Technical Datasheet CARPENTER

Unit Display: English

Print Now

Carpenter Stainless Type 431

E-Mail Datasheet
Add to My Materials

Identification

UNS Number

- S43100

Type Analysis

Carbon	0.20 %	**Manganese**	1.00 %
Phosphorus	0.040 %	**Sulfur**	0.030 %
Silicon	1.00 %	**Chromium**	15.00 to 17.00 %
Nickel	1.25 to 2.50 %	**Iron**	78.23 to 81.48 %

General Information

Description

Carpenter Stainless Type 431 is designed to provide improved corrosion resistance and toughness in a quench-hardenable stainless steel. It has been used for parts such as aircraft fasteners and fittings and should be considered for structural members exposed to marine atmosphere. Mechanical properties include excellent toughness (impact strength) at relatively high hardness level. It offers the best corrosion resistance of the conventional martensitic stainless grades. Considerable quantities of this steel have been produced to MIL-S-18732, and AMS-5628.

Carpenter Stainless Type 431 has been used for highly stressed aircraft components including fasteners, bomb racks, bolting, pump shafts, valve stems, etc. It should be considered for applications requiring the optimum combination of corrosion resistance, hardness and toughness from approximately -100 to 1200ºF (-73 to 650ºC).

Selection

This is the most corrosion resistant of the conventionally hardenable stainless steels. Few variations are produced.

Scaling

The safe scaling temperature for continuous service is 1300ºF (704ºC).

Corrosion Resistance

This alloy has resisted atmospheric corrosion and offers the best resistance to marine atmospheres of the regular martensitic stainless grades. Only the age-hardenable martensitic stainless alloys offer superior corrosion resistance. It also resists attack by many petroleum products and organic materials, and by nitric acid and several other acidic environments.

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	Restricted
Sodium Hydroxide	Moderate	Salt Spray (NaCl)	Moderate
Sea Water	Restricted	Humidity	Good

Properties

Physical Properties

Specific Gravity		
--	7.75	
Density		
--	0.2800	lb/in³
Mean Specific Heat		
32°F, 212°F	0.1100	Btu/lb/°F
Mean Coefficient of Thermal Expansion		
32°F, 1200°F	6.80	$x 10^{-6}$ in/in/°F
Thermal Conductivity		
212°F	140.0	BTU-in/hr/ft²/°F
Modulus of Elasticity (E)		
--	29.0	$x 10^{3}$ ksi

Electrical Resistivity	
70.0°F	433.0 ohm-cir-mil/ft

Typical Mechanical Properties

Effect of Test Temperature on Typical Charpy V-Notch Impact Strength
Hardened 1800°F (982°C), oil quench, tempered 1300°F (704°C)

Test Temperature		Impact Strength	
°F	°C	ft-lb	J
-65	-54	30	41
70	21	50	68
300	149	65	88
500	260	75	102
700	371	80	108

Typical Creep and Stress Rupture Strength
Hardened 1800°F (982°C), oil quench, tempered 1225°F (663°C), 4 hours

Test Temperature		Stress for rupture in				Stress for 1% Creep in 1000 hours	
		1000 hours		10,000 hours			
°F	°C	ksi	MPa	ksi	MPa	ksi	MPa
900	482	34	234	23	159	20	138
1100	593	10	69	6	41	5	34
1200	650	5	34	3	21	3	21

Typical Elevated Temperature Mechanical Properties
Hardened 1850°F (1010°C), tempered one hour 50°F (28°C) above test temperature

Test Temperature		Ultimate Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area	Room Temp. Brinell Hardness After Test
°F	°C	ksi	MPa			
300	149	239	1648	13	32	415
500	260	208	1434	14	48	415
700	371	209	1441	17	48	429
800	427	205	1413	15	47	444
900	482	191	1317	14	48	444
1000	538	105	724	20	68	331
1100	593	63	434	26	82	277

Typical Room Temperature Charpy V-Notch Impact Strength
0.5" x 5" (12.7 x 127 mm) plate longitudinal test direction

Hardening Temperature (Oil quench)		Tempering Temperature (2 hours, air cool plus 2 hours, air cool)		Impact Strength		Rockwell C Hardness
°F	°C	°F	°C	ft-lb	J	
1800	982	400	204	20	27	45½
1800	982	500	260	24	33	44½
1800	982	700	371	13	18	45½
1800	982	800	427	6	8	47½
1800	982	900	482	6	8	47½
1900	1038	400	204	53	72	46½
1900	1038	500	260	72	98	43½
1900	1038	700	371	60	81	44½
1900	1038	800	427	14	19	46½
1900	1038	900	482	7	9	47½

Typical Room Temperature Mechanical Properties of Bar

Tempering Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2"(50.8mm)	% Reduction of Area	Izod V-Notch Impact Strength		Brinell Hardness
°F	°C	ksi	MPa	ksi	MPa			ft-lb	J	
As annealed		95	655	125	862	20	55	50	68	260
Hardened 1800°F (982°C), oil quench, tempered as indicated										
500	260	149	1027	198	1365	16	55	40	54	415
700	371	163	1123	202	1393	16	55	25	34	429
900	482	174	1200	204	1407	16	51	12	16	415
1100	593	115	793	140	965	19	57	48	65	302
1300	704	99	683	129	889	20	60	51	69	269
Hardened 1900°F (1038°C), oil quench, tempered as indicated										
500	260	148	1020	193	1331	17	40	52	71	388
700	371	145	1000	186	1282	21	53	60	81	388
900	482	156	1076	200	1379	18	62	42	57	415
1100	593	113	779	150	1034	18	55	32	43	321
1300	704	98	676	140	965	18	53	45	61	293

Heat Treatment

Annealing

Heat uniformly to 1200/1250ºF (650/677°C)-remove charge from furnace and cool in air. Brinell approximately 270. This treatment will be best for most machining operations.

Hardening

Heat to 1800/1950ºF (982/1066ºC), soak at heat, quench in oil. This grade will also harden by cooling in air. When tempering below 700ºF (371ºC), the high side of the hardening range should be employed for the best impact strength. Lower hardening temperatures should be used when tempering above 1100ºF (538ºC) for best impact strength.

Tempering

Temper to secure hardness and mechanical properties desired. Soak at heat at least one hour, and longer for larger pieces-cool in air. Tempering in the range of 700/1050ºF (371/565ºC) results in decreased impact strength and corrosion resistance.

Workability

Hot Working

It can be readily hot headed and drop forged. Heat uniformly to 2100/2200ºF (1149/1204ºC); then forge. Small forgings should be allowed to cool slowly-large forgings in dry lime or ashes. Anneal after forging; cool to room temperature before annealing. Trim hot, or else anneal and trim cold. Do not forge below 1650ºF (900ºC). Loss of toughness and ductility will result from overheating.

Cold Working

In the annealed condition, the alloy can be blanked, formed, and cold headed.

Machinability

When machining Carpenter Stainless Type 431 in the annealed condition, there is a tendency to gall and build up on the cutting edge of the tool, which results in poor finishes. In turning operations, it is comparable to SAE 3150 or 6150.

Following are typical feeds and speeds for Carpenter Stainless Type 431.

Turning—Single-Point and Box Tools

Depth of Cut (Inches)	High Speed Tools			Carbide Tools (Inserts)			
	Tool Material	Speed (fpm)	Feed (ipr)	Tool Material	Speed (fpm) Uncoated	Speed (fpm) Coated	Feed (ipr)
.150	T15	80	.015	C6	350	475	.015
.025	M42	95	.007	C7	425	575	.007

Turning—Cut-Off and Form Tools

Tool Material		Speed (fpm)	Feed (ipr)						
			Cut-Off Tool Width (inches)				Form Tool Width (inches)		
High Speed Tools	Car-bide Tools		1/16	1/8	1/4	1/2	1	1 ½	2
M2		65	.001	.001	.0015	.0015	.001	.001	.0005
	C6	200	.004	.0055	.007	.005	.004	.0035	.003

Rough Reaming

High Speed		Carbide Tools		Feed (ipr) Reamer Diameter (inches)					
Tool Material	Speed (fpm)	Tool Material	Speed (fpm)	1/8	1/4	1/2	1	1 ½	2
M7	65	C2	85	.003	.005	.008	.012	.015	.018

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 ½	2
M7, M10	50-60	.001	.003	.005	.007	.010	.012	.015	.018

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
M1, M2, M7, M10	5-15	10-20	20-34	25-35

Milling, End-Peripheral

Depth of Cut (inches)	High Speed Tools						Carbide Tools					
	Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in)				Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in)			
			1/4	1/2	3/4	1-2			1/4	1/2	3/4	1-2
.050	M2, M7	80	.001	.002	.003	.004	C6	250	.001	.002	.004	.006

Tapping

High Speed Tools	
Tool Material	Speed (fpm)
M1, M7, M10	12-25

Broaching

High Speed Tools		
Tool Material	Speed (fpm)	Chip Load (ipt)
M2, M7	15	.003

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 Type 431 can be welded satisfactorily with most of the electric welding processes. If a filler metal is required, one of similar composition such as AWS E/ER 410 should be considered. An austenitic filler metal may also be used if the response to heat treatment and mechanical properties of the weld are not required to be similar to those of the base metal.

To prevent cracking of the weldment, it is necessary to preheat the base metal to 400/600ºF (204/316ºC) and maintain an interpass temperature of 400ºF (204ºC) minimum. The weldment should receive a postweld heat treatment at 1200ºF (649ºC) as soon as possible after the part has been allowed to cool to room temperature.

Other Information

Applicable Specifications

- AMS 5628
- ASTM A276
- ASTM A314
- ASTM A479
- ASTM A580
- MIL-S-18732

Forms Manufactured

- Bar-Rounds
- Billet

- Strip
- Wire
- Wire-Rod

Technical Articles

- A Designer's Manual On Specialty Alloys For Critical Automotive Components
- Alloy Selection for Cold Forming (Part I)
- Alloy Selection for Cold Forming (Part II)
- How to Passivate Stainless Steel Parts
- How to Select the Right Stainless Steel or High Temperature Alloy for Heading
- Passivating and Electropolishing Stainless Steel Parts
- Selecting High Temperature Alloys for Fasteners in Automotive Exhaust Systems
- Selection of High Strength Stainless Steels for Aerospace, Military and Other Critical Applications
- Unique Properties Required of Alloys for the Medical and Dental Products Industry

Disclaimer:
The information and data presented herein are typical or average values and are not a guarantee of maximum or minimum values. Applications specifically suggested for material described herein are made solely for the purpose of illustration to enable the reader to make his/her own evaluation and are not intended as warranties, either express or implied, of fitness for these or other purposes. There is no representation that the recipient of this literature will receive updated editions as they become available.

Edition Date: 09/01/1986