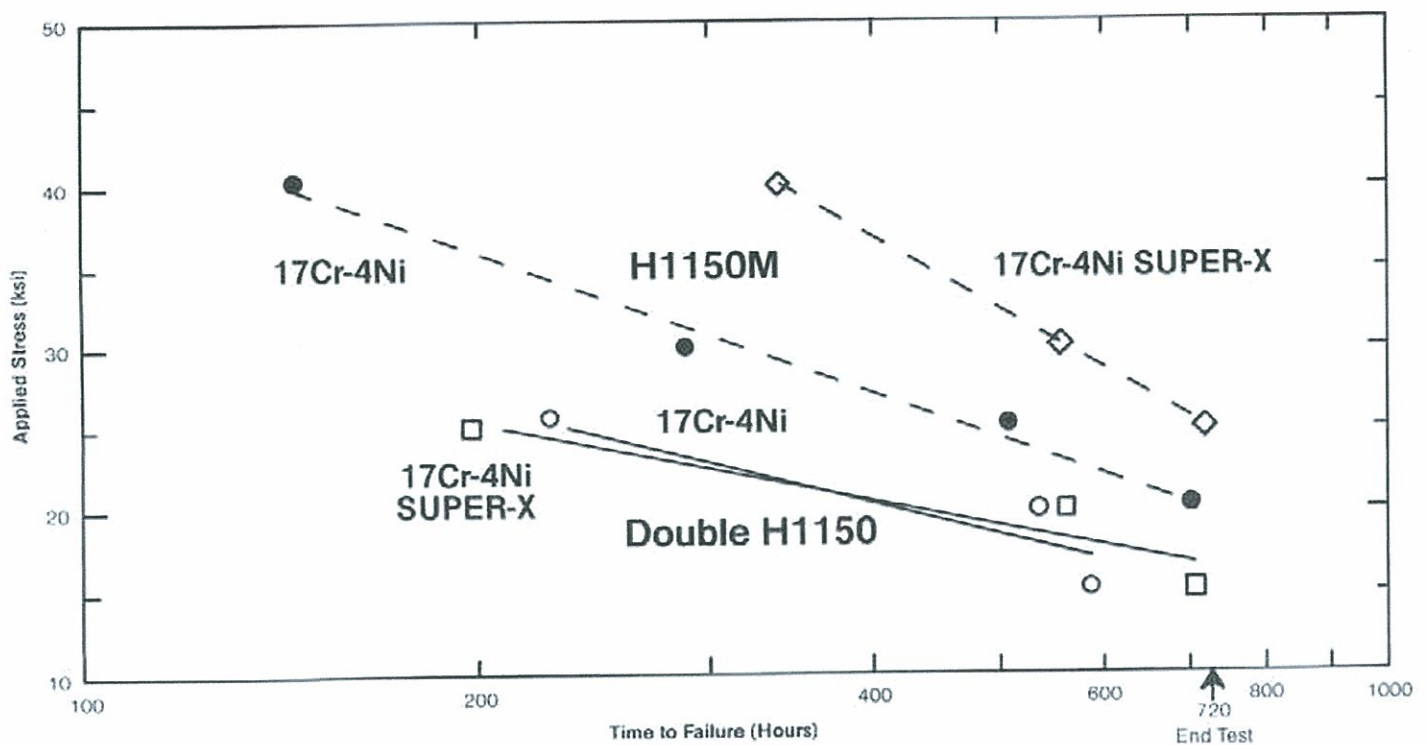


Figure 3.
Average sulfide stress cracking results of double H1150 and H1150M age hardened 17Cr-4Ni and 17Cr-4Ni SUPER-X; NACE TM-01-77.

Physical Properties

	Condition			
	A (Magnetic)	H900 (Magnetic)	H1075 (Magnetic)	H1150 (Magnetic)
Density (grams/cu cm) (lbs/cu inch)	7.78 .280	7.80 .282	7.81 .283	7.82 .284
Electrical resistivity (microhm-cm)	98	77	—	—
Mean coefficient of thermal expansion (inches/inch/°F x 10-6)				
-100/70°F	—	5.8	—	6.1
70/200°F	6.0	6.0	6.3	6.6
70/400°F	6.0	6.0	6.5	6.9
70/600°F	6.2	6.3	6.6	7.1
70/800°F	6.3	6.5	6.8	7.2
Thermal conductivity (Btu/hr/sq ft per inch per°F)				
300°F	—	124	—	—
500°F	—	135	—	—
860°F	—	156	—	—
900°F	—	157	—	—
Specific heat (Btu/lb/°F)				
32/212°F	0.11	0.11	—	—
Modulus of elasticity (psi)				
Tension	—	28.5 x 10 ⁶	—	—
Torsion	—	11.2 x 10 ⁶	10.0 x 10 ⁶	10.0 x 10 ⁶

Typical Mechanical Properties*

Room temperature, longitudinal direction

	Condition							
	A	H900	H925	H1025	H1075	H1100	H1150	H1150-M
Tensile strength-(p.s.i.)	135,000	200,000	190,000	170,000	165,000	150,000	145,000	125,000
0.2% Yield strength-(p.s.i.)	108,000	185,000	175,000	165,000	150,000	135,000	125,000	85,000
Elongation in 2 in. (%)	15	16.0	16.0	17.5	18.0	19.0	21.0	24.0
Reduction of area (%)	63	60.0	62.0	63.0	65.0	67.0	73.0	71.0
Hardness								
Rockwell C	30	44	42	38	36	34	33	27
Brinell	302	420	409	352	341	332	311	277
Impact strength								
Charpy V-notch (ft. lbs.)	100	18	37	40	43	60	98	125
Fatigue strength-(p.s.i.)								
10 million cycles		90,000	88,000	84,000			87,000	—
100 million cycles		77,000	77,000				84,000	—

*Data obtained from 1" Rd. mill-produced bar

Forging

Forging stock is normally supplied in the overaged condition to eliminate the possibility of strain cracking in large sections. CRUCIBLE 17Cr-4Ni SUPER-X should be forged at 2150 to 2200°F. Heating practices are similar to those of the other hardenable stainless steels except that it is recommended to heat fairly rapidly through the 1750 to 1850°F temperature range. It is also not good practice to hot work the steel in this temperature range. After forging, sections should be cooled to room temperature. Material that is hot worked or forged must be solution treated prior to hardening.

Welding

CRUCIBLE 17Cr-4Ni SUPER-X is readily welded by conventional practices. No preheating treatment is required with this grade. Any of the arc and resistance welding processes used on the regular grades of stainless steel are applicable to CRUCIBLE 17Cr-4Ni SUPER-X. Properties comparable to those of the parent metal can be secured in the weld by applicable postweld heat treatment. Weld filler metal of a 17Cr-4Ni composition is utilized when it is desired to obtain properties comparable to those of the base metal. Austenitic stainless steel weld filler metal may be used when high strength at the weld is not needed.

Discoloration on Aging

When CRUCIBLE 17Cr-4Ni SUPER-X is purchased in the solution-treated condition and fabricated by machining, a simple low-temperature (900 to 1175°F) precipitation-hardening heat treatment is required. Parts are lightly discolored or heat tinted when subjected to the final hardening treatment. The light discoloration may be removed by dipping in a 10% nitric—2% hydrofluoric acid (by volume) solution at 110 to 140°F. It can also be removed by electropolishing.

Nitriding

17Cr-4Ni SUPER-X can be nitrided using methods designed for stainless steels. However, any prolonged exposure to high temperature may result in mechanical properties equivalent to aging at that temperature. For this reason, the temperature of the nitriding process must be controlled to prevent undesirable aging from occurring. For example, if a minimum hardness of 40 HRC is required, the nitriding must be performed at 975°F or lower. In general, if the material has been age hardened, nitriding should be performed at or below the age hardening temperature. If desired, the nitriding procedure itself may be used to simultaneously age harden the material.

Passivating

Parts to be passivated should be cleaned and free of scale. Use a 20% nitric acid solution to which has been added 1½-2½% sodium dichromate. At a bath temperature of 150°F, the parts should be immersed for 30 minutes, followed by a water rinse.

Heat Treatment

As shipped from the mill, CRUCIBLE 17Cr-4Ni SUPER-X is usually in the solution-treated condition (Condition A) ready for fabrication and subsequent precipitation hardening by the user. However, it can also be supplied hardened

or in overaged conditions for cold heading or forging if desired.

The heat treatment of CRUCIBLE 17Cr-4Ni SUPER-X consists of a solution treatment (1900°F, 30 minutes, air cool or oil quench) and a precipitation-hardening or aging treatment (900 to 1150°F, 1 to 4 hours, air cool).

Material supplied in the solution-treated (Condition A) condition can be heat treated at different temperatures to develop a wide range of properties. A number of standard heat treatments have been developed as outlined in the table below.

Heat Treatments for 17Cr-4Ni SUPER-X in Solution-Treated Condition

Condition	Precipitation Hardening Temperature (°F)	Hardening Time (hr)	Typical Hardness	
			Cooling	(Rc)
H 900	900	1	Air	44
H 925	925	4	Air	43
H1025	1025	4	Air	38
H1075	1075	4	Air	36
H1100	1100	4	Air	35
H1150	1150	4	Air	33
H1150-M	1400	2	Air	—
	1150	4	Air	28
Double H1150	1150	4	Air	—
	1150	4	Air	31

Stress-Rupture Strength—Condition H 900

Temperature °F	Time to rupture (hrs)	Strength (p.s.i.)	Elongation at rupture (% in 2")	Reduction of area (%)
600°F	100	164,000	3	7
	1000	158,000	2	6
700°F	100	156,000	3	7
	1000	150,000	2	6
800°F	100	140,000	4	8
	1000	128,000	4	6
900°F	100	95,000	5	9
	1000	60,000	12	25

Guaranteed Minimum Properties*

Property	Condition									
	A	H900		H925		H1025	H1075	H1100	H1150	H1150-M
		Up to 3" Incl.	Over 3" to 8"	Up to 3" Incl.	Over 3" to 8"	Up to 8"	Up to 8"	Up to 8"	Up to 8"	Up to 8"
UTS, ksi	—	190	190	170	170	155	145	140	135	115
0.2% YS, ksi	—	170	170	155	155	145	125	115	105	75
Elong. % in 2"	—	10.0	10.0	10.0	10.0	12.0	13.0	14.0	16.0	18.0
Reduction of Area, %	—	40.0	35.0	44.0	38.0	45.0	45.0	45.0	50.0	55.0
Hardness, Brinell	363 Max. or Equivalent	388/448	388/448	375/438	375/438	331/401	302/375	311/364	277/352	255/293
Rockwell	—	C40/47	C40/47	C38/45	C38/45	C35/42	C32/39	C31/38	C28/37	C24/30
Impact, Charpy V-Notch, ft.-lbs.	—	**	**	5	5	15	20	25	30	55

*These values are based on samples taken from mid-radius

**Minimum impact properties cannot be accepted in this condition

Elevated Temperature Properties

Property and Temperature	Condition			
	H900	H925	H1075	H1150
Tensile strength-(p.s.i.)				
Room temperature	200,000	190,000	165,000	145,000
600°F	173,000	165,000	138,000	124,000
800°F	162,000	155,000	128,000	116,000
1000°F	119,000	116,000	99,000	96,000
0.2% Yield strength-(p.s.i.)				
Room temperature	185,000	175,000	150,000	125,000
600°F	150,000	145,000	132,000	120,000
800°F	141,000	139,000	121,000	112,000
1000°F	106,000	103,000	94,000	93,000
Elongation (% in 2")				
Room temperature	14.0	14.0	16.0	19.0
600°F	10.0	12.0	9.0	12.0
800°F	10.0	10.0	10.0	13.0
1000°F	15.0	16.0	16.0	15.0
Reduction of area (%)				
Room temperature	50.0	54.0	58.0	60.0
600°F	31.0	32.0	38.0	54.0
800°F	21.0	34.0	30.0	43.0
1000°F	46.0	45.0	55.0	55.0

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



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