Technical Datasheet

CARPENTER

Carpenter Stainless Custom 630

Identification

UNS Number
- S17400

AISI Number
- 630

Type Analysis

Single figures are nominal except where noted.

Carbon (Maximum)	0.07 %	**Manganese (Maximum)**	1.00 %
Phosphorus (Maximum)	0.040 %	**Sulfur (Maximum)**	0.030 %
Silicon (Maximum)	1.00 %	**Chromium**	15.00 to 17.50 %
Nickel	3.00 to 5.00 %	**Copper**	3.00 to 5.00 %
Columbium + Tantalum	0.15 to 0.45 %	**Iron**	Balance

General Information

Description

Carpenter Stainless Custom 630 is a martensitic precipitation/age-hardening stainless steel offering high strength and hardness along with excellent corrosion resistance. It has good fabricating characteristics and can be age hardened by a single-step, low temperature treatment. It has been used for a variety of applications including oil field valve parts, chemical process equipment, aircraft fittings, fasteners, pump shafts, nuclear reactor components, gears, paper mill equipment, missile fittings, and jet engine parts.

When your application calls for extensive machining of this alloy, you should consider specifying a modified version, Project 70+® Custom 630 stainless, for improved machinability.

Elevated Temperature Use

Carpenter Stainless Custom 630 shows excellent resistance to oxidation up to approximately 1100°F (539°C).

Long-term exposure to elevated temperatures can result in reduced toughness in precipitation hardenable stainless steels. The reduction in toughness can be minimized in some cases by using higher aging temperatures. Short exposures to elevated temperatures can be considered, provided the maximum temperature is at least 50°F (28°C) less than the aging temperature.

Corrosion Resistance

Carpenter Stainless Custom 630 has withstood corrosive attack better than any of the 400 series hardenable stainless steels, and, in most corrodents, its corrosion resistance closely approaches that of Stainless Types 302 and 304.

Good resistance to stress-corrosion cracking is gained by hardening at temperatures of 1025°F (552°C) and higher. Carpenter Stainless Custom 630 also withstands erosion-corrosion well due to the combination of good corrosion resistance and high hardness.

The alloy has acceptable resistance to sulfide stress cracking at Rockwell C 33 maximum hardness per NACE MR-01-75, "Sulfide Stress Cracking Resistant Metallic Materials for Oil Field Equipment." Refer to the current document for details on acceptable conditions.

For optimum corrosion resistance, surfaces must be free of scale, lubricants, foreign particles, and coatings applied for drawing and heading. After fabrication of parts, cleaning and/or passivation should be considered.

Important Note: *The following 4-level rating scale is intended for comparative purposes only. Corrosion testing is recommended; factors which affect corrosion resistance include temperature, concentration, pH, impurities, aeration, velocity, crevices, deposits, metallurgical condition, stress, surface finish and dissimilar metal contact.*

Nitric Acid	Good	Sulfuric Acid	Restricted
Phosphoric Acid	Restricted	Acetic Acid	Moderate
Sodium Hydroxide	Moderate	Salt Spray (NaCl)	Good
Sea Water	Restricted	Sour Oil/Gas	Restricted
Humidity	Excellent		

Comparative Corrosion Rates – Carpenter Custom 630 (17Cr-4Ni) and Other Alloys Mils per Year

Corrodents	TYPE 410		TYPE 431		CUSTOM 630		
	Hardened and Tempered 300°F (150°C)	Hardened and Tempered 1100°F (590°C)	Hardened and Tempered 500°F (260°C)	Hardened and Tempered 1200°F (650°C)	H900	H1025	H1150
5 w/o H_2SO_4 at 75°F (24°C)	1732[1]	1218	1402[1]	2325[1]	2	3	14[2]
20 w/o HNO_3 at 200°F (93°C)	8	59[2]	3	3	2	2	2
50 w/o Acetic Acid Boiling	266[1]	1627	43[1]	54	3	3	4

Notes: Corrosion rates for one 48 hour period
[1] Several or all of subsequent 48 hour test periods showed nil rates.
[2] Rates increased to 200 mpy by 3rd 48 hour test period.

Properties

Physical Properties

Specific Gravity	
Condition A	7.75
Condition H 1075	7.81
Condition H 1150	7.82
Condition H 900	7.80
Density	
Condition A	0.2800 lb/in³
Condition H 900	0.2820 lb/in³
Condition H 1075	0.2820 lb/in³
Condition H 1150	0.2830 lb/in³
Mean Specific Heat	
32 to 212°F, Condition A	0.1100 Btu/lb/°F
32 to 212°F, Condition H 900	0.1000 Btu/lb/°F

Mean CTE		
70 to 200°F, Condition A	6.00	x 10^{-6} in/in/°F
70 to 400°F, Condition A	6.00	x 10^{-6} in/in/°F
70 to 600°F, Condition A	6.20	x 10^{-6} in/in/°F
70 to 800°F, Condition A	6.30	x 10^{-6} in/in/°F
-100 to 70°F, Condition H 900	5.80	x 10^{-6} in/in/°F
70 to 200°F, Condition H 900	6.00	x 10^{-6} in/in/°F
70 to 400°F, Condition H 900	6.10	x 10^{-6} in/in/°F
70 to 600°F, Condition H 900	6.30	x 10^{-6} in/in/°F
70 to 800°F, Condition H 900	6.50	x 10^{-6} in/in/°F
70 to 200°F, Condition H 1075	6.30	x 10^{-6} in/in/°F
70 to 400°F, Condition H 1075	6.50	x 10^{-6} in/in/°F
70 to 600°F, Condition H 1075	6.60	x 10^{-6} in/in/°F
70 to 800°F, Condition H 1075	6.80	x 10^{-6} in/in/°F
-100 to 70°F, Condition H 1150	6.10	x 10^{-6} in/in/°F
70 to 200°F, Condition H 1150	6.60	x 10^{-6} in/in/°F
70 to 400°F, Condition H 1150	6.90	x 10^{-6} in/in/°F
70 to 600°F, Condition H 1150	7.10	x 10^{-6} in/in/°F
70 to 800°F, Condition H 1150	7.20	x 10^{-6} in/in/°F
Thermal Conductivity		
300°F, Condition H 900	127.0	BTU-in/hr/ft^2/°F
500°F, Condition H 900	135.0	BTU-in/hr/ft^2/°F
860°F, Condition H 900	156.0	BTU-in/hr/ft^2/°F
900°F, Condition H 900	157.0	BTU-in/hr/ft^2/°F
Poisson's Ratio		
Condition H 900	0.272	
Condition H 1075	0.272	
Condition H 1150	0.272	
Modulus of Elasticity (E) (Condition H 900)	28.5	x 10^{3} ksi
Modulus of Rigidity (G)		
Condition H 900	11.2	x 10^{3} ksi
Condition H 1075	10.0	x 10^{3} ksi
Condition H 1150	10.0	x 10^{3} ksi
Electrical Resistivity		
70°F, Condition A	589.0	ohm-cir-mil/ft
70°F, Condition H 900	463.0	ohm-cir-mil/ft

Condition	A		H 900		H 1075		H 1150	
Specific gravity	7.75		7.80		7.81		7.82	
Density—lb/in^3 kg/m^3	0.280 7750		0.282 7800		0.282 7810		0.283 7820	
Mean Specific Heat	Btu/lb•°F	J/kg•K	Btu/lb•°F	J/kg•K				
32 to 212°F (0 to 100°C)	0.11	460	0.10	419	—		—	
Electrical resistivity (RT) ohm-cir mil/ft microhm-mm	 589 980		 463 770		 — —		 — —	
Mean Coefficient of Thermal Expansion	10^{-6}/°F	10^{-6}/K	10^{-6}/°F	10^{-6}/K	10^{-6}/°F	10^{-6}/K	10^{-6}/°F	10^{-6}/K
-100 to 70°F (-73 to 21°C)	—	—	5.8	10.4	—	—	6.1	11.0
70 to 200°F (21 to 93°C)	6.0	10.8	6.0	10.8	6.3	11.3	6.6	11.9
70 to 400°F (21 to 204°C)	6.0	10.8	6.1	11.0	6.5	11.7	6.9	12.4
70 to 600°F (21 to 316°C)	6.2	11.2	6.3	11.3	6.6	11.9	7.1	12.8
70 to 800°F (21 to 427°C)	6.3	11.3	6.5	11.7	6.8	12.2	7.2	13.0

Thermal Conductivity		A	H 900		H 1075	H 1150
°F	°C		Btu-in/ft^2•h•°F	W/m•K		
300	149	—	124	17.9	—	—
500	260	—	135	19.5	—	—
860	460	—	156	22.5	—	—
900	482	—	157	22.6	—	—

	A	H 900	H 1075	H 1150
Poisson's Ratio	—	0.272	0.272	0.272

Modulus of Elasticity and Rigidity—See Mechanical Properties.

Typical Mechanical Properties

Typical Creep Strength - Carpenter Custom 630 (17Cr-4Ni)
Condition H 900

Test Temperature		Stress for creep of			
		0.1% in 1000 hrs.		0.01% in 1000 hrs.	
°F	°C	ksi	MPa	ksi	MPa
600	316	135	931	125	862
700	371	105	724	100	689
800	427	60	414	43	296
900	482	23	159	—	—

Typical Cryogenic Charpy V-Notch Impact Strength - Carpenter Custom 630 (17Cr-4Ni)

Test Temperature		Impact Strength									
		H 925		H 1025		H 1150		H 1150M			
°F	°C	ft-lb*	J	ft-lb*	J	ft-lb*	J	ft-lb*	J	ft-lb**	J
75	24	30	41	75	102	95	129	105	142	95	129
10	-12	16	22	58	79	93	126	—	—	85	115
-40	-40	9	12	40	54	76	103	—	—	75	102
-110	-79	5	7	15	20	48	65	—	—	65	88
-175	-115	—	—	—	—	—	—	—	—	35	47
-250	-157	—	—	—	—	—	—	—	—	18	24
-320	-196	3	4	4	6	6	8	28	38	5	7

*Test samples from 1" (25.4 mm) Rd. Bar—Longitudinal Direction
**Test samples from 4" (102 mm) Rd. Bar—Longitudinal Direction

Typical Cryogenic Tensile Properties - Carpenter Custom 630 (17Cr-4Ni)
Condition H 1100

Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8 mm)
°F	°C	ksi	MPa	ksi	MPa	
75	24	135	931	150	1034	17
32	0	183	1262	193	1331	16
-40	-40	189	1303	203	1440	16
-80	-62	196	1351	209	1441	15
-320	-196	243	1675	248	1710	8

Typical Elevated Temperature Tensile Properties - Carpenter Custom 630 (17Cr-4Ni)
Condition H 900

Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area
°F	°C	ksi	MPa	ksi	MPa		
RT	RT	183	1262	198	1365	15	52
600	316	145	1000	172	1186	13	46
800	427	132	910	160	1103	13	51
900	482	118	814	138	952	13	55
1000	538	94	643	115	793	17	64

Typical Room Temperature Mechanical Properties - Carpenter Custom 630 (17Cr-4Ni)

Condition	0.2% Yield Strength		Ultimate Tensile Strength		Elongation in 2" (50.8 mm)	% Reduction of Area	Hardness		Charpy V-Notch Impact Strength		Modulus of Elasticity (E)		Modulus of Rigidity (G)	
	ksi	MPa	ksi	MPa			Rockwell C	Brinell	ft-lb	J	ksi	MPa	ksi	MPa
A	—	—	—	—	—	—	36	352	—	—	—	—	—	—
H 900	183	1262	198	1365	15	52	44	420	16	21	28.5×10^3	197×10^3	11.2×10^3	77×10^3
H 1025	162	1117	168	1158	16	58	38	352	40	54	—	—	—	—
H 1075	148	1020	164	1131	17	59	36	341	45	61	—	—	10×10^3	69×10^3
H 1150	126	869	144	993	20	60	33	311	55	75	—	—	10×10^3	69×10^3
H 1150M	87	600	123	848	22	66	29	293	100	136	—	—	—	—

Typical Stress Rupture Strength - Carpenter Custom 630 (17Cr-4Ni)

Condition	Test Temperature		Stress for rupture in			
			100 Hours		1000 Hours	
	°F	°C	ksi	MPa	ksi	MPa
H 900	625	329	162	1117	157	1082
H 1075	625	329	137	945	134	924
H 900	700	371	156	1076	150	1034
H 1075	700	371	126	869	123	848
H 900	800	427	140	965	128	883
H 1075	800	427	108	745	103	710

Heat Treatment

Carpenter Stainless Custom 630 is hardened by heating solution-treated material, Condition A, to a temperature of 900°F (482°C) to 1150°F (621°C) for one to four hours, depending on the temperature, then air cooling.

Solution Treatment

Heat at 1900°F (1038°C) ±25°F (±14°C) for ½ hour, cool to below 90°F (32°C) so that the material is completely transformed to martensite. Sections under 3" (76.2 mm) can be quenched in a suitable liquid quenchant and sections over 3" (76.2 mm) should be rapidly air cooled.

Do not use this condition without age hardening due to susceptibility to stress-corrosion cracking.

Deformation (Size Change) in Hardening

The precipitation hardening of Carpenter Stainless Custom 630 is accomplished with a slight dimensional change. The amount of contraction in hardening solution-treated (Condition A) material to Condition H 900 is about 0.0004 to 0.0006 in./in. (m/m). Condition A material when hardened to Condition H 1150 will contract approximately 0.0009 to 0.0012 in./in. (m/m).

Age

Condition H 900
Heat solution-treated material at 900°F (482°C) for 1 hour and air cool.

Condition H 925, H 1025, H 1075, H 1100, H 1150
Heat solution-treated material at specified temperature ±15°F (±8°C) for 4 hours and air cool.

Condition H 1150M
Heat solution treated material at 1400°F(760°C) ±15°F (±8°C) for 2 hours, air cool; then treat at 1150°F (621°C) ±15°F (±8°C) for 4 hours and air cool.

Workability

Hot Working

Carpenter Stainless Custom 630 can be readily forged, hot headed and upset. Material which is hot worked must be solution treated prior to hardening if the material is to respond properly to hardening.

Forging

Heat uniformly to 2150/2200°F (1177/1204°C) and hold one hour at temperature before forging. Do not forge below 1850°F (1010°C). To obtain optimum grain size and mechanical properties, forgings should be cooled in air to below 90°F (32°C) before further processing. Forgings must be solution treated prior to hardening.

Cold Working

Carpenter Stainless Custom 630 can be fabricated by cold working to an extent which is limited to the high initial yield strength.

Machinability

Carpenter Stainless Custom 630 is readily machined in both the solution-treated and various age-hardened conditions. In the solution-treated condition, it machines similarly to Stainless Types 302 and 304. The machinability will improve as the hardening temperature is increased. Condition H 1150M provides optimum machinability.

Having procured Condition H 1150M for best machinability, higher mechanical properties can only be developed by solution treating and heat treating at standard hardening temperatures.

Following are typical feeds and speeds for Carpenter Stainless Custom 630.

Typical Machining Speeds and Feeds—Carpenter Custom 630 (17Cr-4Ni)
The speeds and feeds in the following charts are conservative recommendations for initial setup. Higher speeds and feeds may be attainable depending on machining environment.

Turning—Single-Point and Box Tools

Depth of Cut (inches)	High Speed Tools: Tool Material	High Speed Tools: Speed (fpm)	High Speed Tools: Feed (ipr)	Carbide Tools: Tool Material	Carbide Tools: Speed (fpm) Brazed	Carbide Tools: Speed (fpm) Throw Away	Carbide Tools: Speed (fpm) Coated	Carbide Tools: Feed (ipr)
Solution Treated								
.150	M2, T5,	80	.015	C6	300	350	450	.015
.025	T15	95	.007	C7	350	400	525	.007
Double-Aged H1150-M								
.150	M2, T5,	80	.015	C6	300	350	450	.015
.025	T15	95	.007	C7	350	400	525	.007
Aged H1150 H1100 H1075								
.150	T15, M41,	60	.015	C6	250	300	400	.015
.025	M42, M43,	75	.007	C7	300	350	450	.007
	M44							
Aged H1025								
.150	T15, M41,	55	.015	C6	245	275	350	.010
.025	M42, M43,	70	.007	C7	290	325	400	.005
	M44							
Aged H900 H925								
.150	T15, M41,	30	.010	C6	160	190	250	.010
.025	M42, M43,	45	.005	C7	190	225	285	.005
	M44							

Turning—Cut-Off and Form Tools

Tool Material: High Speed Tools	Tool Material: Carbide Tools	Speed (fpm)	Feed (ipr) Cut-Off Tool Width (inches): 1/16	1/8	1/4	1/2	Feed (ipr) Form Tool Width (inches): 1	1 1/2	2
Solution Treated									
M2 T15		70	.001	.0015	.002	.0015	.001	.001	.0005
	C6	210	.003	.003	.004	.003	.002	.002	.002
Double-Aged H1150-M									
M2 T15		100	.0015	.002	.0025	.002	.0015	.001	.001
	C6	250	.003	.003	.0045	.003	.002	.002	.002
Aged H1050 H1100 H1175									
M2 T15		80	.001	.0015	.002	.0015	.001	.001	.0005
	C6	210	.003	.003	.0045	.003	.002	.002	.002
Aged H1025									
T15 M42		65	.001	.001	.0015	.0015	.001	.001	.0005
	C6	160	.003	.003	.0045	.003	.002	.002	.002
Aged H900 H925									
T15 M42		35	.001	.001	.0015	.0015	.001	.001	.0005
	C6	115	.0025	.0025	.004	.0025	.0015	.0015	.0015

Rough Reaming

High Speed Tools		Carbide Tools		Feed (ipr) Reamer Diameter (inches)					
Tool Material	Speed (fpm)	Tool Material	Speed (fpm)	1/8	1/4	1/2	1	1 1/2	2
Solution Treated									
M7	60	C7	190	.003	.005	.008	.011	.015	.018
Double-Aged H1150M									
M7	65	C2	200	.003	.005	.008	.011	.015	.018
Aged H1075-1150									
T15	45	C2	150	.003	.005	.008	.011	.015	.018
Aged H1025									
T15	35	C2	125	.003	.004	.006	.010	.013	.016
Aged H900-925									
T15	30	C2	100	.001	.001	.001	.001	.001	.001

Drilling

High Speed Tools									
Tool Material	Speed (fpm)	Feed (inches per revolution) Nominal Hole Diameter (inches)							
		1/16	1/8	1/4	1/2	3/4	1	1 1/2	2
Solution Treated									
M1, M10	50	.001	.002	.004	.007	.008	.010	.012	.015
Double-Aged H1150M									
M1, M10	60	.001	.002	.004	.007	.009	.011	.013	.016
Aged H1075-1100-1150									
T15, M42	45	—	.002	.004	.007	.008	.010	.012	.015
Aged H1025									
T15, M42	35	—	.002	.004	.006	.008	.009	.011	.012
Aged H900-925									
T15, M42	25	—	.001	.002	.003	.004	.004	.004	.004

Die Threading

FPM for High Speed Tools				
Tool Material	7 or less, tpi	8 to 15, tpi	16 to 24, tpi	25 and up, tpi
Solution Treated				
M1, M2, M7, M10	5-12	8-15	10-20	15-25
Aged				
T15, M42	4-8	6-10	8-12	10-15

Milling, End—Peripheral

Depth of Cut (inches)	High Speed Tools: Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (inches): 1/4	1/2	3/4	1-2	Carbide Tools: Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (inches): 1/4	1/2	3/4	1-2
Solution Treated												
.050	M2, M7	85	.001	.002	.003	.004	C2	270	.001	.002	.004	.006
Double-Aged H1150M												
.050	M2, M7	90	.001	.002	.003	.004	C2	275	.001	.002	.004	.006
Aged H1075-1150												
.050	M2, M7	80	.001	.002	.003	.004	C2	265	.001	.002	.004	.006
Aged H1025												
.050	M2, M7	65	.0005	.001	.002	.003	C2	190	.001	.002	.003	.004
Aged H900-925												
.050	T15	60	.0005	.001	.002	.003	C2	90	.001	.002	.003	.004

Tapping

High Speed Tools: Tool Material	Speed (fpm)
Solution Treated	
M1, M7, M10	12-25
Double-Aged H1150M	
M1, M7, M10	17-28
Aged H1075-1100-1150	
M1, M7, M10	15-25
Aged H1025	
M1, M7, M10	10-20
Aged H900-925	
M1, M7, M10 Nitrided	5-15

Broaching

High Speed Tools: Tool Material	Speed (fpm)	Chip Load (ipt)
Solution Treated		
T15, M42	10	.002
Double-Aged H1150M		
T15, M42	15	.002
Aged H1075-1100-1150		
T15, M42	8	.002
Aged H1025		
T15, M42	8	.002
Aged H900-925		
T15, M42	8	.002

When using carbide tools, surface speed feet/minute (SFPM) can be increased between 2 and 3 times over the high-speed suggestions. Feeds can be increased between 50 and 100%.

Figures used for all metal removal operations covered are average. On certain work, the nature of the part may require adjustment of speeds and feeds. Each job has to be developed for best production results with optimum tool life. Speeds or feeds should be increased or decreased in small steps.

Additional Machinability Notes

When using carbide tools, surface speed feet/minute (sfpm) can be increased between 2 and 3 times over the high speed suggestions. Feeds can be increased between 50 and 100%.

Figures used for all metal removal operations covered are average. On certain work, the nature of the part may require adjustment of speeds and feeds. Each job has to be developed for best production results with optimum tool life. Speeds or feeds should be increased or decreased in small steps.

Weldability

Carpenter Stainless Custom 630 can be satisfactorily welded by the shielded fusion and resistance welding processes. Oxyacetylene welding is not recommended, since carbon pickup in the weld may occur. When a filler metal is required, AWS E/ER630 welding consumables should be considered to provide welds with properties matching those of the base metal. When designing the weld joint, care should be exercised to avoid stress concentrators, such as sharp corners, threads, and partial-penetration welds. When high weld strength is not needed, a standard austenitic stainless filler, such as E/ER308L, should be considered.

Normally, welding in the solution-treated condition has been satisfactory; however, where high welding stresses are anticipated, it may be advantageous to weld in the overaged (H 1150) condition. Usually, preheating is not required to prevent cracking.

If welded in the solution-treated condition, the alloy can be directly aged to the desired strength level after welding. However, the optimum combination of strength, ductility and corrosion resistance is obtained by solution treating the welded part before aging. If welded in the overaged condition, the part must be solution treated and then aged.

Other Information

Descaling (Cleaning)

Descaling following forging and annealing can be accomplished by acid cleaning or grit blasting. The acid treatment consists of 2 minutes in 50% by volume muriatic acid at 180°F (82°C), followed by 4 minutes in a mixture 15% by volume nitric acid, plus 3% by volume hydrofluoric acid at room temperature. Water rinse and desmut in 20% by volume nitric acid at room temperature. Repeat cleaning procedure as necessary but decrease the times by 50% (i.e., 1 and 2 minutes, respectively).

The heat tint from aging can be removed by polishing, vapor blasting or pickling 4 to 6 minutes in a mixture of 15% by volume nitric acid, plus 3% by volume hydrofluoric acid, followed by a water rinse. Repeat the acid cleaning procedure if necessary but decrease the time by 2 to 3 minutes. Desmut in 20% by volume nitric acid at room temperature.

After acid cleaning, back 1 to 3 hours at 300/350°F (149/177°C) to remove hydrogen.

Applicable Specifications

- AMS 5643
- ASTM A564
- ASTM A705
- ASME SA564
- ASTM A693 (Strip)

Forms Manufactured

- Bar-Flats
- Bar-Rounds
- Billet
- Wire
- Bar-Hexagons
- Bar-Squares
- Strip

Technical Articles

- A Guide to Etching Specialty Alloys for Microstructural Evaluation
- Advanced Stainless Offers High Strength, Toughness and Corrosion Resistance Wherever Needed
- Alloy Selection for Cold Forming (Part I)
- Alloy Selection for Cold Forming (Part II)
- New Ph Stainless Combines High Strength, Fracture Toughness and Corrosion Resistance
- New Stainless for Fasteners Combines Corrosion Resistance, High Hardness and Cold Formability
- Steels for Strength and Machinability
- Unique Properties Required of Alloys for the Medical and Dental Products Industry

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