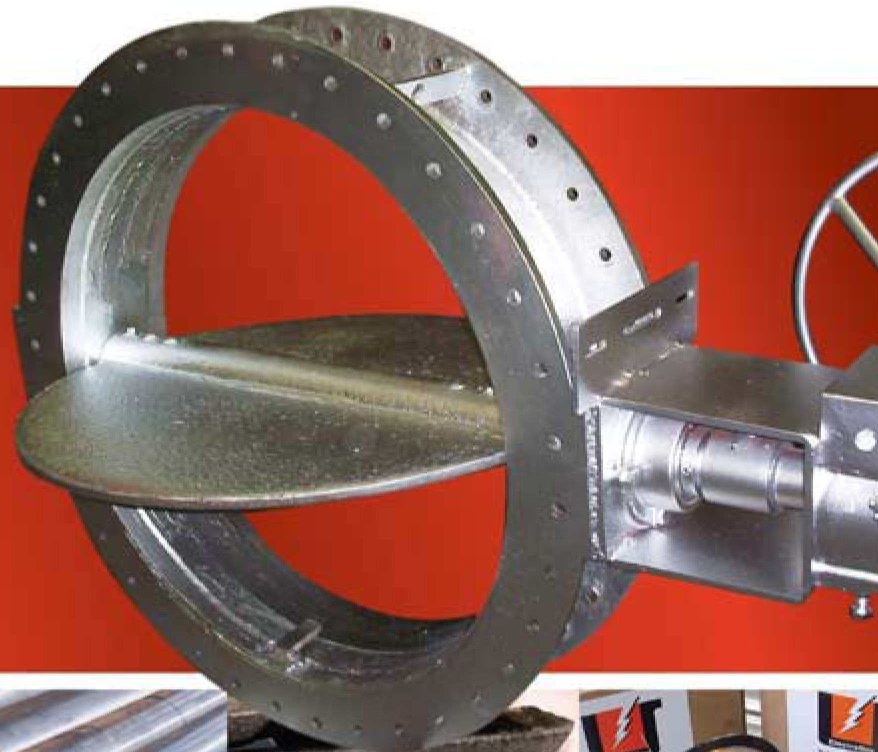
(UNS S20910)

NITRONIC® 50 STAINLESS STEEL PRODUCT FORMS

PUMPS
VALVES
FITTINGS

INGOTS
BILLETS
BARS
PIGS
WELD WIRE
PLATE



STRENGTH AND CORROSION RESISTANCE COMBO

- Best Corrosion Resistance of all stainless steels
- Exceptionally low magnetic permeability
- Strength almost double 316

Product Data Bulletin E-50
Revised 11-2013

Electralloy
ELECTRALLOY

G. O. Carlson
Plate Products

AS/EN/JISQ 9100:2009

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ELECTRALLOY

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NITRONIC® 50

Product Description

Electralloy Nitronic® 50 Stainless Steel provides a combination of corrosion resistance and strength not found in any other commercial material available in its price range.

This austenitic stainless steel has corrosion resistance greater than that provided by Types 316, 316L, 317 and 317L, plus approximately twice the yield strength at room temperature. In addition, Nitronic® 50 Stainless Steel has very good mechanical properties at both elevated and sub-zero temperatures. And, unlike many austenitic stainless steels, Nitronic® 50 does not become magnetic when cold worked or cooled to sub-zero temperatures. High Strength (HS) Nitronic® 50 Stainless Steel has a yield strength about three to four times that of Type 316 stainless steel. Consumable Electrode Electra-Slag Remelted (ESR) product provides improved uniformity, cleanliness and enhanced properties for the most demanding "can't fail" applications.

Available Forms

Electralloy Nitronic® 50 Stainless Steel is available in bar, master alloy, pigs, ingots and forging quality billets. Forms available from other manufacturers include castings, extrusions, seamless tubing and plate. Nitronic® 50 Stainless Steel was originally covered by U.S. Patent 3,912,503.

Composition

Composition	% Min.	% Max
Carbon	---	0.060
Manganese	4.00	6.00
Phosphorus	---	0.040
Sulfur	---	0.030
Silicon	0.20	0.75
Chromium	20.50	23.50
Nickel	11.50	13.50
Molybdenum	1.50	3.00
Nitrogen	0.20	0.40
Columbium	0.10	0.30
Vanadium	0.10	0.30

Applications Potential

Electralloy's Nitronic® 50 is ideal in applications where 316L and 317L are only marginal. It has found wide use in petroleum, petrochemical, chemical, pulp & paper, textile, nuclear, and marine industries. The relative high strength and corrosion resistance of both the annealed condition and high strength condition of the alloy find wide application in oil and gas production for pump shafts, sucker rods and hydraulic manifold blocks for blow-out preventer. In addition the low magnetic permeability make it valuable for down-hole non-magnetic drill string components and "MWD" (measure while drilling) housings.

Nitronic® is used in marine environments in seawater pumps, ballast systems, and propulsion and rudder shafts. The alloy is used for urea production in ammonium carbamate pump parts to make fertilizer and finds application in heat exchangers, pressure vessels, fittings, valves and pumps in petrochemical, chemical and pulp and paper plants. Nitronic® 50 is also providing value in nuclear was disposal applications for waste calcinations systems, aqueous fluoride handling systems and waste canisters. Nitronic® alloys are produced by Electralloy under license from AK Steel.

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The information and data in this product data bulletin are accurate to the best of our knowledge and belief, but are intended for general information only. Applications suggested for the materials are described only to help readers make their own evaluations and decisions, and are neither guarantees nor to be construed as express or implied warranties for suitability for these or other applications.

Data referring to mechanical properties and chemical analyses are the result of test performed on specimens obtained from specific locations of the products in accordance with prescribed sampling procedures; any warranty thereof is limited to the values obtained at such locations and by such procedures. There is no warranty with respect to values of the materials at other locations.

Specifications

Electralloy Nitronic® 50 bar, wire, sheet, plate, forgings and forging billets are covered by the following specifications. It is suggested the issuing agency be contacted for the latest revision of the specifications.

Nitronic® 50 Stainless Steel is listed as Grade XM-19 (UNS S20910) in:

- ASTM A314-Bar and Billet
- ASTM A240-Plate, Sheet and Strip for Fusion Welded Unfired Pressure Vessels
- ASTM A412-Plate, Sheet and Strip
- ASTM A479-Bars and Shapes for use in Boilers and Other Pressure Vessels
- ASTM A276-Bars and Shapes
- ASTM A580-Wire
- ASTM A182-Forged or Rolled Pipe Flanges, Forged Fittings and Valves
- ASTM A193-Bolting (Grade B8S)
- ASTM A194-Nuts (Grade 8S)
- ASTM A249-Welded Superheater, Heat-Exchanger and Condenser Tubes
- ASTM A269-Seamless and Welded Tubing for General Service
- ASTM A312-Seamless and Welded Pipe
- ASTM A351 and A743-Casting (Grade CG6MMN)
- ASTM A403-Wrought Piping, Fittings
- ASTM A358-Electric Fusion Welded Pipe
- AMS 5764-Bar, Forgings and Extrusions
- ASME Design Allowables Listed in Table UHA-23 of Section VII Division 1
- ASME Design Valves Listed in Section III Division 1

Appendices

- NACE MR0175/ISO 15156-3 and MR0103 Annealed and High Strength (HS) Conditions Acceptable to a Hardness of Rockwell C35 Max.
- In valves and chokes, Nitronic® 50 Stainless Steel may be used for valve shafts, stems and pins in the cold-worked condition provided this cold working is preceded by an anneal.
- Application of Nitronic® 50 Stainless Steel in the cold worked condition is permissible in NACE MR0103.

Annealing Temperature

Nitronic® 50 Stainless Steel can be supplied annealed at 1950° F to 2050° F (1066° C to 1121° C). For most applications the 1950° F (1066° C) condition should be selected, as it provides a higher level of mechanical properties along with excellent corrosion resistance. When as-welded material is to be used in strongly corrosive media, the 2050° F (1121° C) condition should be specified in order to minimize the possibility of intergranular attack.

Metric Practice

The values shown in this bulletin were established in U.S. customary units. The metric equivalents of U.S. customary units shown may be approximate.

The term for force per unit of area (stress) is the newton per square metre (N/m^2). Since this can be a large number, the prefix mega is used to indicate 1,000,000 units and the term meganewton per square metre (MN/m^2) is used. The unit (N/m^2) has been designed a pascal (Pa). The relationship between the U.S. and the SI units for stress is: 1000 pounds/in² (psi) = 1 kip/in² (ksi) = 6.8948 meganewtons/m² (MN/m^2) = 6.8948 megapascals (MPa). Other units are discussed in the Metric Practice Guide.

Mechanical Properties

Table 1 Minimum Properties Acceptable for Material Specification Annealed Bars

Condition	UTS, ksi (MPa)	0.2% US, ksi (MPa)	Elongation % in 2” (50.8 mm)	Reduction of Area %
Annealed 1950° F (1066° C) to 2050° F (1121° C) and Water quenched (up to 144 in² [929.0 cm²])	100,000 (690)	55,000 (379)	35	55
Over 144 in² (929.0 cm²) to 324 in² (2091 cm²)	95,000 (655)	50,000 (345)	30	45

Table 2 Typical Room Temperature Properties*, 1” (25.4 mm) Diameter Bar

	Tensile Properties						Torsional Properties	
Condition	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % 2” (50.8 mm)	Red. of Area %	Hardness Rockwell	Impact Charpy V-Notch ft-lbs (J)	0.2% Tortional YS ksi (MPa)	Modulus of Rupture ksi (MPa)
Annealed 2050° F (1121° C) plus water quench	120 (827)	60 (414)	50	70	B98	170 (230)	44.5 (307)	114.5 (789)
Annealed 1950° F (1066° C) plus water quench	125 (862)	65 (448)	45	65	C23	130 (176)	55 (379)	120 (827)

*Average of duplicate tests.

Table 3 Typical Short-Time Elevated Temperature Tensile Properties*

Condition	Test Temp. °F (°C)	UTS, ksi (MPa)	0.2% US, ksi (MPa)	Elongation % in 2” (50.8 mm)	Reduction of Area %
Annealed 1950° F (1066° C) Bars 3/4” to 1-1/4” (19.1 to 31.8 mm) Diameter	75 (24)	124 (855)	78 (538)	40.5	67.5
	200 (93)	112 (772)	66 (455)	40.5	67.5
	400 (204)	102 (703)	58 (400)	37.5	67
	600 (316)	98 (676)	54 (372)	37.5	64
	800 (427)	94 (648)	50 (345)	39.5	63
	1000 (538)	89 (614)	48 (331)	36.5	62.5
	1200 (649)	80 (552)	44 (303)	36.5	63
	1350 (732)	68 (469)	42 (290)	42.5	71.5
	1500 (816)	50 (345)	32 (221)	59.5	85
Annealed 2050° F (1121° C) Bars 1” to 1-1/2” (25.4 to 38.1 mm) Diameter	75 (24)	117 (807)	60 (414)	45	71
	200 (93)	107 (738)	50 (338)	43.5	70.5
	400 (204)	96 (662)	38 (262)	43.5	69.5
	600 (316)	92 (634)	35 (241)	42.5	67.5
	800 (427)	89 (614)	34 (234)	43.5	66
	1000 (538)	84 (579)	32 (221)	41	66.5
	1200 (649)	74 (510)	31 (214)	38	64
	1350 (732)	66 (455)	31 (214)	37	61.5
	1500 (816)	52 (359)	30 (207)	41	61

*Average of triplicate tests from each of three heats.

Table 4 Typical Stress-Rupture Strength*

Condition	Test Temp. °F (°C)	Stress for Failure, ksi (MPa)		
		100 Hours	1,000 Hours	10,000 Hours (est.)
Annealed 1950° F (1066° C) Bars 3/4" to 1-1/4" (19.1 to 31.8 mm) Diameter	1000 (538)	91 (627)	88 (607)	72 (496)
	1100 (593)	72 (496)	62 (427)	47 (324)
	1200 (649)	55 (379)	38 (262)	22 (152)
	1350 (732)	21 (145)	12 (82.7)	6 (41.4)
	1500 (816)	10 (69.0)	3.7 (25.5)	1.3 (9.0)
Annealed 2050° F (1121° C) Bars 1" to 1-1/2" (25.4 to 38.1 mm) Diameter	1000 (538)	---	---	---
	1100 (593)	65 (448)	54 (372)	43 (296)
	1200 (649)	50 (345)	41 (283)	32.5 (224)
	1350 (732)	29 (200)	15 (103)	8.5 (58.6)
	1500 (816)	13 (89.6)	6.5 (44.8)	3.5 (24.1)

*Average of tests from three heats.

Table 5 Typical Creep Strength*, 1" (25.4 mm) Diameter Bar

Condition	Test Temperature °F (°C)	Stress for min. Creep Rate, ksi (MPa)	
		.0001% per Hour	.00001% per Hour
Annealed 2050° F (1121° C)	1100 (593)	41 (283)	34.5 (238)
	1200 (649)	22 (152)	16 (110)

*Tests from one heat.

Table 6 Typical Mechanical Properties*, Cold Drawn Wire

Cold Reduction %	UTS, ksi (MPa)	0.2% US, ksi (MPa)	Elongation % in 4 X D	Reduction of Area %
15	165 (1138)	143 (986)	23	56
30	194 (1338)	174 (1200)	15	49
45	216 (1489)	196 (1351)	11	45
60	234 (1613)	216 (1489)	9	42
75	246 (1696)	234 (1613)	8	39

*Average of duplicate tests. Starting size 1/4" (6.35 mm) dia rod annealed at 2050° F (1121° C).

In common with other Nitronic® Alloys, Nitronic® 50 Stainless Steel, when cold reduced 60% or more without in-process anneals, will embrittle very rapidly when exposed at temperatures in the range of 800 to 1000° F (426 to 538° C). Therefore, springs made of Nitronic® 50 Stainless Steel should not be given the low-temperature, stress-relief treatment commonly used for austenitic stainless steels.

Table 7 Typical Sub-Zero Mechanical Properties* 1" (25.4 mm) Diameter Bar – Annealed 2050° F (1121° C)

Test Temperature °F (°C)	UTS, ksi (MPa)	0.2% US, ksi (MPa)	Elongation % in 2" (50.8 mm)	Reduction of Area %
-100 (-73)	146 (1007)	85 (585)	46.5	65
-320 (-196)	226 (1558)	128 (883)	41	51

*Average of duplicate tests.

Table 8 Typical Impact Strength 1" (25.4 mm) Diameter Bar - Annealed 2050° F (1121° C)

Test Temperature °F (°C)	Impact – Charpy V-Notch, ft-lbs (J)	
	Annealed	Simulated HAZ*
75 (24)	170 (230)	170 (230)
-100 (-73)	115 (156)	115 (156)
-320 (-196)	50 (68)	50 (68)

*Heat treated at 1250° F (677° C) for 1 hour to simulate the heat-affected zone of heavy weldments. Average of duplicate tests.

Table 9 **Effect of Cold Reduction on Mechanical Properties of Bars**

Diameter Bar in. (mm)	Cold Reduction %	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % 2" (50.8 mm) or 4 X D)	Red. of Area %	Hardness Rockwell	Charpy Impact, ft-lbs (J) Test Temperature, °F (°C) 80 (27)	-40° (-40°)	-110° (-79°)
.750 (19.05)	0	116.6 (804)	57.6 (397)	47.0	70.6	B91	232 (314)	---	---
.750 (19.05)	13	142.5 (982)	126.0 (869)	31.0	67.0	C30	116 (157)	---	---
		141.1 (973)	122.5 (844)	31.0	65.7		115 (156)	---	---
.650 (16.51)	28	157.6 (1086)	153.4 (1058)	21.0	63.8	C34	98 (133)	74 (100)	---
		156.0 (1076)	150.6 (1036)	24.0	63.6		91 (123)	54 (73)	---
.750 (19.05)	46	185.9 (1282)	183.8 (1268)	18.0	57.9	C36	54 (73)	48 (65)	38 (51)
		183.1 (1263)	180.6 (1245)	16.0	57.8		53 (71)	43 (58)	39 (53)

Table 10 **Minimum Room Temperature Tensile Properties of High-Strength (HS) Bars (Hot Rolled Unannealed)**

Size in. (mm)	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation or 4 X D	Reduction of Area %	Hardness Brinell	Charpy V-Notch ft-lbs (J)
5/8" to 3.25" incl. (16 to 83)	135 (931)	105 (724)	22	50	260	80 (108)

Table 11 **Torsional Properties of High-Strength (HS) Bars (Hot Rolled Unannealed) 1-1/4" to 2" (31.7 to 50.8 mm) Diameter, Inclusive***

	Prop. Limit, ksi (MPa)	0.2% US, ksi (MPa)	Modulus of Rupture, ksi (MPa)
Typical	65 (448)	100 (690)	140 (965)
Minimum	50 (345)	70 (483)	120 (827)

*Average of duplicate tests. Properties of material over 2" (50.8 mm) are somewhat lower. Please inquire.

Table 12 **Minimum Properties Acceptable for Material Specification High-Strength Bars (Produced by Rotary Forging Special Practice)**

High Strength	3-1/2" (88.9 mm) to 6" incl. (152.4 mm)	Over 6" (152.4 mm) to 10" incl. (254 mm)	Over 10" (254 mm) to 12" incl. (305 mm)
UTS, psi (MPa) min.	135,000 (931)	135,000 (931)	120,000 (827)
0.2% YS, psi (MPa) min.	105,000 (724)	105,000 (724)	90,000 (621)
Elongation % in 4D min.	22	22	22
Red. of Area % min.	50	50	50
Charpy V-Notch, ft* lbs (J)	80 (108)	80 (108)	80 (108)
Super-High Strength			
UTS, psi (MPa) min.	140,000 (965)	140,000 (965)	---
0.2% YS, psi (MPa) min.	120,000 (827)	120,000 (827)	---
Elongation % in 4D min.	22	22	---
Red. of Area % min.	50	50	---
Charpy V-Notch, ft* lbs (J)	60 (81)	60 (81)	---
Ultra-High Strength			
UTS, psi (MPa) min.	150,000 (1034)	---	---
0.2% YS, psi (MPa) min.	140,000 (965)	---	---
Elongation % in 4D min.	20	---	---
Red. of Area % min.	45	---	---
Charpy V-Notch, ft* lbs (J)	40 (54)	---	---

High Strength (HS) Bar Properties

Nitronic® 50 Stainless Steel bars also are available in high-strength condition attained by special processing techniques. The superior strength of Nitronic® 50 HS Stainless Steel is produced by proprietary hot working practices. Because its high strength is produced by mill processing, hot forging, welding or brazing operations cannot be performed on this material without loss of strength. High-strength bars produced by rotary forging—special practice may have somewhat reduced resistance to corrosion and sulfide stress cracking, although much of that risk has been mitigated with low carbon content.

Table 13 Typical Short-Time Elevated Temperature Tensile Properties of High-Strength (HS) Bars* (Hot Rolled Unannealed)

Test Temperature °F (°C)	UTS, ksi (MPa)	0.2% US, ksi (MPa)	Elongation % in 2" (50.8 mm)	Reduction of Area %
75 (24)	150 (1034)	126 (869)	29	64
200 (93)	135 (931)	112 (772)	28	65
400 (204)	124 (855)	101 (696)	27	63.5
600 (316)	117 (807)	93 (641)	27.5	61
800 (427)	111 (765)	86 (593)	28.5	61
1000 (538)	103 (710)	80 (552)	27	60.5
1100 (593)	99 (683)	77 (531)	26	59.5

*Bars 1" to 2" (25.4 to 50.8 mm) diameter.
Average of triplicate tests from each of three heats.

Table 14 Typical Short-Time Elevated Temperature Tensile Properties of High-Strength (HS) Bars* (Hot Rolled Unannealed)

Test Temperature °F (°C)	Stress for Failure, ksi (MPa)		
	100 Hours	1,000 Hours	10,000 Hours (est.)
1000 (538)	98 (676)	95 (655)	78 (538)
1100 (593)	85 (586)	66 (455)	51 (352)

*Average of test from two heats.
Nitronic® 50 high-strength (HS) bars are not recommended for prolonged use at temperatures above 1100° F (593° C).

Table 15 Typical Sub-Zero Impact Strength of High-Strength (HS) Bars* (Hot Rolled Unannealed)

Test Temperature °F (°C)	Charpy V-Notch Impact, ft-lbs (J)		
	1" (25.4 mm) dia.	1-1/2" (38.1 mm) dia.	2" (50.8 mm) dia.
80 (27)	126 (171)	150 (203)	148 (201)
-75 (-60)	114 (155)	131 (178)	131 (178)
-200 (-129)	48 (65)	62 (84)	61 (83)
-320 (-196)	31 (42)	41 (56)	36 (49)

*Average of duplicate tests from two heats of each bar size.

Table 16 Typical Cryogenic Mechanical Properties of High-Strength (HS) 2" (50.8 mm) Bar

Test Temperature °F (°C)	0.2% US, ksi (MPa)	UTS, ksi (MPa)	Elongation % in 2" (50.8 mm)	Reduction of Area %
Room	115.5 (796)	142.5 (983)	40.0	65.0
-100 (-73)	136.6 (942)	169.9 (1171)	35.5	66.5
-200 (-129)	152.4 (1051)	189.7 (1308)	28.0	61.0
-250 (-157)	166.9 (1151)	200.4 (1382)	25.5	63.5
-320 (-196)	192.9 (1330)	241.3 (1664)	28.5	*

*Piece broke from specimen, making accurate determination of final diameter impossible.

Shear Strength

The shear strength of Nitronic® 50 Stainless Steel in double shear has been determined following Boeing Aircraft Co. D2-2860, Procedures for Mechanical Testing of Aircraft Structural Fasteners. The results, determined from a typical heat are as shown.

Elastic Properties

The elastic properties of annealed Nitronic® 50 at room temperature are as shown.

Notch Sensitivity

Tensile tests were performed at room temperature using notched specimens with a stress-concentration factor of K_t = 1.3. The following data at right show Nitronic® 50 Stainless Steel is not notch sensitive.

Fatigue Strength

Table 17 Rotating Beam Fatigue Tests

Condition	Bar Size	Fatigue Strength at 10^8 Reversals of Stress ksi (MPa): Tested in Air*	Tested in Seawater
Annealed 2050° F (1121° C)	1" dia (25.4 mm)	42 (290)	22 (152) **
Annealed 1950° F (1066° C)	1" dia (25.4 mm)	47 (324)	---
High-Strength (HS) Bars (Hot Rolled Unannealed)	1" dia (25.4 mm)	68 (469)	18 (124) **
	2-1/2" dia (63.5 mm)	58 (400)	15 (103) **
	4" dia (102 mm)	44 (303)	15 (103) **
Nitronic® 50 "Super High Strength"	8" dia. (203.2 mm)	---	50 (345) ***

*R.R. Moore specimens tested at room temperature.
**McAdam specimens tested in ambient temperature seawater (11-31° C) at LaQue Corrosion Laboratory, Wrightsville Beach, N.C.
***Westmoreland Mechanical Testing & Research, Inc. tested at room temperature in ASTM D1141-98 seawater. Tests from one heat for each size and condition.

Table 18 Shear Strength

Condition	UTS ksi (MPa)	Double Shear ksi (MPa)	Shear/Tensile Ratio, %
Annealed 1950° F (1066° C)	126 (869)	86.8 (598)	69
Annealed 2050° F (1121° C)	113 (779)	78.5 (541)	69.5

Table 19 Elastic Properties

Modulus of Elasticity in Tension (E), psi (MPa)	Modulus of Elasticity in Torsion (G), psi (MPa)	Poisson's Ratio
28.9×10^6 (199×10^3)	10.8×10^6 (74,500)	0.312

*Average of duplicate tests.

Table 20 Elastic Properties at Elevated Temperatures*

Temperature °F (°C)	Young's Modulus in Tension: psi	(MPa)	Poisson's Ratio
72 (22)	28.9×10^6	(199×10^3)	0.312
200 (93)	27.8×10^6	(192×10^3)	0.307
300 (149)	27.0×10^6	(186×10^3)	0.303
400 (204)	26.1×10^6	(180×10^3)	0.299
500 (260)	25.3×10^6	(174×10^3)	0.295
600 (315)	24.6×10^6	(170×10^3)	0.291
700 (371)	24.0×10^6	(165×10^3)	0.288

*Tests performed on sheet samples in the longitudinal direction using strain gages.

Table 21 Notch Sensitivity

Condition	UTS - Smooth, ksi (MPa)	UTS - Notched, ksi (MPa)
Annealed 2050° F (1121° C)	114.5 (790)	155 (1069)
Annealed 1950° F (1066° C)	120.5 (830)	---
High-Strength (HS) Bars	151 (1041)	196.5 (1354)

Average of duplicate tests.

Galling and Wear Resistance

The galling resistance of Nitronic® 50 Stainless Steel is similar to Type 316 or just slightly better.

Metal-to-metal wear tests demonstrate the superiority of Nitronic® 50 over alloy K-500 despite the higher hardness of the latter. Comparative wear data are shown.

For applications requiring superior galling, wear and cavitation resistance coupled with good corrosion resistance, Nitronic® 60 Stainless Steel should be considered.

Physical Properties

Density at 75° F (24° C)
7.88 gm/cm³
.285 lbs/in³

Electrical Resistivity at 70° F (21° C) – 82 microhm-cm

Magnetic Permeability

Nitronic® 50 Stainless Steel does not become magnetic when severely cold worked. This characteristic makes the alloy useful for applications requiring a combination of excellent corrosion resistance and low magnetic permeability.

The magnetic permeability of Nitronic® 50 Stainless Steel remains very low at cryogenic temperatures, but not as low as Nitronic® 33 and Nitronic® 40 Stainless Steels. The magnetic susceptibility data in Table 25 were obtained on mill-annealed sheet samples using the Curie Force Method.

Note that the magnetic susceptibility of Nitronic® 50 Stainless Steel exhibits a cusp at approximately -400° F (-240° C). This phenomenon, which also occurs with Nitronic® 33 and Nitronic® 40 Stainless Steels, is dependent on temperature but not on field strength. Unlike the AISI 300 series stainless steels, most Nitronic® Alloys show no supermagnetism.

Table 22 **Weight Loss of Couple* mg/1000 Cycles**

Alloy (Rockwell Hardness) vs.	Alloy K-500 (C34)	Nitronic® 50 (C28)	Type 316	Nitronic® 60 (B95)
Type 316 (B91)	33.78	10.37	12.51 (B91)	4.29
17.4 PH (C43)	34.08	12.55	18.50 (B91)	5.46
Cobalt Alloy 6B (C48)	18.78	3.26	5.77 (B72)	1.85
Type 431 (C42)	26.40	6.73	5.03 (B72)	3.01
Ti-6Al-4V (C36)	17.19	6.27	6.31 (B72)	4.32
Alloy K-500 (C34)	30.65	34.98	33.78 (B91)	22.87
Nitronic® 50 (C28)	34.98	9.37	10.37 (B72)	4.00
Nitronic® 60 (B95)	22.87	4.00	4.29 (B91)	2.79

*Test Conditions: Taber Met-Abrader machine, .500" Ø crossed (90°) cylinders, dry, 16-lb load, 105 RPM, room temperature, 120 grit surface finish, 10,000 cycles, degreased, duplicates, weight loss corrected for density differences.

Table 23 **Cavitation Resistance of Annealed Nitronic® 50 Stainless Steel**

Alloy	Weight Loss mg*
Nitronic® 50	30
Type 316	100

*Data provided by outside laboratory per ASTM G32 Test Method.

Table 24 **Wire***

	Typical Magnetic Permeability at Field Strength of		
Condition	50 Oer. (3978 A/m)	100 Oer. (7957 A/m)	200 Oer. (15,914 A/m)
Annealed	1.004	1.004	1.004
Cold Drawn 27%	1.004	1.004	1.003
Cold Drawn 56%	1.004	1.004	1.004
Cold Drawn 75%	1.004	1.004	1.004

*Average of duplicate tests.

Table 25

Temperature °F (°C)	Magnetic Mass Susceptibility, χ, 10^{-6} cm³ g⁻¹	Typical Magnetic Permeability, μ
72 (22)	21.5	1.0021
-9 (-23)	22.5	1.0022
-99 (-73)	25	1.0025
-189 (-123)	28.5	1.0028
-279 (-173)	35.5	1.0035
-369 (-223)	54	1.0053
-400 (-240)	74	1.0073
-432 (-258)	61	1.0060

Reference: Advances in croyogenic Engineering Materials, Vol. 26 (1980), pp. 37-47.

COEFFICIENT OF THERMAL EXPANSION

Table 26 Coefficient of Thermal Expansion Annealed Material*

Temperature Range °F (°C)	Coefficient of Thermal Expansion microinches/in/°F, (µm/m•K)
70 - 200 (21 - 93)	9.0 (16.2)
70 - 400 (21 - 204)	9.2 (16.6)
70 - 600 (21 - 316)	9.6 (17.3)
70 - 800 (21 - 427)	9.9 (17.8)
70 - 1000 (21 - 538)	10.2 (18.4)
70 - 1200 (21 - 649)	10.5 (18.9)
70 - 1400 (21 - 760)	10.8 (19.4)
70 - 1600 (21 - 871)	11.1 (20.0)

*Average of duplicate tests.

Table 27 Thermal Contraction

Temperature °F (°C)	Contraction Parts Per Million (ppm)	Mean Expansion Coefficient Between T and 75° F (24° C)	
		ppm/°F	ppm/°C
-41 (-41)	948	8.17	14.61
-51 (-46)	1016	8.06	14.53
-60 (-51)	1074	7.95	14.34
-80 (-62)	1237	7.98	14.40
-100 (-73)	1398	7.99	14.43
-125 (-87)	1560	7.80	14.07
-150 (-101)	1723	7.66	13.80
-178 (-117)	1951	7.71	13.84
-200 (-129)	2079	7.56	13.60
-225 (-143)	2231	7.44	13.37
-260 (-162)	2333	6.96	12.55
-320 (-196)	2542	6.44	11.56

Table 28 Thermal Conductivity

Temperature °F (°C)	Thermal Conductivity* BTU/hr/ft²/in/°F (W/m•K)	
70 (21)	---	---
300 (149)	108	(15.6)
600 (316)	124	(17.9)
900 (482)	141	(20.3)
1200 (649)	160	(23.0)
1500 (816)	175	(25.2)

*Average of duplicate tests.

Corrosion Resistance

Nitronic® 50 Stainless Steel provides outstanding corrosion resistance—superior to Types 316, 316L, 317 and 317L in many media. For many applications the 1950° F (1066° C) annealed condition provides adequate corrosion resistance and a higher strength level. In very corrosive media or where material is to be used in the as-welded condition, the 2050° F (1121° C) annealed condition should be specified. Electralloy Nitronic® 50 High Strength bars do not quite exhibit the corrosion resistance of the annealed condition in all environments, but some of the risk has been mitigated with low carbon content.

Typical corrosion rates obtained from laboratory tests on Nitronic 50® Stainless Steel in its several conditions are shown in Table 29 along with comparable data for Types 316, 316L, 317 and 317L stainless steels.

Table 29 Laboratory Corrosion Test Data

Test Medium	Corrosion Rates in Inches per Year (IPY) Unless Otherwise Indicated [1]				
	Nitronic® 50 Bar Annealed 1950° F (1066° C)	Nitronic® 50 Bar Annealed 2050° F (1121° C)	Nitronic® 50 Bar High-Strength (HS) Bar [3]	Types 316 & 316L Annealed Bar	Types 317 & 317L Annealed Bar
10% $FeCl_3$, 25° C - plain[2]	<.001 g/in²	<.001 g/in²	<.001 g/in²	<.011 g/in²	---
10% $FeCl_3$, 25° C - creviced[2]	<.001 g/in²	<.001 g/in²	<.001 g/in²	<.186 g/in²	---
1% H_2SO_4, 80° C	<.001	<.001	<.001	0.002	<.001
2% H_2SO_4, 80° C	<.001	<.001	<.001	0.011	<.001
5% H_2SO_4, 80° C	<.001	<.001	<.001	0.060	0.036
10% H_2SO_4, 80° C	---	0.028	---	0.10	0.049
20% H_2SO_4, 80° C	---	0.133	---	.048	0.155
1% H_2SO_4, Boiling	---	0.027	---	---	0.013
2% H_2SO_4, Boiling	---	0.064	---	0.12	0.027
5% H_2SO_4, Boiling	.194	0.131	0.296	0.26	0.093
10% H_2SO_4, Boiling	---	0.356	---	0.73	0.465
20% H_2SO_4, Boiling	---	1.64	---	2.20	1.30
1% HCl, 35° C	<.001	<.001	<.001	0.012	0.002
2% HCl, 35° C	0.024	<.001	0.027	0.021	0.023
1% HCl, 80° C	---	<.001	0.239	---	0.148
2% HCl, 80° C	---	0.439	0.452	---	0.263
65% HNO_3, Boiling	0.010	0.007	---	0.012	0.012
70% H_3PO_4, Boiling	0.203	0.154	---	0.202	0.201
33% Acetic Acid, Boiling	<.001	<.001	<.001	<.001	<.001
20% Formic Acid, Boiling	---	<.001	---	0.027	---
40% Formic Acid, Boiling	---	0.032	---	0.034	---
10% HNO_3 + 1% HF, 35° C	---	0.007	---	0.064	---
10% HNO_3 + 1% HF, 80° C	---	0.069	---	0.442	---

(1) Immersion tests performed on 5/8" dia. x 5/8" (15.9 x 15.9 mm) long machined cylinders. Results are average of five 48-hour periods. Specimens tested at 35° C and 80° C were intentionally activated for third, fourth and fifth periods. Where both active and passive conditions occurred, only active rates are shown.

(2) Exposure for 50 hours with rubber bands on some specimens to produce crevices.

(3) Corrosion rates for hot rolled bars. For other mill products, contact AK Steel.

Table 30 Laboratory Corrosion Test Data* Cast Nitronic® 50

Test Medium	Nitronic® 50 As- Cast	Nitronic® 50 Cast + Annealed 2050° F (1121° C)
10% $FeCl_3$ - Uncreviced 50 hrs., Room Temperature	---	<.001 g/in²
10% $FeCl_3$ - Crevices 50 hrs., Room Temperature	---	.029 g/in²
5% H_2SO_4, 80° C	95 MPY	81 MPY
5% H_2SO_4, Boiling	---	418 MPY
1% HCl, 35° C	< 1 MPY	< 1 MPY
70% H_3PO_4, Boiling	---	83 MPY

*All tests performed on 5/8" (15.9 mm) long machined cylinders. Expect for the ferric chloride tests, all results are the average of five 48-hour periods. Specimens tested at 35° C and at 80° C were intentionally activated for the third, fourth and fifth periods. Where both active and passive periods occurred, only active rates are shown.

Intergranular Attack

The resistance of Nitronic® 50 Stainless Steel to intergranular attack is excellent even when sensitized at 1250° F (675° C) for one hour to simulate the heat-affected zone of heavy weldments. Material annealed at 1950° F (1066° C) has very good resistance to intergranular attack for most applications. However, when thick sections of Nitronic® 50 Stainless Steel are used in the as-welded condition in certain strongly corrosive media, the 2050° F (1121° C) condition gives optimum corrosion resistance. This is illustrated by Table 32.

Stress-Corrosion Cracking Resistance

In common with most stainless steels, under certain conditions, Nitronic® 50 Stainless Steel may stress-corrosion crack in hot chloride environments. When tested in boiling 42% $MgCl_2$ solution, a very accelerated test, Nitronic® 50 Stainless Steel is between types 304 and 316 stainless steels in resistance to cracking. There is little difference in susceptibility to cracking whether in the annealed, high-strength (HS), or cold-drawn conditions. This is illustrated by the comparative data in Table 33 using the direct-loaded tensile-type test method (described in detail in ASTM STP 425, September 1967).

Table 31 **Intergranular Corrosion Resistance of Cast Nitronic 50®**

% Ferrite	Huey Test, IPM	
	Annealed*	Sensitized**
Nil	0.0005	0.0006
4	0.0004	0.0015

*2050° F (1121° C) – 1/2-Hour – Water Quenched
** 2050° F (1121° C) – 1/2-Hour – Water Quenched + 1250° F (677° C) – 1/2-Hour – Air Cooled.
Even sensitized cast Nitronic® to Stainless Steel has an acceptable intergranular corrosion rate less than 0.0020 IPM with up to 4% ferrite present.

Table 32 **Intergranular Attack Resistance of Nitronic® 50 Bar per ASTM A262**

Condition	Practice B: Ferric Sulfate	Practice E: Copper-Copper Sulfate
Annealed 1950° F (1066° C)	0.0010 IPM	Passed
Annealed 1950° F (1066° C) + 1250° F (677° C) - 1 hr. - A.C.	0.0038 IPM	Passed
Annealed 2050° F (1121° C)	0.0009 IPM	Passed
Annealed 2050° F (1121° C) + 1250° F (677° C) - 1 hr. - A.C.	0.0022 IPM	Passed
High-Strength (Bar Mill)	0.0031 IPM	Passed
High-Strength (PRF)		
Edge	0.0013 IPM	Passed
Intermediate	0.0012 IPM	Passed
Center	0.0011 IPM	Passed

Table 33 **Boiling $MgCl_2$**

Alloy	Condition	Time to Failure, Hours Under Stress of		
		75 ksi (517 MPa)	50 ksi (345 MPa)	25 ksi (172 MPa)
Type 304	Annealed	0.2	0.3	0.8
Type 316	Annealed	0.8	2.5	7.0
Nitronic® 50	Annealed	0.4	1.2	5.0
Nitronic® 50	High-Strength	1.2	1.5	6.0
Nitronic® 50	Cold Drawn	1.2	2.6	3.3

Note that this is a severe test, especially at these temperatures. For marine applications, the following better reflects the resistance of Nitronic® 50 Stainless Steel:

U-bend-type stress corrosion test specimens of Nitronic® 50 in the following metallurgical conditions have been exposed to marine atmosphere on the 80' lot at Kure Beach, N.C.

(1) Mill Annealed 1950° F (1063° C)

(2) Mill Annealed & Sensitized 1250° F (675° C)

(3) Cold Rolled 44% (160 ksi yield strength)

Tests were begun on June 3, 1970. No failure occurred after 15 years exposure.

Sulfide Stress Cracking

Both laboratory tests and field service experience show that Nitronic® 50 Stainless Steel has excellent resistance to sulfide stress cracking in all conditions. Nitronic® 50 Stainless Steel in both the annealed and high-strength (hot-rolled) conditions has been included in the 1988 revision of NACE Standard MR-01-75, "Sulfide Stress Cracking Resistant Material for Oil Field Equipment", at hardness levels up to RC35 maximum. The cold-worked conditions to RC35 maximum also is acceptable in valves and chokes for valve shafts, stems and pins, provided this cold working is preceded by an anneal.

Table 34 illustrates the resistance of Nitronic® 50 Stainless Steel to cracking in laboratory test in synthetic sour-well solutions (5% NaCl + 1/2% acetic acid, saturated with H_2S). Comparable data are included for 17-4 PH Stainless Steel, which is considered acceptable by NACE for use in sour-well service in the two heat-treated conditions shown.

Table 34 **Resistance to Sulfide Stress Cracking(1)**

Alloy	Condition	Hardness Rockwell	0.2% YS ksi (MPa)	Time to Failure, hr., Under Stress, ksi (MPa)						
				150 (1034)	140 (965)	125 (862)	100 (690)	75 (517)	50 (345)	25 (172)
Nitronic® 50	Annealed 1950° F (1066° C)	C22	67 (448)	---	---	---	>1000	>1000	>1000	---
Nitronic® 50	High-Strength (HS)(3) 1" (25.4 mm) dia.	C33	135 (931)	---	204	320	>1000	>1000	---	---
Nitronic® 50	High-Strength (HS)(3) 1" (25.4 mm) dia.	C35	146 (1007)	---	358	---	---	---	---	---
Nitronic® 50	High-Strength (HS)(3) 1" (25.4 mm) dia.	C36	144 (993)	170(2)	>1000	>1000	>1000	---	---	---
Nitronic® 50	Cold Drawn 3/8" (9.5 mm) dia.	C41	160 (1103)	>1000	---	---	>1000	---	---	---
17-4 PH	H 1150 + 1150	C32.5	110 (758) est.	---	---	---	---	9.5	16	225
17-4 PH	H 1150-M	C29	85 (586)	---	---	---	---	13.5	29	850

(1) Longitudinal tensile specimens tested according to NACE TM 01-77.

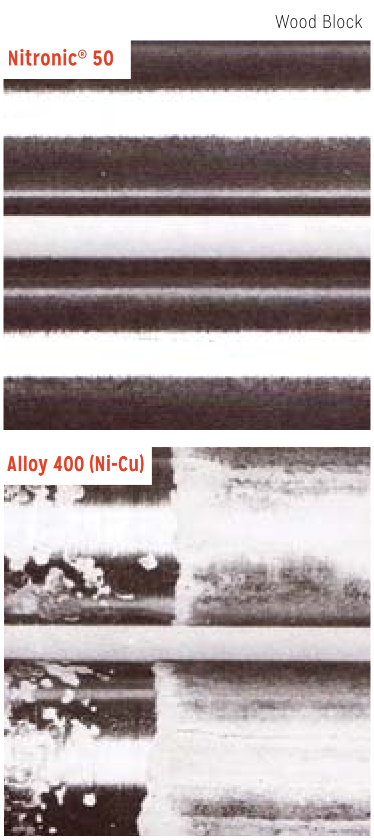
(2) Ductile creep failure.

(3) For hot rolled bars only.

Nitronic® 50 Stainless Steel spring temper wire coiled into a spring was exposed to the NACE solution at room temperature under the following conditions:

Table 35

Condition	Wire UTS, ksi (MPa	Applied Stress, ksi (MPa)	Hrs to Failure
Cold Drawn Wire Wound into a Helical Spring	282 (1944)	100 (689)	>1584 (discontinued)



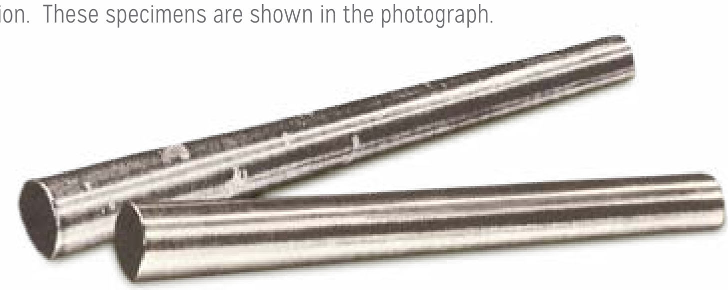
Seawater Resistance

Here is how Nitronic® 50 High-Strength (HS) shafting and Alloy 400 (Ni-Cu) looked after 18 months' exposure in quiet seawater off the coast of North Carolina. The test was conducted without zinc anodes to establish the relative corrosion resistance of Nitronic® 50 High-Strength (HS) shafting. Had zinc anodes been used or a bronze propeller fitted to these bars, no crevice corrosion should have occurred. The photograph was taken after barnacles and other forms of marine life were cleared from the test bars.

Before exposure, all specimens were polished to 120 grit finish, degreased and passivated. They were then clamped into pepperwood racks and exposed fully immersed in seawater. Nitronic® 50 high-strength (HS) shafting showed no crevice attack under the wooden blocks after the 18 months. One bar of Nitronic® 50 high-strength (HS) shafting remained perfect, while the other showed a few areas of very light crevice attack, <.001" (0.025 mm) deep under marine attachments. Both samples of Alloy 400 suffered shallow crevice attack .001" - .003" (0.025 - 0.076 mm) deep under the area in contact with the wooden rack, and also under numerous attached barnacles.

Type 316 stainless steel tested similarly for nine months suffered random pitting and crevice corrosion under the area in contact with the wooden rack and also under marine attachments, while Nitronic® 50 again remained in prefect condition. These specimens are shown in the photograph.

These two bars are immersed in quiet seawater for nine months. Bright shiny bar at right is Nitronic® 50 stainless steel, and at left is Type 316 stainless steel showing considerable pitting and crevice corrosion.



Salt Fog - Marine Environment

No change was apparent in Nitronic® 50 Stainless Steel in any condition after exposure to 5% NaCl fog at 35° C for 500 hours, or after exposure to marine atmospheres on the 800-foot (24.4 m) lot at Kure Beach, North Carolina, for 7 ½ years. Similar exposure to marine atmospheres produce light staining on Type 316 stainless steel.

Food Handling

Nitronic® 50 Stainless Steel is considered suitable for food contact use. The National Sanitation Foundation includes Nitronic® 50 Stainless Steel in their "List of Acceptable Materials for Food Contact Surfaces".

Polythionic Acid Resistance

Polythionic acids are of the general formula $H_2S_xO_6$, where x is usually 3, 4 or 5. These acids can form readily in petroleum refinery units, particularly desulfurizers, during shutdown.

Stressed U-bend specimens of Nitronic® 50 stainless, in both the annealed condition and after sensitizing at 1250° F (677° C) for 1 hour, showed no trace of cracking after exposure to polythionic acids for 500 hours at room temperature.

Pitting Resistance

These pieces of bar were all exposed to 10% ferric chloride solution for 50 hours at room temperature. A rubber band was placed around each to promote crevice corrosion which sometimes occurs in areas where the surface is shielded from oxygen. From left to right, the are Nitronic® 50 Stainless Steel, Type 316 stainless steel and Type 304 stainless steel. Only Nitronic® 50 stainless is still bright and shinny. The Type 316 and Type 304 stainless steels are badly pitted and show severe crevice corrosion in the area where the rubber bands were placed.

Urea Production

Ammonium carbamate—an intermediate produced during the manufacture of urea—is extremely corrosive to process equipment. Pump parts in the process are subjected to a combination of severe corrosive attack, high temperatures and cyclical operating pressures ranging up to 3000 psi. Some parts made of Type 316L stainless steel have shown surface attack in just a few months.

A manufacturer of special valves tested three stainless steels in ammonium carbamate. As shown in the photograph, Type 304 stainless steel became severely etched in two weeks and Type 316 stainless steel showed some corrosive attack in all exposed areas after six weeks. Nitronic® 50 Stainless Steel remained unaffected after six weeks' exposure to this aggressive medium.

Nitronic® 50 Stainless Steel is presently being specified for the blocks, plungers and related parts of reciprocating pumps when service requires handling ammonium carbamate or other corrosive materials.

Fabrication
Although Nitronic® 50 Stainless Steel is considerably stronger than the conventional 300 series stainless steels, the same fabricating equipment and techniques can be used.

Forging
Nitronic® 50 Stainless Steel is readily forged like Type 316 stainless steel, except that it requires more power and the temperature is 2150° F to 2250° F (1177° C to 1232° C).

Annealing
Like other austenitic stainless steels, Nitronic® 50 must be rapidly cooled. In-process anneals to facilitate cold forming should be done at 2050° F (1066° C). Please note Page 3.

Table 36 **Nominal Composition and Typical Mechanical Properties of Several Austenitic All-Weld-Metal Deposits**

Alloy Type	Nominal Composition, Weight %					Typical Mechanical Properties		
	C	Mn	Cr	Ni	Others	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation %
AWS 308L	0.04 max	1.0 2.5	19.5 22.0	9.0 11.0	---	85 (586)	55 (379)	45
AWS 309	0.15 max	1.0 2.5	22.0 25.0	12.0 14.0	---	90 (621)	55 (379)	40
AWS 312	0.15 max	1.0 2.5	28.0 32.0	8.0 10.5	---	110 (758)	80 (552)	30
Nitronic® 50W (AWS E 209)	0.05 max	4.0 7.0	20.5 24.0	9.5 12.0	**Mo** 1.5 3.0 **N** .10 .30	110 (758)	85 (586)	20
Inconel 182	0.10 max	5.0 9.5	13.0 17.0	Bal	**Fe** 6.0 10.0 **Cb** 1.0 2.5	85 (586)	55 (379)	40

Welding
In addition to the improved mechanical properties and corrosion resistance, Nitronic® 50 Stainless Steel can be welded successfully by using any of the conventional welding processes that are normally employed with the austenitic stainless steels.

Nitronic® 50 Stainless is readily arc welded in all forms. As with most austenitic stainless steels, good weld joint properties can be obtained without the necessity of preheat or post-weld annealing. Good shielding of the molten weld puddle is important to prevent any absorption of nitrogen from the atmosphere that could result in porosity.

Autogenous, high-power density joining processes such as electron beam (EB) and laser welding should be used with caution due to the low FN potential of the base metal (FN approximately 2). Field reports also indicate the possibility of severe outgassing during EB welding in a vacuum atmosphere. Under vacuum conditions, the outgassing is to be expected for liquid weld metal containing a high nitrogen level.

Filler Metals

Filler metal, when added to the joint, should be Nitronic® 50W (AWS E/ER 209), a matching filler metal composition that provides comparable strength and corrosion resistance to the base metal. However, sound weld joints may also be obtained using the conventional austenitic stainless steel fillers such as Types 308L and 309. When using these more common filler metal compositions, allowances should be made for the strength and corrosion differences.

Nominal compositions and representative mechanical properties are shown for the more common electrode filler rods in Table 36. The weld metal alloys are listed generally in the order of (a) increasing alloy content, (b) increasing strength level, (c) increasing corrosion resistance and (d) increasing cost.

These data show that the highest strength levels with good tensile ductility and alloy elements that impart good corrosion resistance are provided by the Nitronic® 50W electrode. In some specific applications where the high strength levels or superior corrosion resistance in the weld deposits are not required, other filler metals can be used to advantage because of reduced costs and/or ready availability.

The matching weld filler (Nitronic® 50W, AWS E/ER 209) for Nitronic® 50 Stainless Steel is similar to many of the regular austenitic stainless steel filler metals in that a small percentage of the magnetic ferrite phase has been introduced to assure sound weld deposits. The small quantity of the second phase usually produces a magnetic permeability value of approximately 1.2 in shielded metal-arc weld deposits. This corresponds to a ferrite number (FN) of approximately 6.

Highly overalloyed Ni base fillers are suggested for applications requiring high resistance to pitting media or very low as-deposited magnetic permeability.

Table 37 **Typical Mechanical Properties Nitronic® 50 Stainless Plate Weld Joints**

Weld Process	Weld Filler	UTS, ksi (MPa)	0.2% US ksi (MPa)	Elongation % in 2"	Reduction in Area %	Failure Location
Shielded Metal Arc (SMA)	Nitronic® 50W	113 (779)	76 (524)	20	36	Weld Metal
Gas Metal Arc (GMA) Spray	Nitronic® 50W	112 (772)	77 (531)	21	30	Weld Metal

GTA Weld Joints

Gas tungsten arc weld joints have been fused successfully in several flat-rolled thicknesses of Nitronic® 50 Stainless Steel. Mechanical property values similar to those of the base metal have been obtained in the as-welded condition.

The corrosion resistance of GTA welded joints has been evaluated using the standard Huey test (ASTM A 262, Practice C) for detecting intergranular attack in stainless steels. Laboratory test experience shows that welds made using the Nitronic® 50W Stainless Steel filler metal exhibit the same resistance to intergranular attack as the base metal.

Heavy Section Weld Joint Properties

The mechanical properties of welds in 1-1/4" (32.1 mm) thick plate have been determined using two weld processes that are normally employed in heavy section welding, namely, (a) shielded metal arc (SMA) or stock electrode welding and (b) gas metal arc (GMA) or MIG welding with the spray mode. Typical test values that can be expected from tensile samples cut transverse to the weld centerline are shown above in Table 37.

Heat input is important in obtaining the most satisfactory weld joint. Narrow stringer beads rather that a wide "weave" technique should be used for highest weld ductility. Good shielding of the molten puddle is important to eliminate additional nitrogen from the atmosphere that could cause porosity. Both stringer beads and adequate shielding are normal factors in good stainless steel welding practice.

Resistance Welding

Although no direct resistance welding experience has been obtained with Nitronic® 50 Stainless Steel, the similarity of the alloy to Nitronic® 40 Stainless Steel suggests a good response to resistance spot welding and cross-wire welding techniques.

Machinability

Nitronic® 50 Stainless Steel has machining characteristics similar to other austenitic stainless steels. It is suggested that coated carbides be considered when machining all Nitronic® alloys, since higher cutting rates may be realized. Nitronic® 50 Stainless Steel is more susceptible to cold work hardening than types 304 and 316 stainless steels. Also, the alloy has higher strength. Machining tests show the alloy to machine at approximately 21% of the cutting rate for B1112. this means Nitronic® 50 Stainless Steel can be machined at approximately ½ the cutting rate (SFM) used for Type 304 or 316 stainless steels, based on using high-speed tool steels. For that reason, as stated above, coated carbides are recommended for best results.

Because of the high strength of Nitronic® 50 Stainless Steel, more rigid tool and work holders than used for Types 304 and 316 stainless steels should be used. Care should be taken not to allow tools to slide over the alloy. Positive cutting action should be initiated as soon as possible. The alloy provides a good surface finish.

Table 38 **Machinability***

AISI B 1112	Type 304	Nitronic® 50
100%	45%	21%

*1" ø (24.4 mm)—annealed—R_B 95. Five-hour form tool life using high-speed tools. Data based on duplicate tests.

Table 39 **Recommended Machining Rates for Nitronic® 50**

Machining Operation	Cutting Rates, SFM
Automatic Screw Machine	40-65
Heavy duty Single or Multiple Spindle and Turret Lathe High Speed Tools. Rates may be increased 15-30% with High-Cobalt or Cast Alloys	40-65
Automatic Screw Machine (Swiss Type) Cast Alloy or Carbide Tools	40-65
Single Point Turning **Carbide Tools** Roughing Finishing	 90-140 120-190
High Cobalt or Cast Alloy Tools Roughing Finishing	 50-65 50-75
High-Speed Steel Tools Roughing Finishing	 30-45 50-60
Milling (When using end mills, use two-fluted type and shorten it 25%)	20-40
Reaming Smooth Finish Work Sizing High-speed steel reamers. Greatly increased rates obtainable with carbide tooling.	 15-40 40-60
Threading and Tapping	10-25
Drilling High-Speed Drills	30-50

Table 40 **Typical Room Temperature and Short-Time Elevated Temperature Properties of Cast Nitronic® 50 Stainless Steel (CG6MMN) Annealed***

Test Temperature °F (°C)	UTS, ksi (MPa)	0.2% US, ksi (MPa)	Elongation % in 2" (50.8 mm)	Reduction of Area %
75 (24)	93 (641)	50 (345)	48	46
200 (93)	84 (579)	39 (269)	47	57
400 (204)	74 (510)	30 (207)	50	54
600 (316)	67 (462)	27 (186)	49	48
800 (427)	65 (448)	27 (186)	47	55
1000 (538)	60 (414)	25 (172)	46	51
1200 (649)	54 (372)	24 (166)	43	55

*Average of three heats, two tests per heat. Data supplied by Wisconsin Centrifugal, Inc.

Surface

A manufacturer of valves for gas wells tested Nitronic® 50 Stainless Steel against the material previously used. Electralloy Nitronic® 50 Stainless Steel Shafts delivered the needed extra corrosion resistance without sacrificing strength.

Seal rings for some high-performance industrial butterfly valves operating at 350 psi must have high hardness plus superior corrosion resistance to meet the demands of a variety of chemical media. One valve manufacturer found Electralloy Nitronic® Stainless Steel met the needs better than Type 316 stainless, and adopted the material as the standard for this precision part.

Mounted in the bodies of the company's 30-, 36- and 48-inch valves, the Nitronic® 50 Stainless Steel rings give the body seat a positive seal with excellent finish and high resistance to cavitation and crevice corrosion. The material also provides high resistance to mechanical damage.

Oilfield Equipment

Nitronic® 50 shows better resistance than Types 316 and 316L to pitting and crevice corrosion by sour oil and gas fluids, plus much higher strength. It is included in NACE MR0175/ISO 15156-3 and MR0103 in both the annealed and high-strength bar conditions.

Castings

Electralloy Nitronic® 50 Stainless Steel may be readily cast by all conventional techniques. Castings should be annealed at 2050° F (1121° C) for 1/2-hour and water quenched in order to attain a high level of corrosion resistance. Cast Nitronic® 50 Stainless Steel is listed as Grade CG6MMN in ASTM A 351/351M and A 743.

Learn more about our Nitronic® 50 products at
www.electralloy.com

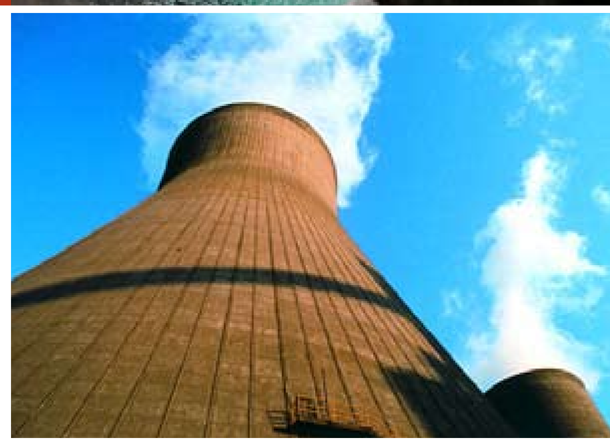
Case Studies:

Electralloy Nitronic® 50 Stainless Steel takes ammonium carbamate corrosion longer

Ammonium carbamate—created during the manufacture of urea fertilizer—is notorious for being extremely rough on process equipment. Pump parts, such as these blocks, for example, are subjected to severe corrosive attack, heat and cyclical operating pressures ranging up to 3000 psi. Some parts made of Type 316L stainless have show surface attack in just a few months. Several pump manufacturers have found a better answer—Electralloy Nitronic® 50 Stainless Steel. Trials by pump manufacturers over a three-year period effectively demonstrate the superiority of Nitronic® 50 Stainless Steel in ammonium carbamate environments.

Electralloy Nitronic® 50 Stainless Steel helps dispose of nuclear waste

High strength and excellent corrosion resistance were the reasons Nitronic® 50 Stainless Steel was chosen for a new prototype vessel for nuclear waste calcinations. Part of an entire calcinations system, this single-wall chamber is actually the scrubber tower which cleans the hot gases coming off the calciner—the unit that drives off volatile material. Type 316 stainless was first considered, but the strength level just couldn't measure up. So the choice of Nitronic® 50 stainless which not only delivered the needed strength, but gave greater corrosion resistance as well.



Electralloy is North America's exclusive licensed producer of all NITRONIC® ingot, billet, bar, coil rod, master alloy pigs as well as plate, weld wire and weld consumables.

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