Technical Datasheet

CarTech® 20Cb-3® Stainless

Identification

UNS Number

• N08020

Type Analysis

Single figures are nominal except where noted.

Carbon (Maximum)	0.06 %	**Manganese (Maximum)**	2.00 %
Phosphorus (Maximum)	0.035 %	**Sulfur (Maximum)**	0.035 %
Silicon (Maximum)	1.00 %	**Chromium**	19.00 to 21.00 %
Nickel	32.50 to 35.00 %	**Molybdenum**	2.00 to 3.00 %
Copper	3.00 to 4.00 %	**Columbium + Tantalum**	8 X C Minimum/1.00% Maximum
Iron	Balance		

General Information

Description

CarTech 20Cb-3 stainless is an austenitic stainless steel possessing excellent resistance to hot sulfuric acid and many other aggressive environments which would readily attack 316 stainless. This alloy exhibits superior resistance to stress-corrosion cracking in boiling 20 to 40% sulfuric acid.

CarTech 20Cb-3 stainless is also stabilized to limit intergranular attack, even in the sensitized condition. Corrosion tests on annealed and sensitized material conducted in the Ferric Sulfate - 50% Sulfuric Acid Test resulted in rates of 0.002 inches per month maximum.

Important advantages of CarTech 20Cb-3 stainless are its excellent mechanical properties and comparative ease of fabrication. The presence of columbium in the alloy minimizes the precipitation of carbides during welding. Assemblies usually have been placed in service in the as-welded condition.

Applications

This material has found wide use in all phases of the chemical and allied industries. It has been used extensively in the processing of synthetic rubber, high-octane gasoline, solvents, explosives, plastics, synthetic fibers, heavy chemicals, organic chemicals, pharmaceuticals, and agrichemicals.

CarTech 20Cb-3 stainless has also been used in SO2 scrubbers where acid content, such as sulfuric acid, is of more concern than high-halogen content, such as chlorides.

Other applications have included use in fans, mixing tanks, agitators, distillation towers, heat exchangers, process piping, bubble caps, metal cleaning and pickling tanks, spray pickling equipment, pump shafts and rods, valve stems, bolts, nuts, washers, tie rods, continuous-line pickling equipment including racks, etc.

Selection

There are three Carpenter-developed alloys with properties which complement 20Cb-3 stainless.

20Mo-4® stainless and 20Mo-6® stainless, modifications of the 20Cb-3 stainless chemistry, have been found useful in halogenated environments where pitting and/or crevice corrosion are the major modes of attack.

In addition, Carpenter addressed fabrication issues with the development of Carpenter 20Cb-3LR® stainless, a weld filler metal which displays high resistance to hot cracking.

Contact Carpenter for more detailed information regarding these alloys.

Scaling

20Cb-3 stainless has a safe scaling temperature of 1800°F (982°C) in continuous service.

Corrosion Resistance

The corrosion resistance of 20Cb-3 stainless in reagent-grade sulfuric acid at 176°F (80°C) and at the boiling point is shown in the "Typical General Corrosion Resistance in Nonaerated Sulfuric Acid" hyperlink, and "Typical General Corrosion Resistance in Boiling Sulfuric Acid" hyperlink. The corrosion rates in reagent-grade sulfuric acid should be used only as a guide since many contaminants in commercial sulfuric acid can change the degree of corrosive attack. Corrosion rates in sulfuric acid can be actually much lower in the presence of iron, copper and chromium ions, usually present in pickling and plating solutions. However, the presence of chloride ions can increase attack.

The graph in the "Typical Iso-corrosion Properties in Sulfuric Acid" hyperlink illustrates an iso-corrosion chart for 20Cb-3 stainless. The chart is divided into zones according to the resistance of 20Cb-3 stainless to general corrosion, exposed to the range of temperatures and concentrations represented by each zone. These data are based on laboratory tests in reagent grade H_2SO_4 with no intentional aeration or deaeration. Charts of general corrosion data are intended for general guidance as the corrosion resistance can vary with factors such as impurities, aeration, heat transfer, velocity, deposits, material condition and fabrication.

Heat Transfer Conditions:
The corrosion rates presented in the hyperlink entitled "Typical Corrosion Resistance in Boiling Sulfuric Acid as a Function of Metal Temperature" were obtained under conditions that are frequently encountered in the chemical processing industries. Many times the application of a materials involves a situation where the metal is maintained at a temperature above that of the corrosive environment. Thus, heat is transferred from the metal to the solution with the metal acting as a heat transfer surface. Corrosion rates under these conditions can be markedly higher than those experienced where metal and solution are at the same temperature, at atmospheric pressure. These heat transfer tests were conducted by sealing a circular specimen to the bottom of a custom-designed glass vessel. One side of the specimen was exposed to a particular corrodent while the other side was being heated by and external source. This enables testing to be conducted where the metal specimen temperature is higher than the temperature of the corrodent, simulating heat exchanger conditions.

The curves shown in the hyperlink entitled "Typical Corrosion Resistance in Boiling Sulfuric Acid as a Function of Metal Temperature" indicate the corrosion rate of 20Cb-3 stainless to various sulfuric acid concentrations as a function of the metal temperature. While the sulfuric acid solutions were maintained at their normal atmospheric boiling points, 214/222°F (101/106°C), corrosion rates were obtained at metal temperatures of 221/257°F (105/125°C). These data are particularly useful where sulfuric acid solutions are being heated, such as in pickling tanks.

Stress-Corrosion Resistance:
The higher nickel content of 20Cb-3 stainless confers even better resistance to chloride stress-corrosion cracking than that exhibited by Carpenter 20Cb stainless. In laboratory tests the nickel content of 20Cb-3 stainless provided resistance to stress-corrosion cracking at a variety of temperatures and concentrations. It also displayed improved resistance to stress-corrosion cracking in boiling 42% magnesium chloride ($MgCl_2$), a standard test for susceptibility to stress-corrosion cracking.

Sour Service:
The excellent resistance of 20Cb-3 stainless to sulfide stress cracking has enabled inclusion of this alloy in NACE MR0175, "Sulfide Stress Cracking Resistant Metallic Materials for Oil Field Equipment." The alloy (UNS N08020) is acceptable in the annealed or cold worked condition at a hardness level of Rockwell C 32 maximum.

Intergranular Corrosion Resistance:
In the annealed and annealed plus sensitized (1250°F [677°C], on hour) conditions, 20Cb-3 stainless will pass the Nitric Acid Test (240 hours in boiling 65% nitric acid) and the Ferric Sulfate-Sulfuric Acid Test (120 hours in a 50% sulfuric acid solution containing ferric sulfate) with a rate of 0.002 ipm maximum. The Nitric Acid Test is descried in ASTM A-262, Practice C, the Ferric Sulfate-Sulfuric Acid Test in ASTM A262, Practice B, and ASTM G-28, Method A.

The Nitric Acid-Hydrofluoric Acid Test of A-262, Practice D, and the 24-hour Copper Accelerated Acidified Copper Sulfate Test in A-262, Practice E, are also applicable to 20Cb-3 stainless in the annealed and annealed plus sensitized - (1250°F [677°C], one hour) - conditions.

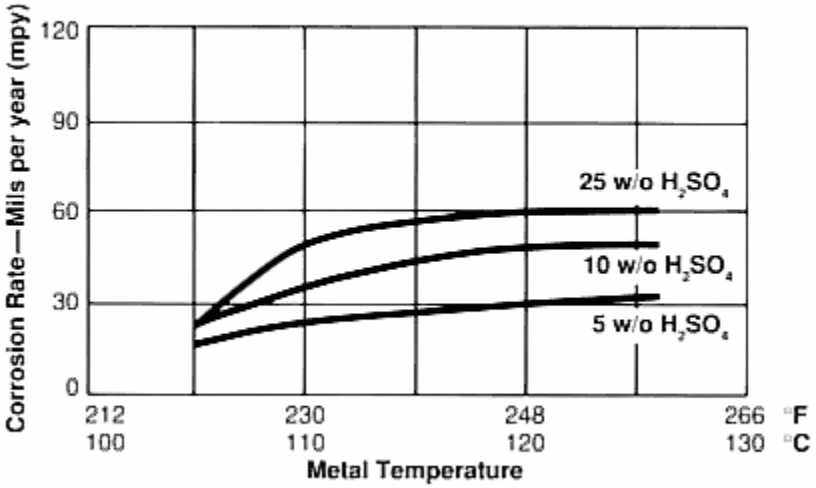
For optimum corrosion resistance, surfaces must be free of scale, lubricants, foreign particles, and coatings applied for drawing and heading. After fabrication of parts, cleaning and/or passivation should be considered.

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

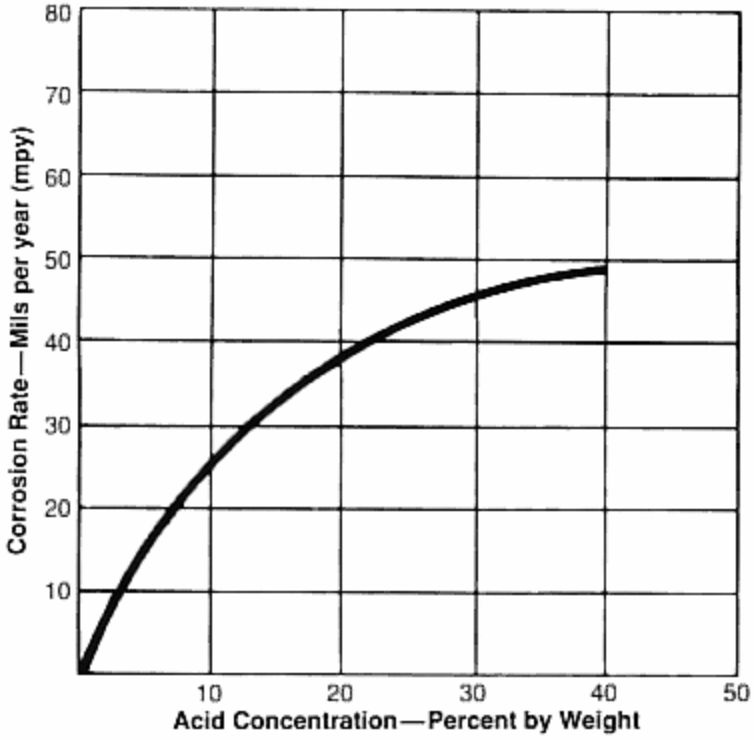
Typical Corrosion Resistance in Boiling Sulfuric Acid as a Function of Metal Temperature - 20Cb-3 Stainless

Material in the annealed condition.

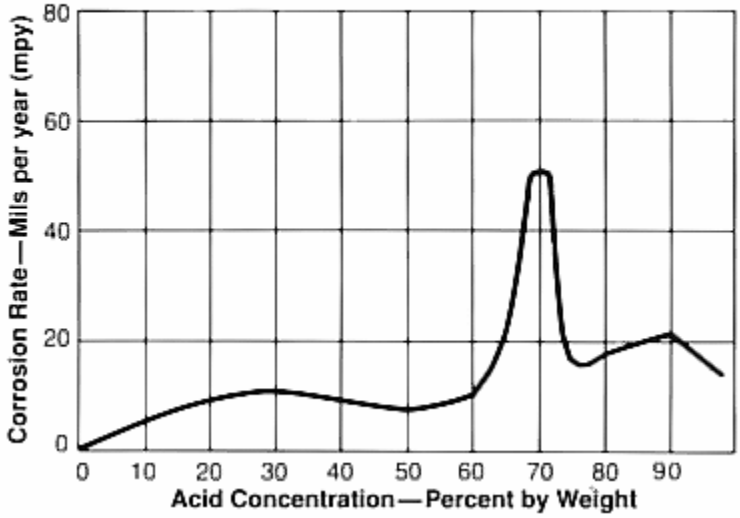


Note: These data are based on laboratory tests with pure chemicals. Rates in field service may differ.

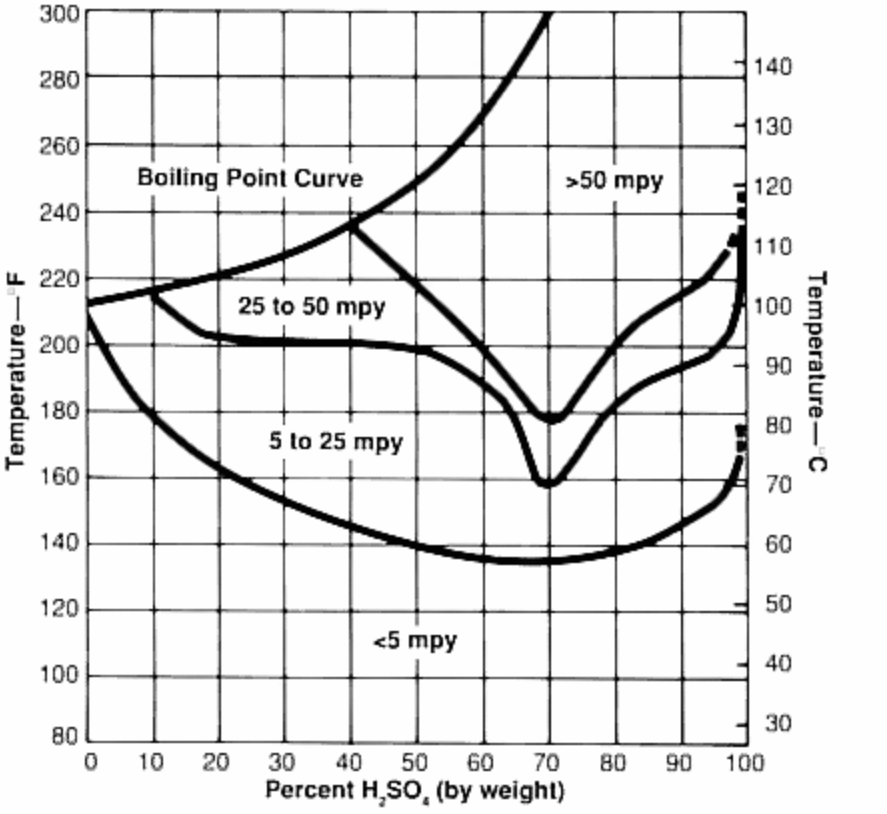
Typical General Corrosion Resistance in Boiling Sulfuric Acid–20Cb-3 Stainless



Typical General Corrosion Resistance in Nonaerated Sulfuric Acid–20Cb-3 Stainless
At 176°F (80°C)



Typical Iso-corrosion Properties in Sulfuric Acid - 20Cb-3 Stainless



Properties

Physical Properties

Specific Gravity	8.08	
Density	0.2920	lb/in³
Mean Specific Heat (90 to 216°F)	0.1200	Btu/lb/°F

Mean CTE	
77 to 212°F	8.16 x 10 -6 in/in/°F
77 to 842°F	8.84 x 10 -6 in/in/°F
77 to 1652°F	9.53 x 10 -6 in/in/°F

Mean Coefficient of Thermal Expansion

Temperature		Coefficient	
77°F to	25°C to	10 -6/°F	10-6/K
212	100	8.16	14.69
842	450	8.84	15.91
1652	900	9.53	17.15

Thermal Conductivity	
122°F	84.60 BTU-in/hr/ft²/°F
212°F	90.80 BTU-in/hr/ft²/°F
392°F	103.0 BTU-in/hr/ft²/°F
572°F	114.0 BTU-in/hr/ft²/°F
752°F	126.0 BTU-in/hr/ft²/°F

Thermal Conductivity

Test Temperature		Btu/ft·h·°F	Btu·in/ft²·h·°F	W/m·K
°F	°C			
122	50	7.05	84.6	12.2
212	100	7.57	90.8	13.1
392	200	8.56	103.0	14.8
572	300	9.53	114.0	16.5
752	400	10.50	126.0	18.1

Comparative type test conducted on a 2.5" sq. (63.5 mm) x 1.250" (31.8 mm) thick block derived from a 3-5/8" (92.1 mm) rd. bar sample and reannealed 1725°F (941°C)/1 hr./W.Q.

Poisson's Ratio	0.310

Modulus of Elasticity (E)	
75°F	29.0 x 10 3 ksi
200°F	28.2 x 10 3 ksi
400°F	27.0 x 10 3 ksi
600°F	26.0 x 10 3 ksi
800°F	25.5 x 10 3 ksi
In Tension (E)	28.0 x 10 3 ksi

Modulus of Rigidity (G)	
--	11.0 x 10 3 ksi
75°F	11.0 x 10 3 ksi
200°F	10.6 x 10 3 ksi
400°F	10.1 x 10 3 ksi
600°F	9.80 x 10 3 ksi
800°F	9.60 x 10 3 ksi

Electrical Resistivity (73°F)	651.0 ohm-cir-mil/ft

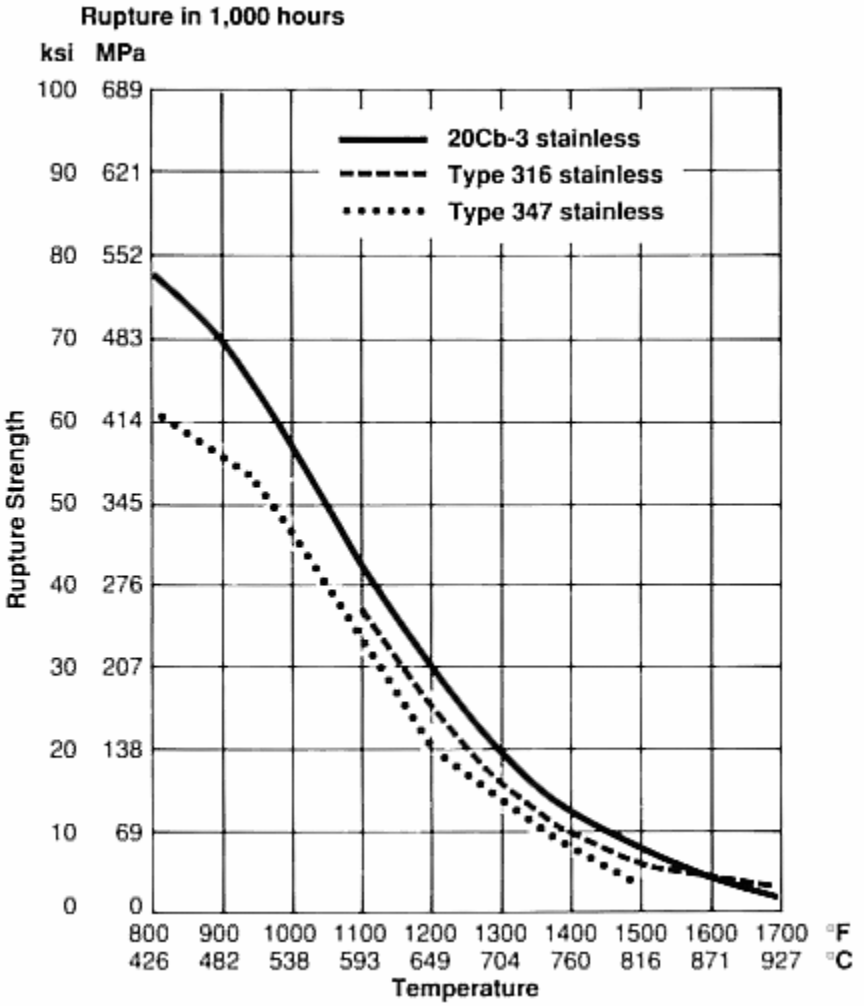
Effect of Temperature on Dynamic Modulus Values

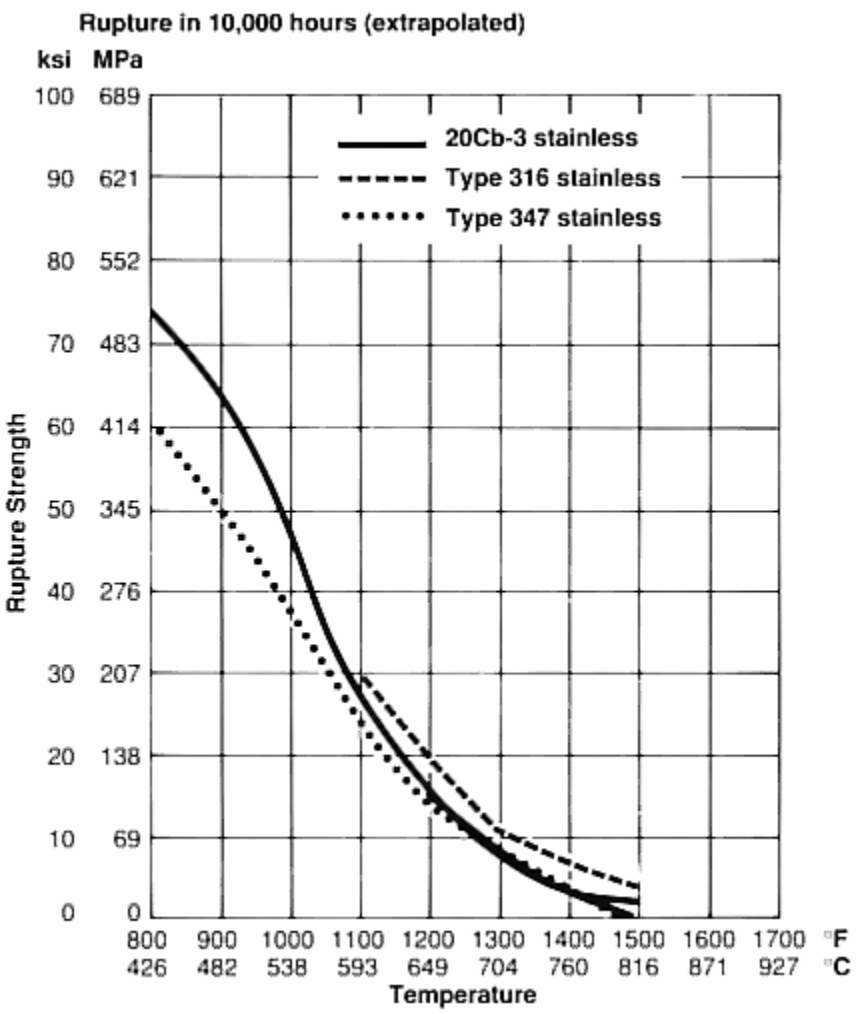
Test Temperature		Modulus of Elasticity (E)		Modulus of Rigidity (G)	
°F	°C	ksi x 10³	MPa x 10³	ksi x 10³	MPa x 10³
75	24	29.0	200	11.0	76
200	93	28.2	194	10.6	73
400	204	27.0	186	10.1	70
600	316	26.0	179	9.8	68
800	427	25.5	176	9.6	66

Magnetic Properties

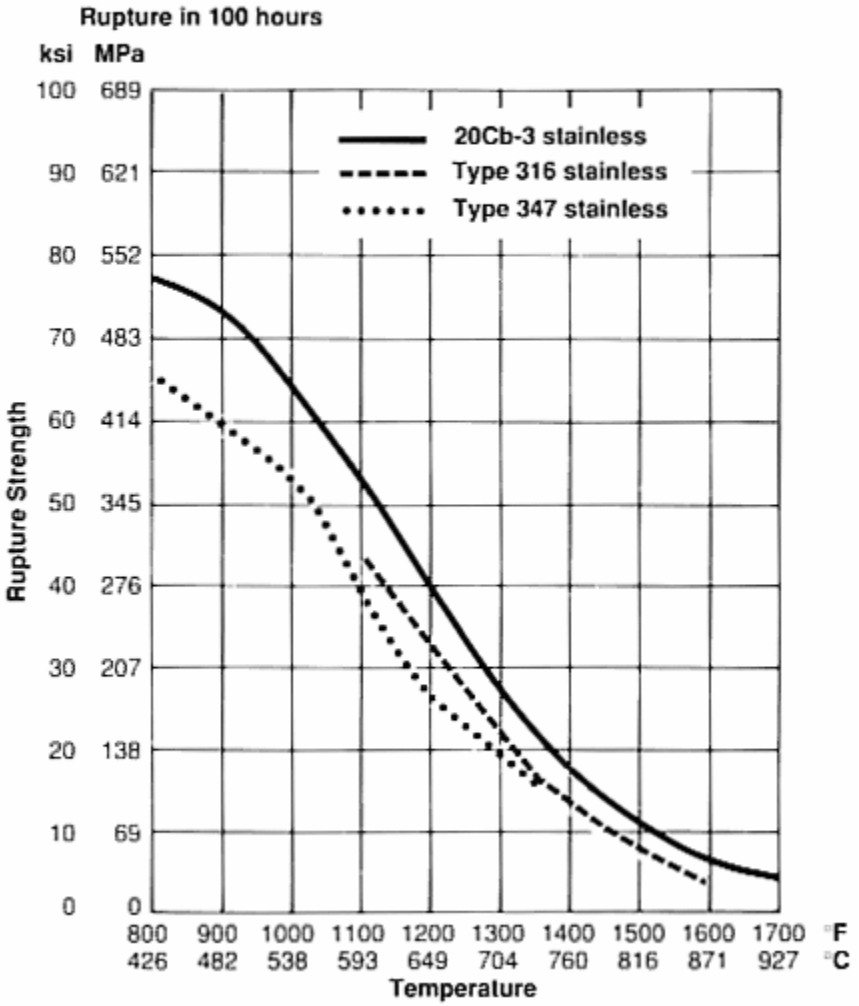
Magnetic Permeability		
Annealed, 200 Oe	1.0020	Mu
Cold Reduced up to 80%, 200 Oe	1.0020	Mu

Typical Mechanical Properties




Rupture in 10,000 hours (extrapolated)
ksi
MPa
100
689
90
621
80
552
70
483
60
414
50
345
40
276
30
207
20
138
10
69
0
0
20Cb-3 stainless
Type 316 stainless
Type 347 stainless
Rupture Strength
800
900
1000
1100
1200
1300
1400
1500
1600
1700
°F
426
482
538
593
649
704
760
816
871
927
°C
Temperature

Stress Rupture Properties - 20Cb-3 Stainless
Typical values



Typical Cryogenic Tensile Properties - 20Cb-3 Stainless

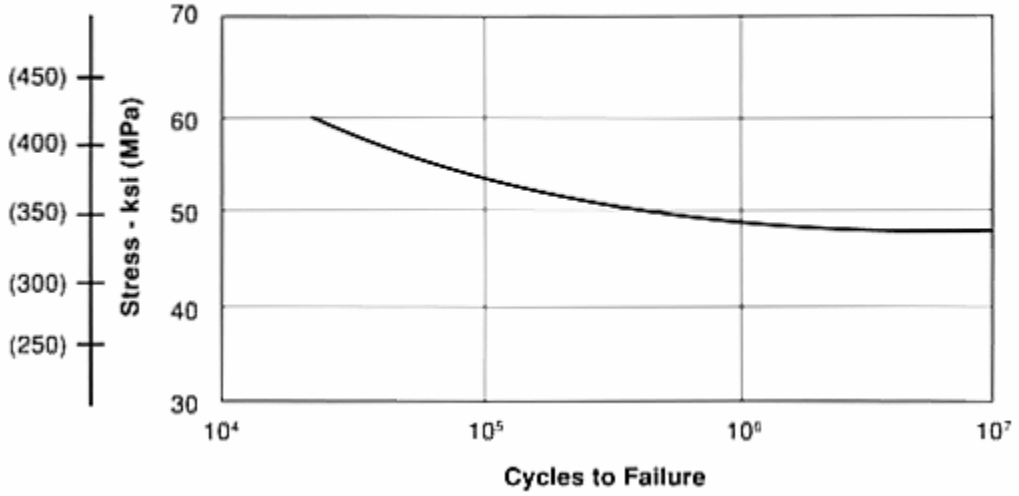
Test Temperature		Direction	0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8mm)	Notched-Unnotched Strength Ratio (K_t = 10)
°F	°C		ksi	MPa	ksi	MPa		
Base								
80	27	L[a]	55	379	96	662	33	0.92
		T[b]	49	338	93	641	36	
-100	-73	L	63	434	109	752	36	0.93
		T	59	407	106	731	37	
-200	-129	L	71	490	120	827	36	0.92
		T	67	462	116	800	40	
-320	-196	L	87	600	154	1062	64	0.82
		T	80	552	150	1034	64	
-423	-253	L	105	724	163	1124	30	0.89
		T	99	683	180	1241	54	
Welded								Joint Efficiency, %
80	27	L	53	365	97	669	32	101
-100	-73	L	64	441	111	765	33	102
-200	-129	L	71	490	124	855	38	105
-320	-196	L	85	586	155	1069	58	101
-423	-253	L	109	752	191	1317	49	117

[a] Longitudinal to rolling direction.
[b] Transverse to rolling direction.

Typical Elevated Temperature Tensile Properties - 20Cb-3 Stainless

Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8mm)	% Reduction of Area
°F	°C	ksi	MPa	ksi	MPa		
Room		45	310	91	627	45	67
200	93	40	276	86	593	46	68
400	204	35	241	83	572	44	67
600	316	33	228	80	552	42	65
800	427	30	207	79	545	40	60
1000	538	28	193	77	531	38	57
1400	760	26	179	45	310	52	75
1600	871	19	131	29	200	75	75

Typical Fatigue Strength
R.R. Moore specimens from 1.250" (31.8mm) rd. bar, annealed 1750°F (955°C), water quench



Typical Room Temperature Mechanical Properties - 20Cb-3 Stainless
Annealed 1750°F (955°C), water quenched

Product Form	0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2" (50.8mm)	% Reduction of Area	Rockwell B Hardness	Charpy V-Notch Impact Strength	
	ksi	MPa	ksi	MPa				ft-lb	J
Bar	48	331	91	627	45	67	86	200	271
Strip	46	317	93	641	38	62	90	—	—

Heat Treatment

Annealing

To anneal 20Cb-3 stainless heat to 1725/1850°F (941/1010°C) for thirty minutes per inch (25.4 mm) of thickness and water quench. Do not overheat. Brinell hardness 187.

In this condition, 20Cb-3 stainless is stabilized against possible intergranular corrosion.

At a sacrifice of stabilization, lower hardness for improved formability may be obtained by annealing up to 2100°F (1149°C). The higher temperatures are permissible if 20Cb-3 stainless will not be subject to welding or heating over 1000°F (538°C).

Hardening

20Cb-3 stainless cannot be hardened by heat treatment - it can be hardened only through cold working.

Stress Relieving

There have been occasions when stress relieving is desired for welding complex structures involving 20Cb-3 stainless. The data shown in the hyperlink entitled "Effect of Stress Relieving on Corrosion Resistance of Welded Coupons in Ferric Sulfate-Sulfuric Acid", developed for a specific case, indicate that stress relieving of 20Cb-3 stainless is safe at temperatures below 1000°F (538°C).

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Effect of Stress Relieving on Corrosion Resistance of Welded Coupons in Ferric Sulfate-Sulfuric Acid - 20Cb-3 Stainless

ASTM A-262 Practice B - Rates shown in mils per year (mpy)

Stress Relief Treatment	Annealed + Stress Relieved	Welded + Stress Relieved
None	12	13
900°F (482°C), 24 hrs.	12	14
1000°F (538°C), 24 hrs.	14	13

Workability

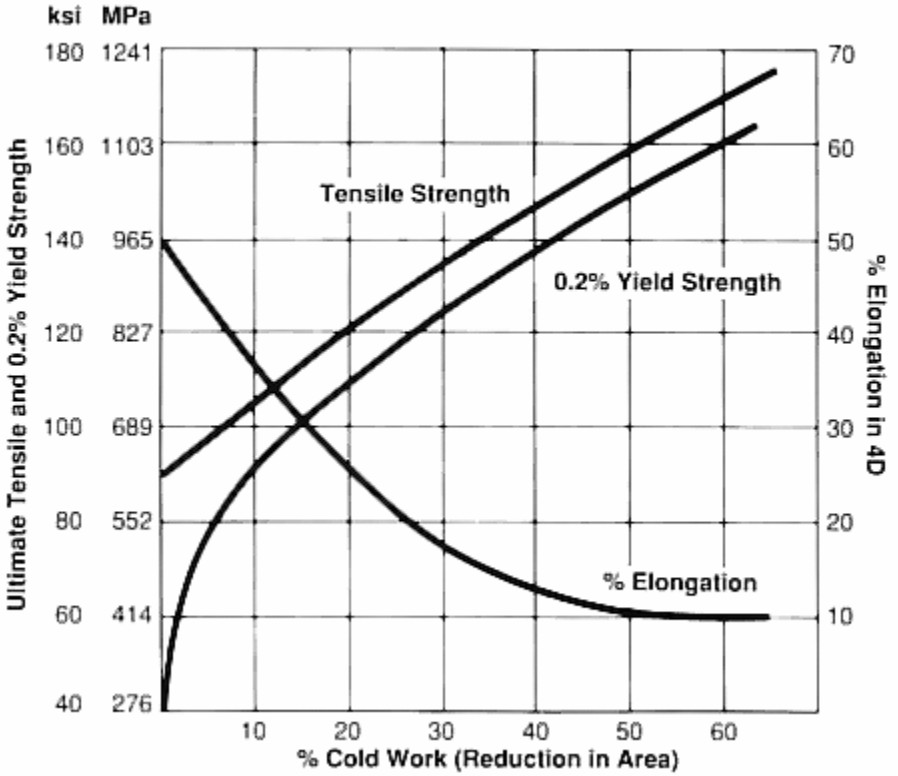
Hot Working

This metal can be forged, upset, headed and riveted satisfactorily. For forging, heat uniformly to 2100/2250°F (1149/1232°C). Do not forge below 1800°F (982°C). After hot working operations, it should be reheated to 1725/1850°F (941/1010°C) for a minimum of 30 minutes per inch (25.4 mm) of thickness and water quenched for optimum stabilization.

Cold Working

20Cb-3 stainless can be readily blanked, deep drawn, formed and upset. The hyperlink entitled "Work Hardening Characteristics" illustrates the increase in strength attainable with cold work. Yield strength is significantly improved with only 10 to 20% cold work. Percent elongation is the best indication of ductility for forming operations.

Work Hardening Characteristics - 20Cb-3 Stainless



Machinability

20Cb-3 stainless, being an austenitic steel, machines with a tough chip but not quite as stringy as the 18-8's. It machines with a somewhat better finish than most austenitic steels.

The hyperlink entitled "Machinability Tables" shows the typical feeds and speeds for 20Cb-3 stainless.

Effect of Cold Reduction – 20Cb-3® Stainless

% Cold Reduction	Ultimate Tensile Strength		% Elongation in 2" (50.8 mm)
	ksi	MPa	
0	89	614	43
10	103	710	25
20	119	820	12
30	133	917	7
50	155	1069	5
80	175	1207	2

Typical Machining Speeds and Feeds – 20Cb-3® 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)	Micro-Melt® Powder High Speed Tools			Carbide Tools (Inserts)			
	Tool Material	Speed (fpm)	Feed (ipr)	Tool Material	Speed (fpm) Uncoated	Speed (fpm) Coated	Feed (ipr)
.150	M48, T15	78	.015	C2	290	375	.015
.025	M48, T15	90	.007	C3	390	425	.007

Turning—Cut-Off and Form Tools

Tool Material		Speed (fpm)	Feed (ipr)						
			Cut-Off Tool Width (Inches)				Form Tool Width (Inches)		
Micro-Melt® Powder HS Tools	Carbide Tools		1/16	1/8	1/4	1/2	1	1 ½	2
M48,T15		60	.001	.0015	.002	.001	.001	.001	.001
	C2	210	.004	.0055	.007	.005	.004	.0035	.0035

Rough Reaming

Micro-Melt® Powder HS		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
M48, T15	72			.003	.005	.008	.012	.015	.018
		C2	80	.003	.005	.008	.011	.014	.017

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
M42	45-55	.001	.003	.006	.010	.014	.017	.021	.025
C2 Coated	140	.0005	.002	.004	.006	.0077	.0088	.0098	.0098

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)	Micro-Melt® Powder 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	M48, T15	84	.001	.002	.003	.004	C2	250	.001	.002	.003	.005

Tapping

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

Broaching

Micro-Melt® Powder High Speed Tools		
Tool Material	Speed (fpm)	Chip Load (ipt)
M48, T15	12	.003

Typical Cold Drawn Tensile Properties of Coiled Product - 20Cb-3 Stainless

20Cb-3 stainless can be supplied in cold drawn coils to tensile properties as shown in the following table. *When ordered in straightened and cut lengths, the tensile strength will be about 10% less than the values shown here.* Cold drawn high tensile wire can be furnished in round sizes starting from 0.0025" (0.0635 mm) to 0.4375" (11.1125 mm) inclusive. Such material has been used for the manufacture of springs, and similar applications where high strength is required. When 20Cb-3 stainless is cold drawn in larger sizes, the mechanical properties are similar to those of Type 302 stainless.

Wire Diameter		Ultimate Tensile Strength			
		Minimum		Maximum	
inches	mm	ksi	MPa	ksi	MPa
0.0025	0.0635	240	1655	280	1931
0.010	0.254	225	1551	260	1793
0.020	0.508	210	1448	227	1565
0.030	0.762	201	1386	220	1517
0.040	1.016	198	1365	218	1503
0.050	1.270	196	1351	216	1489
0.0625	1.5875	192	1324	212	1462
0.125	3.1750	182	1255	202	1393
0.1875	4.7625	172	1186	192	1324
0.250	6.350	165	1138	185	1276
0.3125	7.9375	158	1089	178	1227
0.375	9.525	150	1034	170	1172
0.4375	11.1125	146	1007	166	1145

Additional Machinability Notes

Figures used for all metal removal operations covered are starting points. 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

20Cb-3 stainless has been satisfactorily welded by the shielded fusion and resistance welding processes.

Oxyacetylene welding is not recommended, since carbon pickup in the weld may occur. Since austenitic welds do not harden on air cooling, the welds should have good toughness. It is important to keep the heat input and joint restraint to a minimum to avoid hot cracking. When a filler metal is required, AWS E/ER320LR (20Cb-3LR) welding consumables are suggested. These "low-residual" consumables greatly improve the resistance to weld hot cracking, which can be a problem, especially with higher heat inputs and thicker sections. The alloy has been used in the as-welded condition; however, for elevated temperature service, a post-weld stabilizing heat treatment should be considered.

Other Information

Applicable Specifications

20Cb-3 stainless can be supplied to NACE MR0175; ASTM A265, B366, B462, B463, B464, B468, B471, B472, B473, B474, B475, B729 and their corresponding ASME specifications (as available).

This alloy is included in the ASME Boiler and Pressure Vessel Code, Section VIII Division 1, Section III Classes 2 and 3, Section IX per QW422.45 ("P" No. 45) and in AWS A5.4 (Grades E-320 and E-320LR) and A5.9 (Grades ER-320 and ER-320LR).

Consult Carpenter Technology, Trent Tube or Rolled Alloys for verification of material certification to your specification requirements.

- ASTM A265
- ASTM B366
- ASTM B462
- ASTM B463
- ASTM B464
- ASTM B468
- ASTM B471
- ASTM B472
- ASTM B473
- ASTM B474
- ASTM B475
- ASTM B729
- NACE MR0175

Forms Manufactured

Tubing & Piping - Available by Special Arrangement Through Trent Tube, E. Troy, WI

Sheet & Plate - Available Through Rolled Alloys, Temperance, MI

- Bar-Rounds
- Billet
- Plate
- Sheet
- Strip
- Wire

Technical Articles

- A Designer's Manual On Specialty Alloys For Critical Automotive Components
- A Guide to Etching Specialty Alloys for Microstructural Evaluation
- Alloy Selection for Cold Forming (Part I)
- Alloy Selection for Cold Forming (Part II)
- How to Select the Right Stainless Steel or High Temperature Alloy for Heading
- Selecting Alloys for Severely Corrosive Environments
- Selecting Stainless Steels for Valves
- Selection of High Strength Stainless Steels for Aerospace, Military and Other Critical Applications

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