

# Crucible Data Sheet

Issue #1

CRUCIBLE 15-5 is a Premium Quality precipitation-hardening stainless steel which is capable of high strength and hardness levels after a relatively simple heat-treatment procedure. This grade is Vacuum Arc remelted for improved cleanliness. CRUCIBLE 15-5 is martensitic and magnetic in both the solution-treated and precipitation-hardened conditions. It has a high resistance to crack propagation, good transverse properties, and corrosion resistance is normally superior to the regular martensitic chromium-type stainless steel.

Because of the single low-temperature (900 to 1150°) 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.

## Typical Applications

Valves	Bolts
Motor Shafts	Fasteners
Propeller shafts	Instrument Parts
Pump parts	Forgings
Gears	Aircraft Parts
Storage Tanks	Ball bearings
Turbine Blades	

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

## Specifications

CRUCIBLE 15-5 meets the following specifications:

AMS 5659  
ASTM A-705 Forgings  
ASTM A-564—Type XM-12

## CRUCIBLE 15-5 STAINLESS STEEL

Carbon	0.07% max.
Silicon	1.00% max.
Phosphorus	0.04% max.
Chromium	14-15.50
Copper	2.5-4.50
Columbium plus Tantalum	0.15/0.45%
Nickel	3.50/5.50
Manganese	1.00% max.
Sulfur	0.03% max.

Associate Member



## Heat Treatment

As shipped from the mill, CRUCIBLE 15-5 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 15-5 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 on the following page.

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

## Heat Treatments for 15-5 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	42
H1025	1025	4	Air	38
H1075	1075	4	Air	36
H1100	1100	4	Air	34
H1150	1150	4	Air	33
H1150-M	1400	2	Air	—
	1150	4	Air	27

## 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 <sup>-6</sup> )				
—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 <sup>6</sup>	—	—
Torsion	—	11.2 x 10 <sup>6</sup>	10.0 x 10 <sup>6</sup>	10.0 x 10 <sup>6</sup>

## Typical Mechanical Properties

Room temperature, longitudinal direction

	Condition							
	A	H900	H925	H1025	H1075	H1100	H1150	H1150-M
Tensile strength-(p.s.i.)	150,000	200,000	190,000	170,000	165,000	150,000	145,000	125,000
0.2% Yield strength-(p.s.i.)	110,000	185,000	175,000	165,000	150,000	135,000	125,000	85,000
Elongation in 2 in. (%)	10.0	14.0	14.0	15.0	16.0	17.0	19.0	22.0
Reduction of area (%)	45	50.0	54.0	56.0	58.0	58.0	60.0	68.0
Hardness								
Rockwell C		44	42	38	36	34	33	27
Brinell	332	420	409	352	341	332	311	277
Impact strength								
Charpy V-notch (ft. lbs.)		17	25	35	40	45	50	100
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	—

## 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	15,000	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

## 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
0.25% Y, 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

## 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

## Resistance to Scaling

When CRUCIBLE 15-5 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.

## Corrosion Resistance

CRUCIBLE 15-5 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 15-5 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 welding without subsequent stress relieving. Environments that contain hydrogen sulfide or high concentrations of chlorides can also cause stress-corrosion cracking.

## Machining

CRUCIBLE 15-5 stainless can be readily machined in both solution-treated (Condition A) and the precipitation hardened conditions. 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 15-5 cause only a thin discoloration film and a dimensional contraction of 0.0004 to 0.0006" per inch.

In Condition A (solution treated), CRUCIBLE 15-5 is machined at approximately the same speed as Type 304 stainless.

## Machining Data

Operation	Tool Width or (in) Depth of Cut	High Speed Tooling		Carbide Tooling	
		Speed (fpm)	Feed (in/rev)	Speed (fpm)	Feed (in/rev)
Turning single point	0.050	90	0.0055	200	0.010
	0.250	85	0.0050	200	0.020
	0.500	80	0.0045	175	0.025
Forming	1/2 wide	90	0.0015	180	0.0022
	1 wide	85	0.0012	170	0.0022
	1-1/2 wide	85	0.0012	170	0.0020
	2 wide	80	0.0010	160	0.0015
Cutoff	1/16 wide	80	0.0015	160	0.0020
	1/8 wide	80	0.0015	160	0.0020
	3/16 wide	85	0.0015	170	0.0022
	1/4 wide	85	0.0020	170	0.0030
Drilling	1/16 dia.	50	0.0015		
	1/8 dia.	50	0.0020		
	1/4 dia.	50	0.0030		
	1/2 dia.	50	0.0035		
	3/4 dia.	55	0.0040		
	1 dia.	55	0.0050		
Threading†		5-15			
Tapping†		5-15			

†Use the higher speeds for the finer threads.

## Welding

CRUCIBLE 15-5 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 15-5. Properties comparable to those of the parent metal can be secured in the weld by applicable postweld heat treatment. Weld metal of a 15-5 composition is utilized when it is desired to obtain properties comparable to those of the base metal. Austenitic stainless steel weld metal may be used when high strength at the weld is not important.

## Forging

Forging stock is normally supplied in the overaged condition to eliminate the possibility of strain cracking in large sections. CRUCIBLE 15-5 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.

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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