Technical Datasheet

CarTech® 22Cr-13Ni-5Mn Stainless

Identification

UNS Number

• S20910

Type Analysis

Single figures are nominal except where noted.

Carbon (Maximum)	0.06 %	**Manganese**	4.00 to 6.00 %
Phosphorus (Maximum)	0.040 %	**Sulfur (Maximum)**	0.030 %
Silicon (Maximum)	1.00 %	**Chromium**	20.50 to 23.50 %
Nickel	11.50 to 13.50 %	**Molybdenum**	1.50 to 3.00 %
Columbium/Niobium	0.10 to 0.30 %	**Vanadium**	0.10 to 0.30 %
Nitrogen	0.20 to 0.40 %	**Iron**	Balance

General Information

Description

CarTech 22CR-13Ni-Mn is a nitrogen-strengthened austenitic stainless steel that provides very good corrosion resistance in combination with high strength. The alloy has better corrosion resistance that CarTech 316 with approximately twice the yield strength. It can be welded, machined and cold worked using the same equipment and methods used for the conventional 300 series stainless steels. It remains nonmagnetic after severe cold work.

The alloy has an excellent combination of strength, ductility, toughness, corrosion resistance and fabricability. It has been used in applications such as valve shafts and taper pins, pumps and fittings for chemical and petrochemical equipment, fasteners, cables, chains, screens, wire cloth, marine hardware, boat shafting, heat exchanger parts, springs and photographic process equipment. Additionally, the alloy has good toughness at cryogenic temperatures and relatively high tensile and yield strengths at moderately high elevated temperatures. These properties further increase the versatility and usefulness of the alloy.

Corrosion Resistance

Carpenter 22Cr-13Ni-5Mn has very good corrosion resistance in many reducing and oxidizing acids, chlorides, and pitting environments. In particular, the alloy provides an excellent level of resistance to pitting and crevice corrosion in sea water; tests have shown it to be completely unaffected after 9 months in quiet sea water. Resistance to intergranular attack in boiling 65% nitric acid and in ferric sulfate-sulfuric acid (ASTM A262, practices B and C) is excellent for both the annealed and sensitized conditions. Like other austenitic stainless steels, Carpenter 22Cr-13Ni-5Mn, under certain conditions, may stress-corrosion crack in hot chloride environments.

The alloy also demonstrates good resistance to sulfide stress cracking at ambient temperatures. It is included in NACE MR-01-75, "Sulfide Stress Corrosion Cracking Resistant Metallic Materials for Oil Field Equipment" at a maximum hardness of Rockwell C 35. 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	Excellent	Sulfuric Acid	Moderate
Phosphoric Acid	Moderate	Acetic Acid	Good
Sodium Hydroxide	Moderate	Salt Spray (NaCl)	Excellent
Sea Water	Moderate	Sour Oil/Gas	Moderate
Humidity	Excellent		

Typical Corrosion Properties
Annealed condition

Environment	Time of Test	Average Corrosion Rate	
		Carpenter 22Cr-13Ni-5Mn	Type 316
10 w/o formic acid-boiling	3 periods-48 hrs. ea.	2.3 mpy	19.3 mpy
50 w/o acetic acid-boiling	3 periods-48 hrs. ea.	0.1 mpy	0.1 mpy
20 w/o HNO_3-200°F (93°C)	3 periods-48 hrs. ea.	0.3 mpy	0.8 mpy
5 w/o H_2SO_4-176°F (80°C)	3 periods-48 hrs. ea.	0.2 mpy	33 mpy
10 w/o H_2SO_4-176°F (80°C)	3 periods-48 hrs. ea.	15 mpy	112 mpy
10 w/o $FeCl_3$-R.T.	10 days	0.002 g*	1.1 g*
5 w/o NaCl spray-95°F (35°C)	200 hours	superior to Type 316**	

*total weight loss for specimen 0.095" x 1" x 2" (2.41 mm x 25.4 mm x 50.8 mm)
**based on the amount of rusting

Properties

Physical Properties

Specific Gravity	7.88	
Density	0.2850	lb/in³
Mean Specific Heat (32 to 212°F)	0.1200	Btu/lb/°F
Mean CTE		
70 to 200°F	9.00	x 10^{-6} in/in/°F
70 to 400°F	9.20	x 10^{-6} in/in/°F
70 to 600°F	9.60	x 10^{-6} in/in/°F
70 to 800°F	9.90	x 10^{-6} in/in/°F
70 to 1000°F	10.2	x 10^{-6} in/in/°F
70 to 1200°F	10.5	x 10^{-6} in/in/°F
70 to 1400°F	10.8	x 10^{-6} in/in/°F
70 to 1600°F	11.1	x 10^{-6} in/in/°F

Mean Coefficient of Thermal Expansion

Temperature		10^{-6}/°F	10^{-6}/K
70°F to	21°C to		
200	93	9.0	16.2
400	204	9.2	16.6
600	316	9.6	17.3
800	427	9.9	17.8
1000	538	10.2	18.4
1200	649	10.5	18.9
1400	760	10.8	19.4
1600	871	11.1	20.0

Thermal Conductivity		
300°F	108.0	BTU-in/hr/ft²/°F
900°F	141.0	BTU-in/hr/ft²/°F
1500°F	175.0	BTU-in/hr/ft²/°F

Thermal Conductivity

Test Temperature		Btu·in/ft²·h·°F	W/m·K
°F	°C		
300	149	108	15.6
900	482	141	20.3
1500	816	175	25.2

Modulus of Elasticity (E)	28.0	x 10 ³ ksi
Electrical Resistivity (70°F)	493.0	ohm-cir-mil/ft

Magnetic Properties

Magnetic Permeability		
Annealed, 200 Oe	1.0040	Mu
Cold Drawn 27% (Wire), 200 Oe	1.0040	Mu
Cold Drawn 75% (Wire), 200 Oe	1.0040	Mu

Typical Mechanical Properties

Typical Cryogenic Mechanical Properties
1" (25.4 mm) round bar, annealed 2050°F (1121°C)

Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area	Charpy V-Notch Impact Strength	
°F	°C	ksi	MPa	ksi	MPa			ft-lb	J
-100	-73	85	586	146	1007	50	65	115	156
-320	-196	128	883	226	1558	40	50	50	68

Typical Elevated Temperature Tensile Properties
1" (25.4 mm) round bar, annealed 2050°F (1121°C)

Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8 mm) or 4D	% Reduction of Area
°F	°C	ksi	MPa	ksi	MPa		
75	24	65	448	120	827	45	65
600	316	46	317	104	717	36	62
800	427	45	310	98	676	30	62
1000	538	41	283	90	621	40	62
1200	649	41	283	82	565	36	62
1350	732	39	269	68	469	38	64
1500	816	34	234	52	359	42	75

Typical Room Temperature Mechanical Properties
1" (25.4 mm) round bar, annealed 2050°F (1121°C)

0.2% Yield Strength		0.2% Tensile Strength		% Elongation in 2" (50.8 mm) or 4D	% Reduction of Area	Rockwell B Hardness	Charpy V-Notch Impact Strength	
ksi	MPa	ksi	MPa				ft-lb	J
65	448	120	827	45	65	96	160	217

Typical Room Temperature Tensile Properties of Cold-Drawn Wire
Wire annealed before cold drawing

Wire Diameter		% Cold Work	0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area
in.	mm		ksi	MPa	ksi	MPa		
0.250	6.35	0	65	448	120	827	40	65
0.230	5.84	15	140	965	165	1138	20	55
0.208	5.28	30	170	1172	190	1310	15	48
0.185	4.70	45	190	1310	215	1482	10	45
0.158	4.01	60	215	1482	230	1586	8	40
0.136	3.45	70	230	1586	245	1689	7	38

Heat Treatment

Annealing

Heat to 1950/2050ºF (1066/1121ºC) and cool rapidly. Thin sections are usually cooled in air and heavy sections in water.

Hardening

Cannot be hardened by heat treatment. Can be hardened only by cold work.

Workability

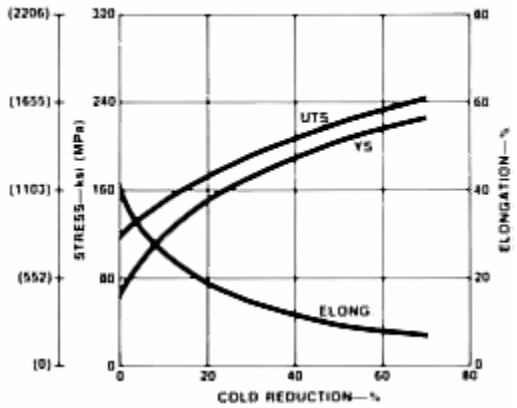
Hot Working

Carpenter 22CR-13Ni-5Mn can be forged, hot rolled, hot headed and upset. An initial forging temperature of 2100/2200ºF (1149/1204ºC) is normally used. Preheating to an intermediate temperature is not required. Forgings can be rapidly cooled without danger of cracking. For best corrosion resistance, anneal after forging.

Cold Working

Carpenter 22Cr-13Ni-5Mn can be cold formed by drawing, bending, upsetting and stamping. Because of its higher strength and work-hardening rate, the force required is somewhat greater than for Types 302, 304 and 316. The high work-hardening rate can be advantageous when cold working to increase strength; i.e., high strengths with good ductility can be achieved with less reduction.

The Effect of Cold Work on the Typical Tensile Properties of Wire



Machinability

Carpenter 22Cr-13Ni-5Mn has a machinability rating about 30% of AISI 1212. Slow to moderate speeds, moderate feeds and rigid tools should be considered; tools must be kept sharp. Chips tend to be tough and stringy. Chip curlers or breakers are helpful. Use a sulfurized cutting fluid, preferably of the chlorinated type.

Following are typical feeds and speeds for Carpenter 22Cr-13Ni-5Mn.

Typical Machining Speeds and Feeds – Carpenter 22Cr-13Ni-5Mn Stainless

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			Carbide Tools (Inserts)			
	Tool Material	Speed (fpm)	Feed (ipr)	Tool Material	Speed (fpm) Uncoated	Speed (fpm) Coated	Feed (ipr)
.150	M2	55	.015	C6	250	300	.015
.025	T15	70	.007	C7	300	350	.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	Carbide Tools		1/16	1/8	1/4	1/2	1	1 ½	2
T15		40	.001	.001	.0015	.0015	.001	.0007	.0007
	C6	140	.004	.0055	.0045	.004	.003	.002	.002

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	60	C2	80	.003	.005	.008	.012	.015	.018

Drilling

Tool Material	Speed (fpm)	High Speed Tools: Feed (inches per revolution) Nominal Hole Diameter (inches)							
		1/16	1/8	1/4	1/2	3/4	1	1 ½	2
T15, M42	45-50	.001	.002	.004	.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
T15, M42	4-8	6-10	8-12	10-15

Milling, End-Peripheral

Depth of Cut (inches)	High Speed Tools						Carbide Tools					
	Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in) 1/4	1/2	3/4	1-2	Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in) 1/4	1/2	3/4	1-2
.050	M2, M7	65	.001	.002	.003	.004	C2	245	.001	.002	.003	.005

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	10	.003

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 22Cr-13Ni-5Mn 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/ER209 welding consumables should be considered for welds with strength approaching that of the base metal. If high weld strength is not necessary, then E/ER309 should be considered. Resistance to intergranular corrosion can be restored by a postweld annealing treatment.

Other Information

Applicable Specifications

- AMS 5764
- AMS 5861
- ASTM A240 (Grade XM-19)
- ASTM A276 (Grade XM-19)
- ASTM A412 (Grade XM-19)
- ASTM A479 (Grade XM-19)
- ASTM A580 (Grade XM-19)
- ASTM F1314

Forms Manufactured

- Bar-Rounds
- Billet
- Strip
- Wire
- Wire-Rod

Technical Articles

- Forging Difficult Alloys: How to Get Better Results, Consistently
- Higher Performance Material Solutions for a Dynamic Spine Market
- Properties of an Essentially Nickel-Free Stainless Alloy for Medical Implants
- Selecting Alloys for Severely Corrosive Environments
- Selecting Optimal Stainless Steels for Bio-Pharmaceutical Service
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Edition Date: 07/17/2003

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