NITRONIC® 30

STAINLESS STEEL

Hose Clamps

Hopper Cars

Safety Belt Anchors

Treatment Plant Structures

Truck and Bus Frames

NITRONIC® 30 STAINLESS STEEL offers significantly higher strength than Type 304 and potential for applications requiring resistance to aqueous and atmospheric corrosion combined with good toughness and economy. The nickel content is among the lowest of all commercially-available austenitic steels.

Applications include automotive hose clamps, safety belt anchors, truck and bus frames, water supply and control structures, sewage treatment plant structures, bulk solids handling equipment, magnetic ore separator screens, coal buckets and hopper cars.

Product Description

Stainless steels have served successfully in many structural components in the transportation industry. Bus space frames and bumpers take advantage of the excellent fabricability and high strength and toughness of stainless steel. Tensilized NITRONIC 30 Stainless Steel has been used in rapid transit structurals where the strength-to-weight ratio of up to three times that of carbon steel has improved operating efficiency. Rear frames of refrigerated trucks are easily welded and formed from NITRONIC 30 Stainless Steel, resulting in protective units that can withstand impact blows without cracking. Shipboard container structurals use stainless steel successfully where carbon steel becomes scuffed and rusts wherever the paint is damaged.

NITRONIC 30 Stainles Steel is a nitrogen-strengthened austenitic stainless steel developed for applications requiring a good level of aqueous corrosion resistance combined with toughness and economy. NITRONIC 30 Stainless Steel provides approximately 50% higher yield strength than Type 304L, and may allow lighter gauges to further reduce costs. NITRONIC 30 Stainless Steel work hardens rapidly while retaining ductility. Unlike some other nitrogen-strengthened stainless steels, NITRONIC 30 Stainless Steel is subject to magnetic transformation and Transformation Induced Plasticity (TRIP) behavior when cold worked.

Composition		(wt %)
Carbon	(C)	0.03 max.
Manganese	(Mn)	7.0 – 9.0
Phosphorus	(P)	0.040 max.
Sulfur	(S)	0.030 max.
Silicon	(Si)	1.00 max.
Chromium	(Cr)	15.0 – 17.0
Nickel	(Ni)	1.5 – 3.0
Nitrogen	(N)	0.15 – 0.30
Copper	(Cu)	1.00 max.

AVAILABLE FORMS

NITRONIC 30 Stainless Steel is available in sheet, strip,and plate in thicknesses from 0.020 – 0.250 in. (0.5 – 6.4 mm) and up to and including 48 in. (1219 mm) wide.

METRIC PRACTICE

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

SPECIFICATIONS

NITRONIC 30 Stainless Steel is listed as Grade UNS S20400 in:

- **ASTM A240** – Plate, Sheet and Strip for Pressure Vessels.
- **ASTM A666** – Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.

Mechanical Properties

As noted in Table 1, NITRONIC 30 Stainless Steel has annealed tensile properties which are well above those of typical austenitic alloys such as Type 304L. Excellent elongation is also maintained. This higher strength affords the opportunity to reduce gauge at equivalent engineering loads.

The high work-hardening rate or TRIP behavior of NITRONIC 30 Stainless Steel results in a high-strength material with elongation equal or superior to Type 304L and the same cold reduction. Comparative properties are shown in Table 4 and provided graphically in Figure 1. Table 5 presents additional data on the effect of cold reduction at heavy gauge. Such cold reductions would produce a smoother surface and reduce the coefficient of friction for sliding applications such as coal chutes.

TABLE 1 – TYPICAL ROOM TEMPERATURE MECHANICAL PROPERTIES

UTS, ksi. (MPa)	0.2% YS, ksi. (MPa)	Elongation% in 2 in. (50.8 mm)	Rockwell Hardness, B
110 (758)	55 (379)	50	95

TABLE 2 – PROPERTIES ACCEPTABLE FOR MATERIAL SPECIFICATION

Condition	ASTM Spec.	UTS, ksi. (MPa)	0.2% YS, ksi. (MPa)	Elongation% in 2 in. (50.8 mm)	Rockwell Hardness, B	Free Bend
Annealed	A240 A666	95 min. (655)	48 min. (331)	35 min.	100 max.	180°-1T
1/4 Hard	A666	140 min. (965)	100 min. (689)	20 min.	—	≤ 0.050 in., 180°-1T > 0.050 in. – ≤ 0.1874 in., 90°-2T

TABLE 3 – TYPICAL ANNEALED PLATE PROPERTIES

Thickness, in. (mm)	UTS, ksi. (MPa)	0.2% YS, ksi. (MPa)	Elongation% in 2 in. (50.8 mm)	Rockwell Hardness, B	CVN, ft.•lbs. (J)
0.375 (10)	114 (786)	57 (393)	56	94	—
0.875 (22)	124 (855)	50 (345)	50	92	217 (244)
2.0 (50.8)	120 (827)	52 (358)	54	—	—

Mechanical Properties

FIGURE 1 – EFFECT OF COLD REDUCTION ON TENSILE PROPERTIES OF NITRONIC 30 STAINLESS STEEL

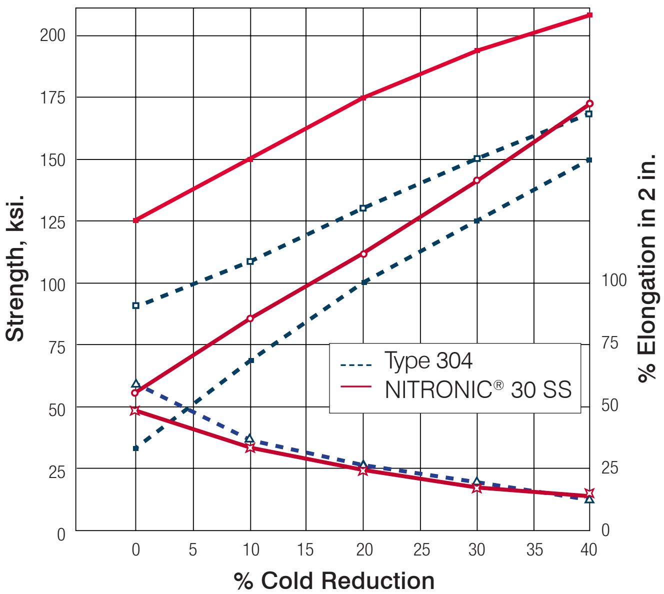


TABLE 4 – EFFECT OF COLD WORK ON TENSILE PROPERTIES (Laboratory data for comparison only – not for specification)

NITRONIC 30®				
% Cold Work	UTS, KSI. (MPa)	0.2% YS, ksi. (MPa)	Elongation % in 2 in. (50.8 mm)	Rockwell Hardness
0	125 (862)	57 (393)	49	B95
10	150 (1034)	86 (593)	35	C31
20	173 (1193)	113 (779)	25	C37
30	194 (1338)	142 (979)	18	C43
40	207 (1467)	172 (1186)	15	C45
Type 304				
0	89 (614)	35 (241)	61	B74
10	110 (758)	70 (483)	40	C21
20	130 (896)	100 (689)	27	C30
30	148 (1020)	125 (862)	20	C36
40	167 (1151)	150 (1034)	13	C39

**Average of five thickness ranges – 0.215 – 0.026 in. (5.5 – 0.7 mm).*

Mechanical Properties

EFFECT OF COLD WORK ON MARTENSITE FORMATION

NITRONIC 30 Stainless Steel will undergo magnetic transformation due to cold reduction. This magnetism is the result of forming deformation martensite with cold work. This martensite increases the strength, work-hardening rate and abrasion resistance of the alloy.

TABLE 5 – TYPICAL TENSILE PROPERTIES 1/4-HARD NITRONIC 30 PLATE

Thickness, in. (mm)	Direction	UTS, ksi. (MPa)	0.2% YS, ksi. (MPa)	Elongation % in 2 in. (50.8 mm)	Rockwell Hardness, C	Bend 180°
0.1875* (4.8)	Longitudinal	148.0 (1020)	104.0 (717)	35.5	34	—
	Transverse	148.6 (1025)	111.4 (768)	31.5	34	11
0.25** (6.4)	Longitudinal	144.7 (998)	101.8 (702)	35.5	34	—
	Transverse	146.6 (1011)	110.1 (759)	29.6	34	11

TABLE 6 – ELEVATED TEMPERATURE TENSILE PROPERTIES OF NITRONIC 30 STAINLESS STEEL SHEET*

Test Temperature, °F (°C)	UTS, ksi. (MPa)	0.2% YS, ksi. (MPa)	Elongation % in 2 in. (50.8 mm)	Rockwell Hardness, B
75 (24)	122.5 (844)	63.1 (437)	46.8	97
200 (93)	100.3 (691)	47.3 (326)	63.3	—
300 (149)	86.8 (599)	41.1 (284)	53.7	—
400 (204)	81.4 (561)	37.6 (259)	44.8	—
500 (260)	79.3 (547)	34.9 (240)	41.3	—
600 (316)	79.3 (547)	33.8 (234)	41.3	—
700 (371)	76.7 (529)	31.4 (217)	44.3	—
800 (427)	73.4 (506)	30.0 (207)	43.7	—
900 (482)	70.3 (485)	28.6 (197)	40.7	—
1000 (538)	66.5 (458)	27.1 (187)	34.1	—

**0.088 in. (2.2 mm) and 0.074 in. (1.9 mm) thicknesses, average of 6 tests from 2 heats.*

TABLE 7 – ELEVATED TEMPERATURE TENSILE PROPERTIES OF NITRONIC 30 STAINLESS STEEL PLATE*

Test Temperature, °F (°C)	UTS, ksi. (MPa)	0.2% YS, ksi. (MPa)	Elongation % in 2 in. (50.8 mm)	Rockwell Hardness, B
75 (24)	123.3 (850)	52.4 (362)	55.0	93
200 (93)	91.4 (630)	38.6 (266)	77.8	—
300 (149)	78.2 (539)	32.1 (222)	65.5	—
400 (204)	71.8 (496)	27.6 (190)	48.0	—
500 (260)	70.6 (487)	26.4 (182)	48.6	—
600 (316)	70.7 (488)	25.3 (174)	46.4	—
700 (371)	69.5 (480)	24.4 (168)	49.0	—
800 (427)	66.7 (460)	22.7 (157)	48.3	—
900 (482)	63.7 (439)	22.4 (155)	47.7	—
1000 (538)	60.4 (417)	20.4 (131)	42.9	—

**0.075 in. (22.2 mm) and 0.1875 in. (4.8 mm) thicknesses, average of 4 tests from 2 heats.*

Mechanical Properties

FIGURE 2 – TYPICAL ENGINEERING STRESS-STRAIN CURVE

Typical engineering stress-strain curves for NITRONIC 30 Stainless Steel and Type 304 (tested in tension in the longitudinal direction) are shown in Figure 2.

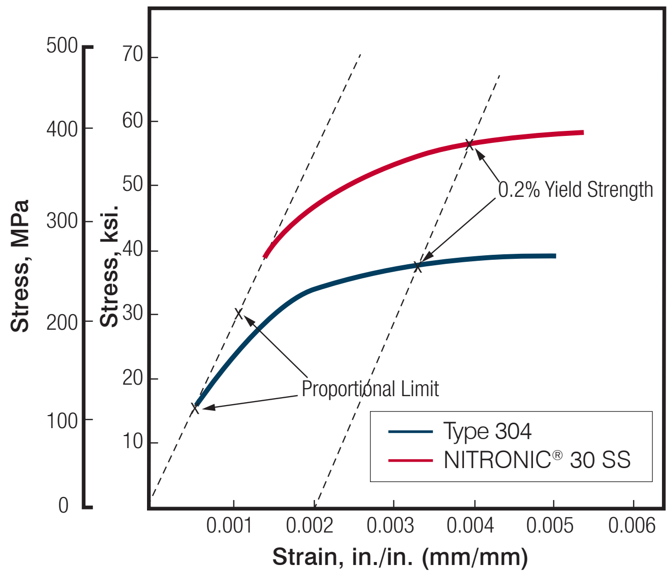
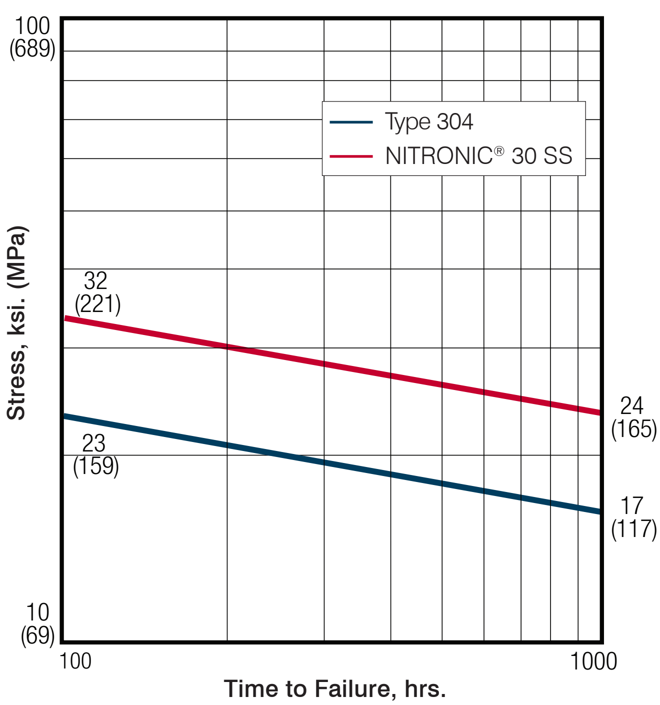


TABLE 3 – NITRONIC 30 STAINLESS STEEL STRESS RUPTURE AT 1200 °F (648 °C)



Mechanical Properties

NITRONIC 30 Stainless Steel offers superior fatigue resistance due to its higher strength relative to other austenitic stainless steels like Type 304. Figures 4 through 7 show the excellent fatigue resistance of NITRONIC 30 Stainless Steel that may benefit users in the transport and vibratory equipment industries.

FIGURE 4 – NITRONIC 30 STAINLESS STEEL UNIAXIAL FATIGUE 0.072 in. SHEET COLD-ROLLED + ANNEALED R = 0.5 TRANSVERSE DIRECTION

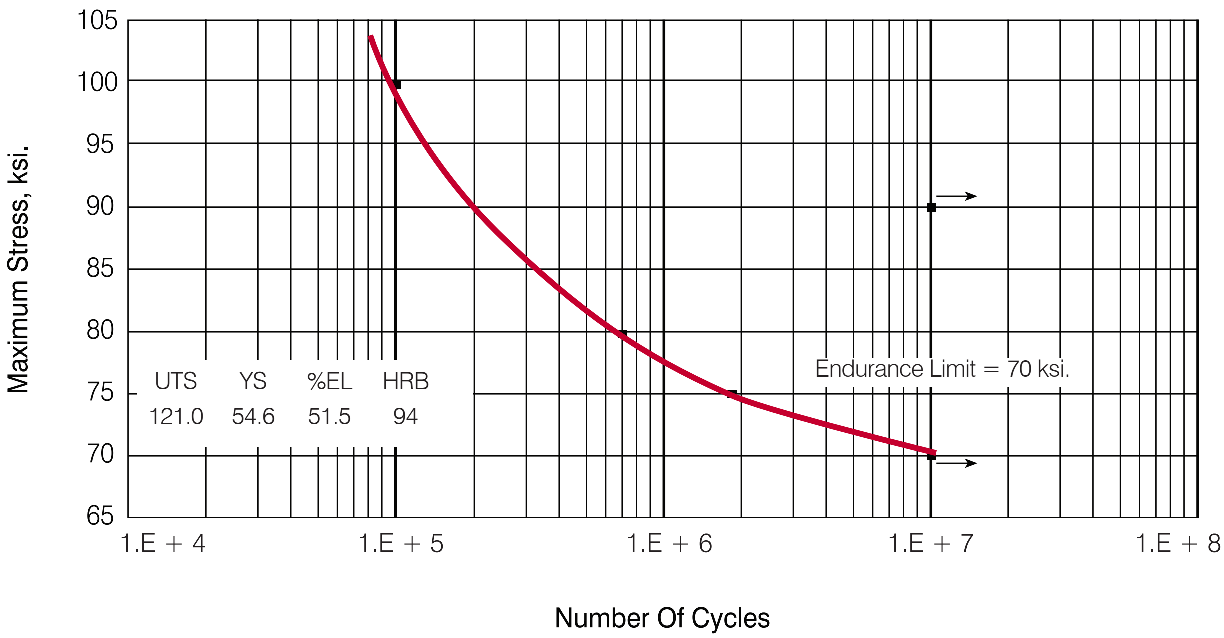
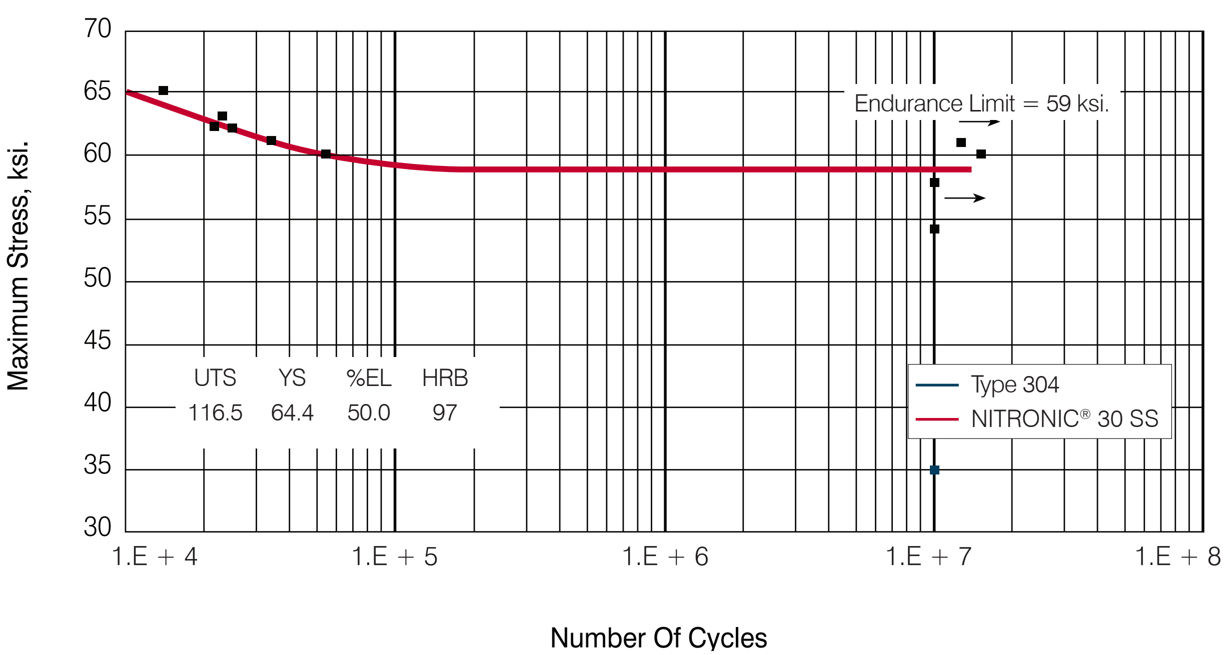


FIGURE 5 – NITRONIC 30 STAINLESS STEEL REVERSE BEND FATIGUE 0.072 in. SHEET COLD-ROLLED + ANNEALED R = -1 TRANSVERSE DIRECTION



Mechanical Properties

FIGURE 6 – NITRONIC 30 STAINLESS STEEL UNIAXIAL FATIGUE 0.1875 in. PLATE HOT-ROLLED + ANNEALED R = 0.1, 16 TO 20 H_z, TRANSVERSE DIRECTION

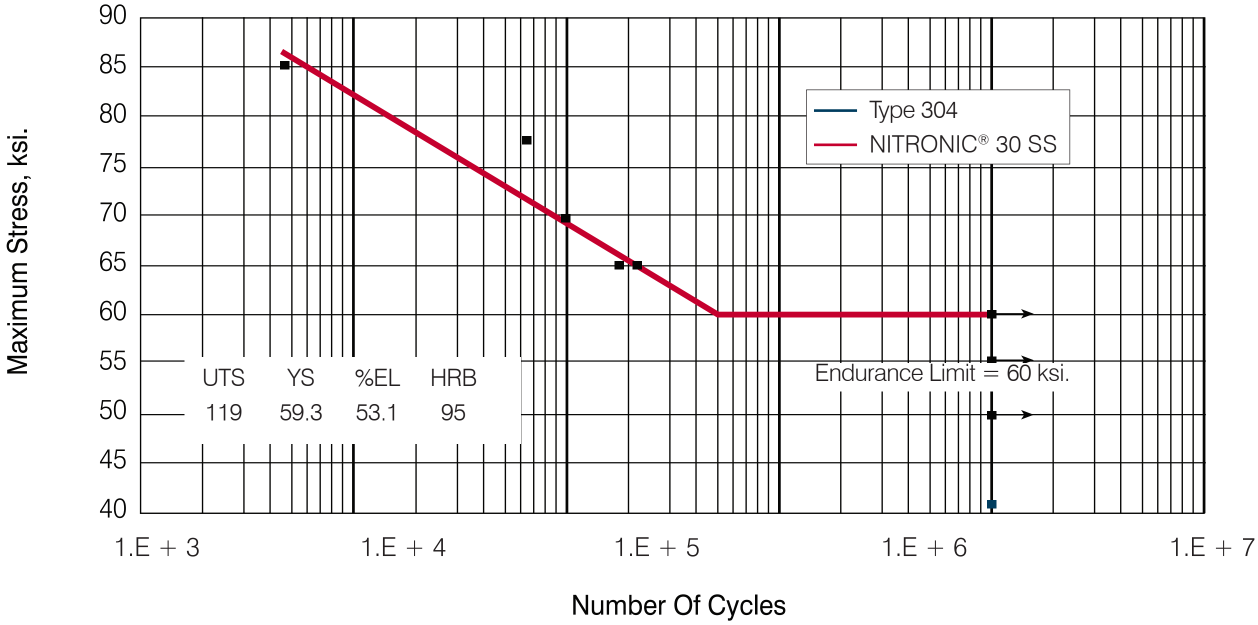
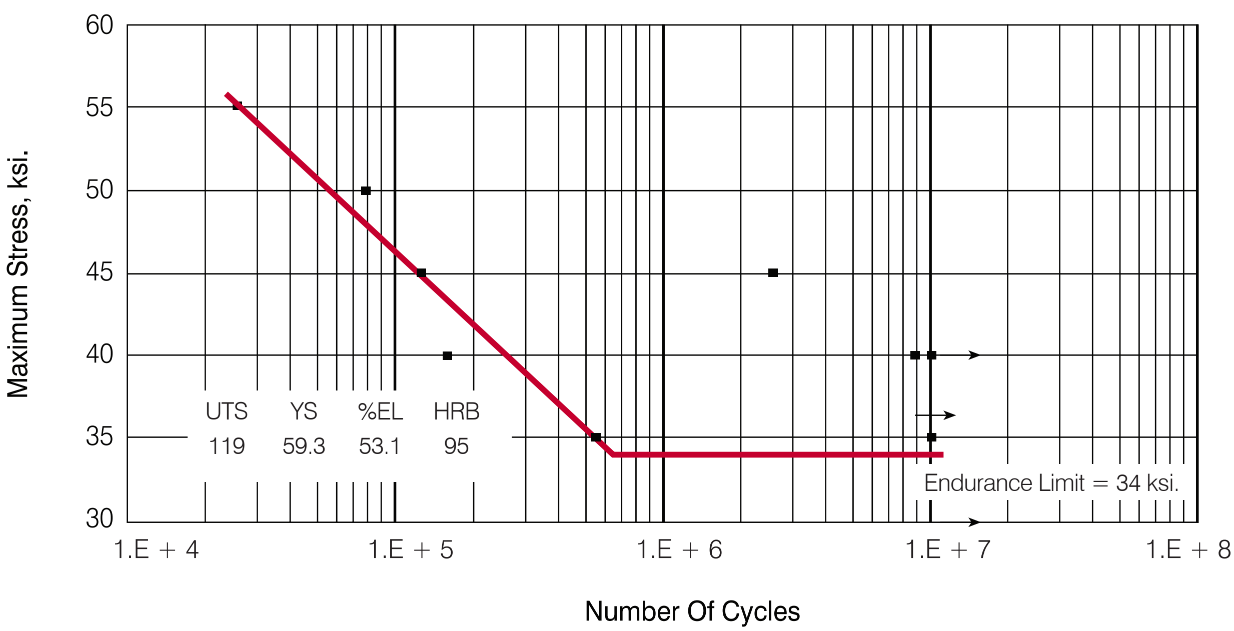


FIGURE 7 – NITRONIC 30 STAINLESS STEEL NOTCHED UNIAXIAL FATIGUE 0.1875 in. PLATE HOT-ROLLED + ANNEALED R = 0.1, 16 H_z, KT = 3, TRANSVERSE DIRECTION



Wear Resistance

The following tables and figures demonstrate the outstanding corrosive wear resistance of NITRONIC 30 Stainless Steel under many different sliding conditions. The stainless steels as a class are much more abrasion resistant than abrasion resistant (AR) steels under even mildly corrosive conditions. NITRONIC 30 Stainless Steel is more cost effective than Cleveland-Cliffs 409 Ni and Type 304, which are sometimes used in wet abrasive applications.

TABLE 8 – METAL-TO-METAL WEAR*

Alloy	Rockwell Hardness	Wear, mg/1000 cycles**		
		25 RPM	105 RPM	415 RPM
Type 4340	C52	0.8	0.7	0.5
Stellite 6	C48	1.1	1.0	1.3
Hadfield Mn	B95	1.7	1.2	0.4
NITRONIC 30 SS	B93	1.9	3.3	2.2
NITRONIC 32 SS	B95	2.4	7.4	3.1
4130 (H+400 °F S.R.)	C47	3.8	9.4	—
Type 304	B85	13.9	12.8	7.6
17-4 PH® SS (H900)	C43	45.3	52.8	12.1
Type 410 (H+600 °F S.R.)†	C40	—	244.0	22.5
4130 (H+1000 °F S.R.)	C32	66.0	258.0	—
Type 410 (Annealed)	B95	—	261.0	116.0

**Self-mated crossed cylinders, 16 lbs. (71 N), 10,000 or 40,000 cycles, unlubricated, in air, room temperature, corrected for density differences.*
***Relative wear rate for comparison of alloys and not for design purposes.*
†H-hardened S.R. stress relieved

TABLE 9 – METAL-TO-METAL WELD WEAR*

Alloy	Rockwell Hardness, C	Total Wear, (mated to 17-4 PH, Condition H900), 105 RPM mg/100 cycles
NITRONIC 30 SS WELD**	24	27.58
Type 420 Weld 1150 °F (621 °C) Temper	34	68.32

**Self-mated crossed cylinders, 16 lbs. (71 N), 10,000 or 40,000 cycles, unlubricated, in air, room temperature, corrected for density differences.*
***Weldment in stationary position.*

Wear Resistance

TABLE 10 – DRY ABRASIVE WEAR

Alloy	Rockwell Hardness	Volume of Metal Removed			
		Alloy Wear-Mated to WC, mm^3/10,000 cycles		Alloy Wear-Mated to SIC, mm^3/10,000 cycles	
		105 RPM	415 RPM	105 RPM	415 RPM
Type 4340	C52	0.1	0.1	0.8	—
Colmonoy 6	C56	0.1	0.8	2.9	2.2
NITRONIC 30 SS	B93	1.9	3.3	3.8	11.3
NITRONIC 60 SS	B95	2.8	2.3	—	—
NITRONIC 32 SS	B95	4.2	4.3	7.1	6.8
Type 304	B85	6.2	13.2	25.2	13.5
Type 431	C42	9.8	1.5	22.6	—
17-4 PH SS	C42	9.9	5.6	104.2	37.9

Crossed cylinders, 16 lbs (71 N), 10,000 or 40,000 cycles,unlubricated, in air, room temperature, corrected for density differences.

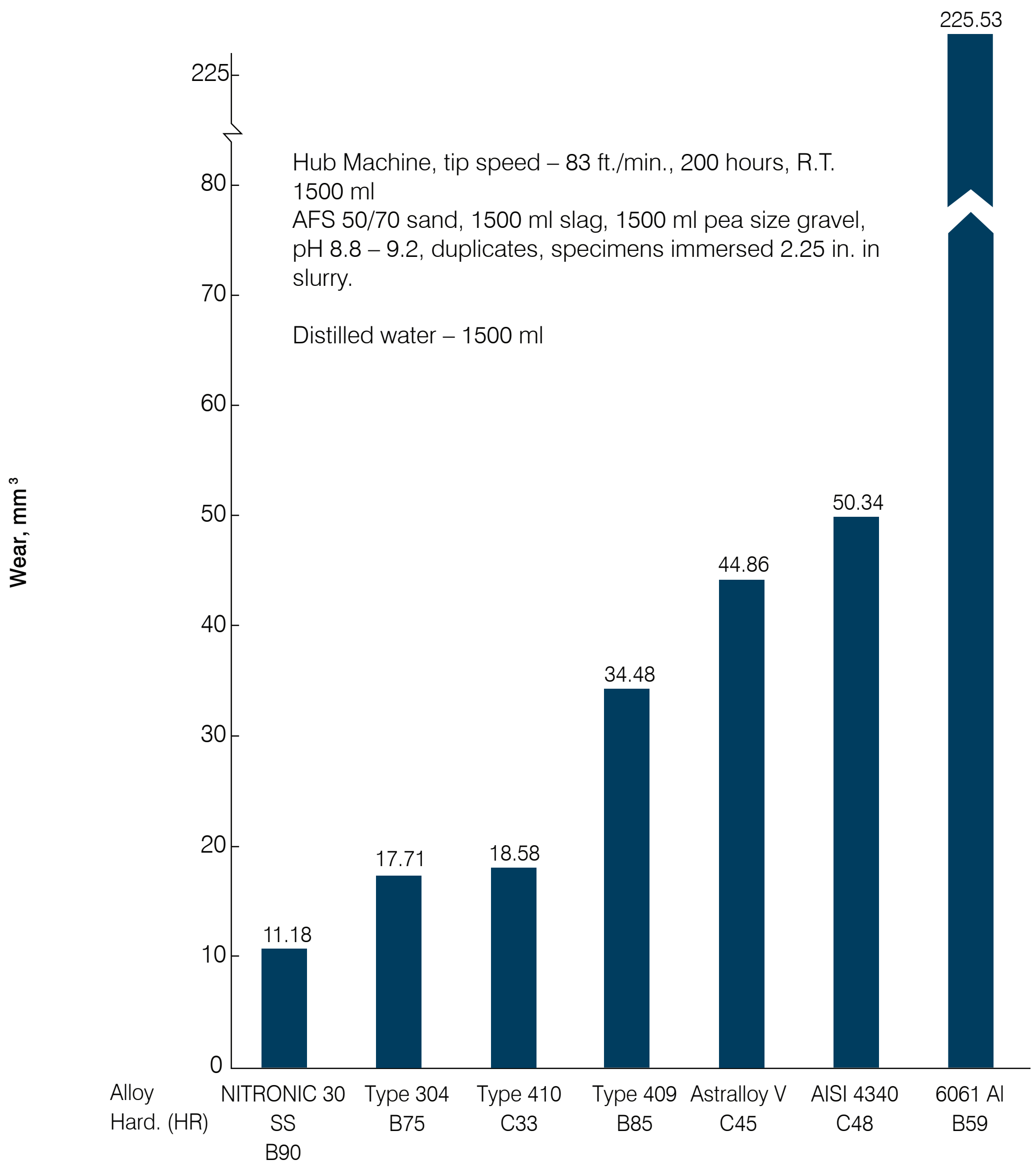
TABLE 11 – CORROSIVE WEAR HUB TEST*

Alloy	Rockwell Hardness	Wear, mm^3	Dry
		5% NaCl + 0.5% Acetic Acid	
NITRONIC 30 SS	B91	8.15	2.79
17-4 PH SS	C46	11.95	3.32
NITRONIC 33 SS	B94	13.74	3.40
Type 409	B85	28.50	10.56
Hadfield Mn	B93	39.20	2.28
4340	C49	45.47	2.27

**Abrasives: 2.5 liters pea sized gravel plus slag, 1 liter angular quartz, 400 hrs., 1000 in./min. tip speed, 0.095 in. (2.4 mm) sheet thickness, triplicate tests, sheet specimens mounted on hub rotating in and out of slurry.*

Wear Resistance

FIGURE 8 – CORROSIVE WEAR OF ALLOY AND STAINLESS STEELS



Wear Resistance

TABLE 12 – BALL MILL TEST

Alloy	Rockwell Hardness	Wear mm³
NITRONIC 30 SS	B91	4.89
NITRONIC 33 SS	B94	6.46
17-4 PH SS	C46	7.00
Type 304	B75	7.76
Type 409	B85	10.15
Astralloy V	C45	32.14
Type 434	C49	36.54

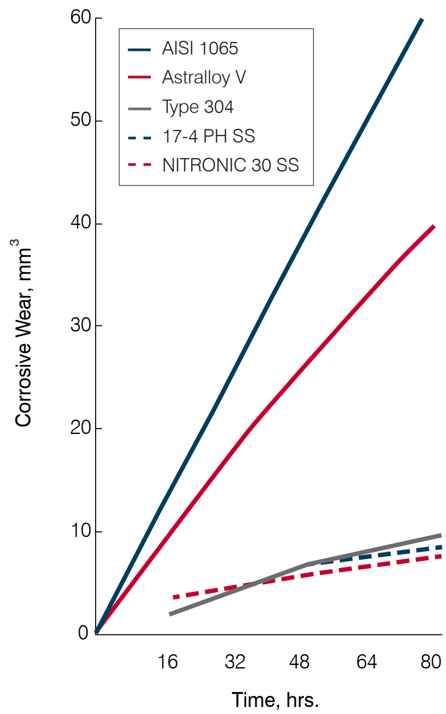
TABLE 13 – CORROSIVE WEAR OF ALLOY AND STAINLESS STEELS IN A COAL MINE EFFLUENT*

Alloy	Rockwell Hardness	Cumulative Volume Loss, mm³		
		Period 1	Period 2	Period 3
Astralloy V	C45	3.50	11.45	20.17
ANSI 4340	C48	4.25	12.76	21.75
Type 409	B85	3.80	5.46	8.99
17-4 PH SS	C44	1.51	4.55	7.39
NITRONIC 30 SS	B90	1.31	4.27	7.13
Type 304	B75	1.58	4.98	8.30
Type 316	B73	2.08	7.39	12.56

**Test Conditions: Laboratory ball mill, 0.64 m/s, room temperature, Five 16-hr. periods, pH 6.7, 2 liters of coal mine effluent, 0.2 liters pea size gravel – 6.4 mm + 3.2 mm, duplicate sheet specimens*

FIGURE 9 – CORROSIVE WEAR OF ALLOY AND STAINLESS STEELS

Ball Mill – Synthetic Nickel Mine Water
Speed – 126 ft./min., R.T., pH 9.1 – 9.6 2000 ml of 2 g/l sulfate + 0.2 g/l chloride ion 100 ml – 1/4 in. + 1/8 in. and 100 ml – 3/8 in. + 1/4 in. pea sized gravel.



Wear Resistance

TABLE 14 – CORROSIVE WEAR OF STEEL, STAINLESS STEELS AND CAST IRONS IN A COAL PREPARATION PLANT

Alloy	Rockwell Hardness	Metal Loss	
		mils/year	μm/year
NITRONIC 30 SS (Annealed)	B94	0.3	8
NITRONIC 30 SS (Tensilized)	C33	0.3	8
Type 304	B90	0.4	10
Type 316	B85	0.4	10
Type 410 (Annealed)	B81	0.5	13
Type 301	C36	0.6	15
F45009 (Ni Hard* #1)	C55	1.6	41
F45003 (Ni Hard* #4)	C42	13.1	333
F45001 (White Cast)	C58	51.5	1308
AISI 1044	B84	68.4	1737

**Trademark of The International Nickel Co.*

TABLE 15 – NITRONIC 30 STAINLESS STEEL THE RUST RESISTANT STEEL

Alloy	Formability	Weldability	Impact Resistance	Corrosive Wear (CW)	Alloy Cost Factor (ACF)	Life Cycle Cost Facto (CW x ACF)
AR500	Very Poor	Very Poor	Poor	4.50	1.00	4.50
409 Ni	Good	Good	Fair	3.10	1.16	3.60
Type 304	Excellent	Excellent	Excellent	1.60	1.49	2.40
NITRONIC 30 SS	Excellent	Excellent	Excellent	1.00	1.42	1.40

Typical Applications: buckets, ore separator screens, hopper cars, chutes, distributors.

Corrosion Resistance

NITRONIC 30 Stainless Steel exhibits good corrosion resistance to a variety of media. Pitting resistance, as measured by tests in 10% FeCl3 solution, is better than Type 304. In sulfuric acid and hydrochloric acid, NITRONIC 30 Stainless Steel is much better than Types 409 and 410, and approaches Type 304 in more dilute solutions. However, caution should be used with reducing acids. Activated NITRONIC 30 Stainless Steel may not repassivate when exposed to HCl or H_2SO_4 and significant corrosion may occur. Typical laboratory test data obtained on these alloys are shown in Table 16.

TABLE 16 – IMMERSION TESTS IN VARIOUS MEDIA

Test Medium	Corrosion Rates in IPY (unless otherwise indicated*)			
	NITRONIC 30 SS	Type 304	Type 409	Type 410
65% HNO_3 @ Boiling	0.043	0.010	0.671	0.266
50% H_3PO_4 @ Boiling	0.008	0.008	0.48	12.1 @ 80 °C
5% Formic @ 80 °C	<0.001	<0.001	0.056**	0.334 @ 35 °C
1% H_2SO_4 @ 80 °C	<0.001 – 0.360	<0.001 – 0.063	Dissolved	1.0 @ 1/2% H_2SO_4 @ 35 °C
1% HCl @ 35 °C	<0.001 – 0.012	<0.001	0.535	2.11
2% HCl @ 35 °C	0.100	<0.001 – 0.014	—	—
33% Acetic @ Boiling	Nil	Nil	—	—

**Immersion tests of 1 x 2 in. sheet coupons in lab-annealed (1950 °F – 5 min. – AC) condition for NITRONIC 30 Stainless Steel, and mill-annealed for the other alloys. Results are the average of duplicate specimens exposed for five 48-hr. periods. Those specimens tested at 35 °C and at 80 °C were intentionally activated for the third, fourth and fifth periods. Where both active and passive conditions occurred, the averages of both are shown.*
***Average of three 48-hour periods, not activated.*

INTERGRANULAR ATTACK

Intergranular attack tests were performed following the procedures of ASTM A262 on duplicate annealed sheet specimens of NITRONIC 30 Stainless Steel and Type 304. Before testing, some of these specimens were heat treated at 1250 °F (675 °C) for one hour and air cooled to exaggerate the conditions that might be found in the heat-affected zones of heavy weldments. Results are shown in Table 17.

TABLE 17 – INTERGRANULAR CORROSION RESISTANCE OF NITRONIC 30 STAINLESS STEEL

Alloy	Practice C Treatment	Practice E Boiling 65% HNO_3 (Huey Test)	Copper – Accelerated Copper Sulfate
NITRONIC 30 SS	Annealed 1250 °F (675 °C) 1 hr.	0.0034 IPM 0.0052 IPM	Passed Passed
Type 304	Annealed 1250 °F (675 °C) 1 hr.	0.0010 IPM 0.0620 IPM	Passed Failed Badly

Note that although the nitric acid attack rate for NITRONIC 30 Stainless Steel in the annealed condition is higher than that for Type 304, it did not increase greatly with the 1250 °F (675 °C) heat treatment. This indicates that there would be little tendency for preferential attack of weldments in service. NITRONIC 30 Stainless Steel is currently limited to a maximum 0.03% carbon content.

Oxidation Resistance

FIGURE 10 – CYCLIC OXIDATION AT 1000 °F (538 °C)

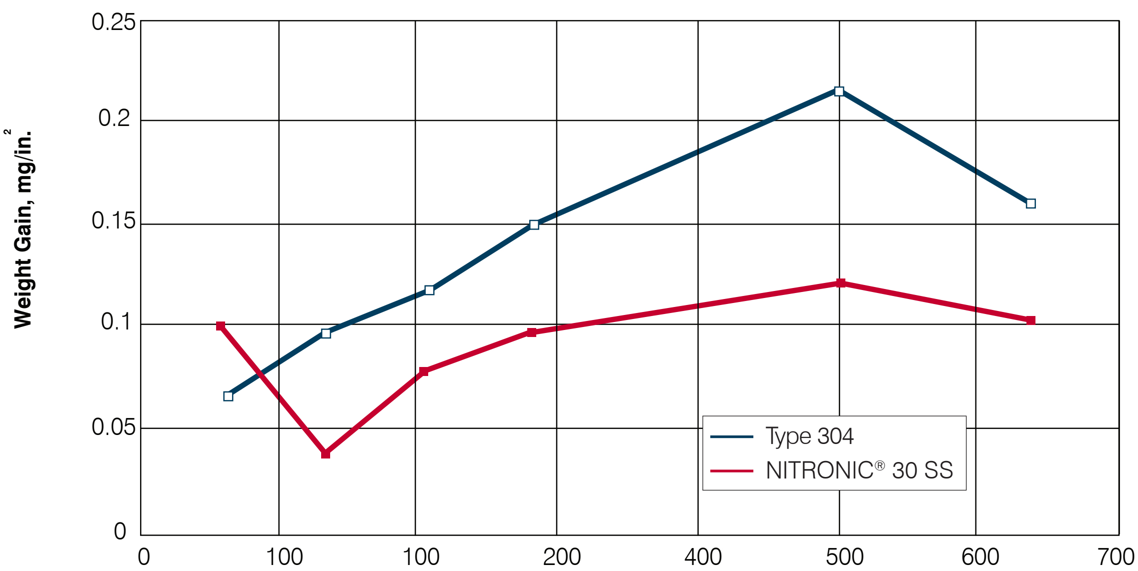
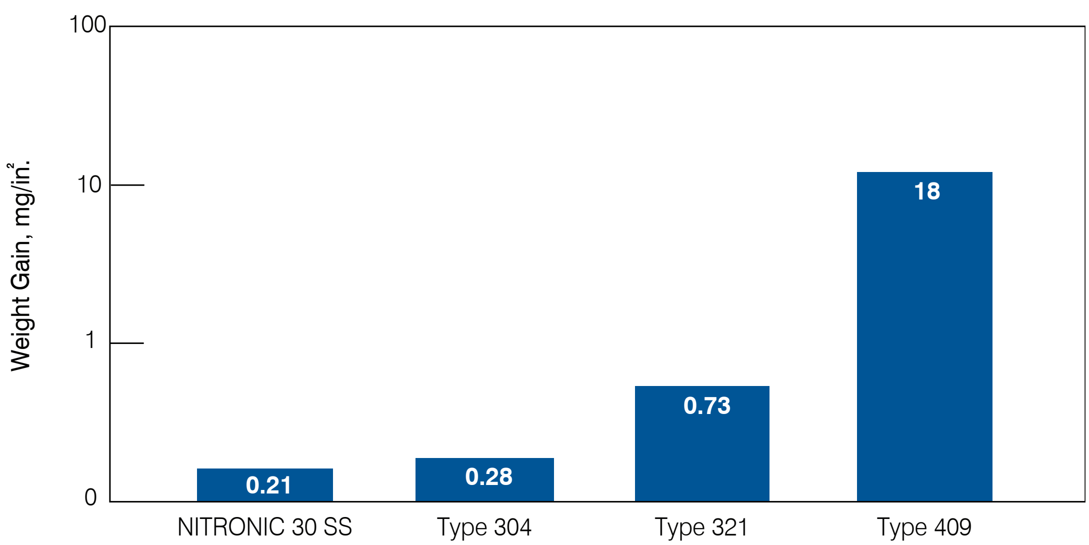


FIGURE 11 – CYCLIC OXIDATION AT 1250 °F (677 °C) 1000 CYCLES OF 15 MIN. HEATING + 5 MIN. COOLING



Weldability

The austenitic class of stainless steels is generally considered to be weldable by the common fusion and resistance techniques including high frequency tube and pipe welding. Special consideration is required to avoid weld “hot cracking” by assuring formation of ferrite in the weld deposit. This particular alloy is generally considered to have similar weldability to the most common alloy of this stainless class, Type 304L. A major difference is that the alloy requires slower arc welding speed to obtain penetration. When a weld filler is needed, AWS E/ER 308L, 309L and 209 are most often specified. Additional information concerning the welding of austenitic stainless steels can be obtained in the following references:

1. ANSI/AWS A5.9, A5.22, and A5.4 (stainless welding electrode specifications).
2. “Welding of Stainless Steels and Other Joining Methods,” SSINA,(www.ssina.com).
3. ANSI/AWS B2.1.009:2002 (GTAW 300’s @ 0.50 – 0.14 in.).
4. ANSI/AWS B2.1-8-024:2001 (GTAW 300’s @ 0.125 – 1.5 in.).
5. ANSI/AWS B2.1.013:1997 (SMAW 300’s @ 0.050 – 0.14 in.).
6. ANSI/AWS B2.1-8-023-94 (SMAW 300’s @ 0.125 – 1.5 in.).
7. ANSI/AWS B2.1.005:2002 (GMAW 300’s @ 0.050 – 0.14 in.).
8. ANSI/AWS D1.6/D1.6M:2007 (Structural Welding Code – Stainless Steel).
9. “High Frequency Welding of Stainless Steel Tubes,” by H. N. Udall and R. K. Nichols, Thermatool Corp. (www.thermatool.com).

STRESS-CORROSION CRACKING

As shown by Table 18, the threshold stress for cracking of NITRONIC 30 Stainless Steel in boiling 42% MgCl2 solution is about 25 ksi. (172 MPa), compared with about 10 ksi. (69 MPa) for Types 304 and 304L. This suggests that NITRONIC 30 Stainless Steel is more resistant than these alloys to cracking in hot MgCl2 solutions at lower stress levels. At higher stress levels, about 25 ksi. (172 MPa) and above, the MgCl2 stress corrosion cracking resistance of NITRONIC 30 Stainless Steel appears similar to Types 304 and 304L.

TABLE 18 – TYPICAL MECHANICAL PROPERTIES OF NITRONIC 30 IN AUTOGENOUS TUNGSTEN ARC WELDING*

Area Tested	Thickness, in. (mm)	UTS, ksi. (MPa)	0.2% YS, ksi. (MPa)	Elongation % in 2 in. (50.8 mm)	Rockwell Hardness, B
As-Welded (Stressed Transverse to Weld Direction)	0.060 (1.52)	119.1 (821)	57.6 (397)	50.7	87
Unwelded (Annealed)	0.060 (1.52)	113.0 (779)	46.1 (318)	55.7	87
Unwelded (As Hot Rolled)	0.112 (2.8)	120.4 (829)	48.9 (337)	60.0	90

*GTA Welded vs. Unwelded An0.1122050 °F (1121 °C)
Mechanical properties from duplicate tests.

TABLE 19 – WELD BEND TEST RESULTS*

Bend Direction	Bend Diameter
Weld Face	OT
Weld Root	OT

*NITRONIC 30 hot-rolled and pickled sheet 0.112 in. (2.8 mm) has been autogenous gas tungsten arc welded to make bend tests.

Bend tests on this material (HR Condition) were successfully flattened (0 bend diameter) when either the weld face or weld root was in tension, illustrating the excellent formability of as-welded NITRONIC 30 Stainless Steel

TABLE 20 – TENSILE PROPERTIES OF NITRONIC 30 GTAW WELDED PIPE (1.25 in. (31.8 mm) OD, 0.135 in. (3.4 mm) WALL THICKNESS)

	Elongation % in 2 in. (50.8 mm)	Rockwell Hardness, C
Base Metal*	40.1	34
As-Welded**	37.8	—

*Taken from pipe side wall away from weld.

**Weld parallel to specimen length; cut from pipe side wall. 1 heat – duplicate tests

Cryogenic Impact Properties

FIGURE 12 – IMPACT TOUGHNESS EFFECT OF TEMPERATURE ON THE IMPACT TOUGHNESS OF NITRONIC 30 STAINLESS STEEL, TYPE 304 AND TYPE 409*

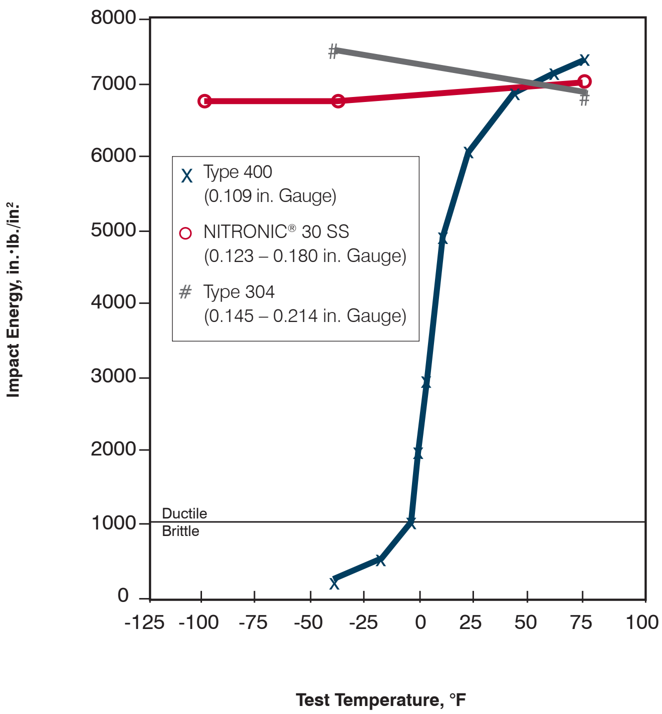


TABLE 12 – CRYOGENIC IMPACT STRENGTH OF ANNEALED SHEET AND PLATE*

Thickness, in. (mm)	Direction	Number of Tests	Test Temperature, °F (°C)	Impact Energy, W/A in.•lbs./in.² (mm•N/mm²)	Lateral Expansion, mils (mm)
0.130 (3)	Longitudinal	2	-100 (-73)	9340 (1633)	18.5 (0.73)
0.130 (3)	Transverse	2	-100 (-73)	7257 (1269)	15.2 (0.60)
0.130 (3)	Longitudinal	2	-320 (-196)	5557 (972)	9.6 (0.38)
0.130 (3)	Transverse	2	-320 (-196)	3606 (631)	7.5 (0.29)
0.1875 (5)	Transverse	3	-320 (-196)	4626 (809)	21.7 (0.86)
0.50 (13)	Transverse	5	-320 (-196)	5597 (979)	27.8 (1.10)
Weld Metal w/Notch in HAZ**					
05 (13)	Transverse	5	-320 (-196)	4068 (711)	18.5 (0.73

**ASTM A353 and A20*
***With 308L Filler Metal*

Cryogenic Impact Properties

TABLE 22 – CRYOGENIC IMPACT STRENGTH OF ANNEALED NITRONIC 30 STAINLESS STEEL PLATE*

Thickness, in. (mm)	Test Temperature, °F (°C)	Direction	Impact Strength Charpy V-Notch, ft.•lbs. (J)	Lateral Expansion, mils (mm)
0.875 (22)	-100 (-73)	Transverse	125* (167)	69 (1.8)
	-150 (-101)		77 (103)	47 (1.2)
	-320 (-195)		25 (33)	14 (0.4)

**Average of 4 tests.*

Formability

TABLE 23 – FORMABILITY

Alloy	Olsen Cup Height, in. (mm)	3 in. Stretch Cup	LDR*
NITRONIC 30 SS Base Metal	0.480 (12.2)	1.40	2.04
NITRONIC 30 SS Weld Face in Tension	0.483 (12.3)	—	—
NITRONIC 30 SS Weld Root in Tension	0.498 (12.6)	—	—
Type 301 Base Metal	0.480 (12.2)	—	2.06
Type 304L Base Metal	—	1.14	2.04

**Limiting Draw Ratio*

TABLE 24 – EFFECT OF STRENGTH LEVEL ON FORMABILITY ASTM E643 STRETCH (Cup Height)

0.2% YS, ksi. (MPa)	Type 304L, in. (mm)	NITRONIC 30 SS, in. (mm)
40 (276)	0.43 (11)	—
50 (345)	0.39 (10)	0.52 (13)
60 (414)	0.36 (9)	0.46 (12)
60 (483)	0.34 (9)	0.40 (10)
80 (552)	0.32 (8)	0.37 (9)
90 (621)	0.31 (8)	0.34 (9)
100 (689)	0.30 (8)	0.33 (8)

TABLE 25 – PHYSICAL PROPERTIES

Density, lbs/in.^{3} (g/cm^3) @70 °F (21 °C)	0.284 (7.862)
Modulus of Elasticity, ksi. (MPa) @70 °F (21 °C)	28.0 x 10^3 (0.193 x 10^6)

NITRONIC® 30 STAINLESS STEEL

TABLE 26 – MAGNETIC PERMEABILITY (ANNEALED)

Field Strength Oersteds	Permeability
100	1.011
200	1.011
500	1.014
1000	1.015

TABLE 27 – THERMAL EXPANSION*

Temperature °F	Relative Expansion %	Coefficient of Expansion, Δ/L/°F x 10⁶	Temperature °C	Relative Expansion %	Coefficient of Expansion, Δ/L/°F x 10⁶
79 – 200	0.123	9.35	26– 50	0.048	16.13
79 – 300	0.223	9.60	26 – 100	0.135	16.90
79 – 400	0.326	9.81	26 –150	0.225	17.29
79 – 500	0.432	10.01	26 – 200	0.317	17.64
79 – 600	0.541	10.18	26 – 250	0.413	17.95
79 – 700	0.654	10.35	26 – 300	0.511	18.24
79 – 800	0.768	10.50	26 – 350	0.611	18.51
79 – 900	0.884	10.63	26 – 400	0.713	18.77
79 – 1000	1.002	10.75	26 – 450	0.817	19.00
79 – 1100	1.123	10.88	26 – 500	0.922	19.20
79 – 1200	1.245	11.00	26 – 550	1.029	19.41
79 – 1300	1.368	11.11	26 – 600	1.137	19.61
79 – 1400	1.492	11.21	26 – 650	1.248	19.80
79 – 1500	1.619	11.31	26 – 700	1.358	19.98
79 – 1600	1.749	11.42	26 – 750	1.470	20.14
—	—	—	26 – 800	1.583	20.32
—	—	—	26 – 850	1.700	20.48

Average of duplicate tests. Full heating curves available upon request.

About Cleveland-Cliffs Inc.

Cleveland-Cliffs is the largest flat-rolled steel producer in North America. Founded in 1847 as a mine operator, Cliffs also is the largest manufacturer of iron ore pellets in North America. The Company is vertically integrated from mined raw materials, direct reduced iron, and ferrous scrap to primary steelmaking and downstream finishing, stamping, tooling, and tubing. The Company serves a diverse range of markets due to its comprehensive offering of flat-rolled steel products and is the largest supplier of steel to the automotive industry in North America. The Company is headquartered in Cleveland, Ohio with mining, steel and downstream manufacturing operations located across the United States and in Canada. For more information, visit www.clevelandcliffs.com.

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