

product data

Armco NITRONIC 32 Stainless Steel

(XM-28, UNS S24100)

Armco NITRONIC 32 is a low-nickel austenitic stainless steel that provides approximately twice the yield strength of Type 304 as well as comparable corrosion resistance. Its high work-hardenability permits cold drawing to high strength levels. Good ductility is maintained even at these high strengths. And, the cost of Armco NITRONIC 32 stainless is lower than that of Type 304.

COMPOSITION

	%
Carbon	0.15 max
Manganese	11.00-14.00
Silicon	1.00 max
Chromium	16.50-19.00
Nickel	0.50-2.50
Nitrogen	0.20-0.45

AVAILABLE FORMS

Armco NITRONIC 32 stainless steel is available in bar, wire and forging billets.

100
55
30
50

The information and data in this 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 the reader make his own evaluation and decision, and are neither guarantees nor to be construed as express or implied warranties of suitability for these or other applications.

Data referring to mechanical properties and chemical analyses are the result of tests 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.

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Bulletin No. S-44d
Armco NITRONIC 32 Stainless Steel



APPLICATIONS

Armco NITRONIC 32 stainless steel is an ideal material for simple cold-headed parts requiring high mechanical properties. Examples are clamps for pole line hardware and concrete reinforcing accessories. Other applications include skid wire for underground transmission lines, abrasion and corrosion-resistant screens, high strength non-magnetic springs, wire forms, racks and cages. Cold drawn NITRONIC 32 stainless has an excellent response to electropolishing and greater strength in weld joints than other austenitic stainless steels such as Type 304.

METRIC PRACTICE

The values shown in U.S. Customary units in this bulletin are to be regarded as specification values. The metric equivalents of U.S. Customary units shown may be approximate. Conversion to the metric system, known as the International System of Units (SI), has been accomplished in accordance with the American Iron and Steel Institute "Metric Practice Guide, 1978."

The newton (N) has been adopted by SI as the metric standard unit of force. 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 designated a pascal (Pa). The relationship between the U.S. and SI units for stress is: 1000 pounds/in² (psi) = 1 kip/in² (ksi) = 6.8948 meganewtons/m² (MN/m^2) = 6.8948 megapascals (MPa). These and other units used are discussed in the AISI "Metric Practice Guide."

SPECIFICATIONS

Armco NITRONIC 32 bar and wire are covered by the following specifications. It is suggested the issuing agency be contacted for the latest revision of the specification.

Armco NITRONIC 32 Stainless Steel is listed as Grade XM-28 (UNS S24100) in:

- ASTM A313 Spring Wire
- ASTM A276 Stainless and Heat Resisting Bars and Shapes
- ASTM A580 Stainless and Heat Resisting Wire

HEAT TREATMENT

Being a fully austenitic stainless, Armco NITRONIC 32 is not hardenable by heat treatment. An annealing temperature of 1950 F (1063 C) followed by rapid cooling is recommended.

MECHANICAL PROPERTIES

Table I
Minimum Tensile Properties Acceptable for Material Specification
Annealed Bars — Up to 8" (203.2 mm) Inclusive

UTS, psi (MPa)	0.2% YS, psi (MPa)	Elong. % in 2" (50.8 mm) or 4xD	Red. of Area, %	Hardness, Rockwell B
100,000 min (690)	55,000 min (379)	30 min	50 min	92 min.

Table II
Typical Room Temperature Tensile Properties*
1" (25.4 mm) Diameter Bar

Condition	UTS ksi (MPa)	0.2% YS, ksi (MPa)	Elong in 4xD, %	Red. of Area, %	Hardness Rockwell	Impact, Charpy V-Notch ft-lbs (J)
Annealed	115 (793)	60 (414)	55	70	R _B 96	230 (307)

* Average of duplicate tests from one heat.

Table III
Typical Room Temperature Torsional Properties*
1" (25.4 mm) Diameter Bar

Condition	Proportional Limit, ksi (MPa)	0.2% YS, ksi (MPa)	Modulus of Rupture, ksi (MPa)
Annealed	45.5 (314)	58.5 (403)	134.5 (927)

* Average of duplicate tests from one heat.

Table IV
Typical Short-Time Elevated Temperature Tensile Properties*

Temperature F (C)	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elong in 4xD, %	Red. of Area %
80 (27)	118 (814)	70 (483)	53	70
200 (93)	104 (717)	57 (393)	52	75
400 (204)	94 (648)	44 (303)	50	75
600 (315)	89 (614)	39 (269)	50	75
800 (426)	83 (572)	36 (248)	50	76
1000 (538)	76 (524)	34 (234)	47	76
1200 (648)	66 (455)	31 (214)	39	67
1400 (760)	50 (345)	29 (200)	31	38

* 1" (25.4 mm) dia. mill annealed bar. Average of duplicate tests from one heat.

Fatigue Strength

The rotating beam fatigue strength of 1" (25.4 mm) diameter bar stock, measured in air at room temperature, is 52 ksi (359 MPa) at 100 million reversals of stress.

Table V
Typical Mechanical Properties
Cold Drawn Wire*

Property	Cold Reduction, %						
	0	10	20	30	40	50	60
UTS, psi (MPa)	120,000 (827)	145,000 (1000)	172,000 (1186)	190,000 (1310)	210,000 (1448)	238,000 (1640)	265,000 (1827)
0.2% YS, psi (MPa)	65,000 (448)	110,000 (758)	135,000 (931)	158,000 (1089)	180,000 (1241)	204,000 (1407)	224,000 (1545)
Elong. % in 2" (50.8 mm) or 4xD	55	43	28.5	18.5	12.5	10	9.5
Red. of Area, %	70	65	60	55	50	45	40
Hardness, Rockwell C	—	23	27.5	32	37	40	44

* Starting size: ¼" (6.4 mm) dia. annealed rod. Average of duplicate tests from one heat.

High-Strength NITRONIC 32 Bars

Armco NITRONIC 32 stainless steel bars also are available in a high-strength condition attained by special processing techniques. This material can be used to advantage in applications requiring high-strength shafting and bolting.

The superior strength of NITRONIC 32 stainless in this form is size-dependent, and approaches that of annealed bars with sizes greater than 2½" (63.5 mm) diameter. Because its high strength is produced by mill processing, hot forging or welding operations cannot be performed on this material without loss of strength.

Table VI
Minimum Mechanical Properties
High-Strength Bars

Property	Up to 1¾" (44.4 mm) Incl	Over 1¾" (44.4 mm) To 2½" (63.5 mm) Incl	Over 2½" (63.5 mm) To 5" (127 mm) Incl	Over 5" (127 mm) To 8" (203.2 mm) Incl	Over 8" (203.2 mm) To 12" (304.8 mm) Incl
	UTS, psi min (MPa)	120,000 (827)	110,000 (758)	105,000 (724)	100,000 (690)
0.2% YS, psi (MPa)					
Tension, min	90,000 (620)	70,000 (483)	65,000 (448)	60,000 (414)	50,000 (345)
Torsion, min	60,000 (414)	47,000 (324)	43,000 (296)	40,000 (276)	33,000 (228)
Elong in 2" (50.8 mm), % min	30	35	40	40	35
Red. of Area, % min	50	55	55	55	45
Charpy V-Notch Impact (Typical) ft-lbs (J)	150 (204)	150 (204)	200 (272)	200 (272)	200 (272)

Table VII
Typical Fatigue Strength
High-Strength Bars *

Bar Size	Fatigue Strength at 10 ⁸ Reversals of Stress, ksi (MPa)	
	1" (25.4 mm) dia	70
3" (76.2 mm) dia	52.5	(362)
5" (127 mm) dia	45	(310)

* Rotating beam specimens tested in air at room temperature. One heat tested each size.

WEAR RESISTANCE

Armco NITRONIC 32 stainless steel exhibits excellent wear resistance in the Taber Test. This is a severe abrasion test of a ceramic grit against the metal and would most nearly simulate rocky (SiO₂) conditions found in excavating. Test conditions were: 100 rpm, air, 1.1 lb (0.499 kg) load for about 1000 feet (304.8 m). A Wear Index with Type 316 stainless steel based at 1.00 is listed in Table VIII. Higher values than 1.00 have poorer abrasion resistance than Type 316 and lower values have better abrasion resistance.

Table VIII
Abrasive Wear Resistance

Alloy	Hardness	Wear Index
Type 440C	R _C 59	0.35
Armco NITRONIC 32	R _B 97	0.76
Type 316	R _B 75	1.00
Type 347	R _B 84	1.05
AISI 4337	R _C 52	1.18
Type 420	R _C 46	1.18
Type 410	R _C 34	1.70
AISI 1034	R _B 93	1.71
Type 430	R _B 84	1.93

Metal-to-metal wear resistance was evaluated on a modified Taber Met-Abrader wear machine. The test conditions were: 0.5" (12.7 mm) crossed 90° cylinders, no lubricant, 16 lb (71 N) load, 105 rpm, room temperature, 120 grit surface finish, 10,000 cycles, degreased in acetone, duplicates, weight loss corrected for density differences.

Table IX
Metal-To-Metal Wear Resistance

Alloy (Hardness)	Weight Loss of Couple (mg/1000 cycles)		
	NITRONIC 32 (B95)	Type 304 (B99)	17-4 PH (H900) (C43)
NITRONIC 32 (B95)	7.4	8.4	17.2
Type 304 (B99)	8.4	12.8	24.7
17-4 PH (H900) (C43)	17.2	24.7	52.8

GALLING RESISTANCE

The galling resistance of Armco NITRONIC 32 stainless was tested by the following test method: A dead-load weight is applied in the Brinell Hardness Tester on two flat, polished surfaces (3/0 emery grit finish). One specimen is slowly rotated 360° under the load and then examined for galling at 10X. New samples are tested at higher loads until galling occurs. Results are shown in Table X. For further details of test procedure, see April 1973 *Materials Engineering*, page 60.

Table X
Unlubricated Galling Resistance of Stainless Steels
Threshold Galling Stress in ksi (MPa)
(Stress at which galling began)

Condition & Nominal Hardness (Brinell)	Type 410	Type 416	Type 430	Type 440C	Type 303	Type 304	Type 316	17-4 PH	NITRONIC 32
Hardened & Stress Relieved (352) Type 410	3 (21)	4 (28)	3 (21)	3 (21)	4 (28)	2 (14)	2 (14)	3 (21)	46 (317)
Hardened & Stress Relieved (342) Type 416	4 (28)	13 (90)	3 (21)	21 (145)	9 (62)	24 (165)	42 (290)	2 (14)	45 (310)
Annealed (159) Type 430	3 (21)	3 (21)	2 (14)	2 (14)	2 (14)	2 (14)	2 (14)	3 (21)	8 (55)
Hardened & Stress Relieved (560) Type 440C	3 (21)	21 (145)	2 (14)	11 (76)	5 (34)	3 (21)	37 (255)	3 (21)	50+(345)
Annealed (153) Type 303	4 (28)	9 (62)	2 (14)	5 (34)	2 (14)	2 (14)	3 (21)	3 (21)	50+(345)
Annealed (140) Type 304	2 (14)	24 (165)	2 (14)	3 (21)	2 (14)	2 (14)	2 (14)	2 (14)	30 (207)
Annealed (150) Type 316	2 (14)	42 (290)	2 (14)	37 (255)	3 (21)	2 (14)	2 (14)	2 (14)	3 (21)
H950 (415) 17-4 PH	3 (21)	2 (14)	3 (21)	3 (21)	2 (14)	2 (14)	2 (14)	2 (14)	50+(345)
Annealed (235) NITRONIC 32	46 (317)	45 (310)	8 (55)	50+(345)	50+(345)	30 (207)	3 (21)	50+(345)	30 (207)

+ Did Not Gall

(Note: Condition and Hardness apply to both horizontal and vertical axes.)

PHYSICAL PROPERTIES

Density at 75 F (24 C) — 7.781 gm/cm³
0.281 lbs/in³

Magnetic Permeability

Armco NITRONIC 32 stainless is useful in applications requiring low magnetic permeability because it remains nonmagnetic even after severe cold working. After approximately 70% cold reduction, the permeability is still less than 1.02.

Field Strength, Oersteds (A/m)	Magnetic Permeability	
	Annealed	Cold Drawn 70%
50 (3978)	1.009	1.018
100 (7957)	1.009	1.015
200 (15.914)	1.008	1.011

Elastic Properties

The elastic properties of annealed NITRONIC 32 at room temperature are as follows:

Modulus of Elasticity in Tension (E)*		Modulus of Elasticity in Torsion (G)		Poisson's Ratio
psi	(GPa)	psi	(GPa)	
28.9x10 ⁶	(199.2)	11.0x10 ⁶	(75.8)	0.290

* Average of duplicate tests.

Thermal Expansion

Temperature Range		Mean Coefficient of Linear Expansion	
F	(C)	in/in/°F	(mm/mm/°C)
73- 200	(23- 93)	8.98x10 ⁻⁶	(16.16x10 ⁻⁶)
73- 400	(23-204)	9.35x10 ⁻⁶	(16.83x10 ⁻⁶)
73- 600	(23-316)	9.77x10 ⁻⁶	(17.59x10 ⁻⁶)
73- 800	(23-427)	10.03x10 ⁻⁶	(18.05x10 ⁻⁶)
73-1000	(23-538)	10.31x10 ⁻⁶	(18.56x10 ⁻⁶)
73-1200	(23-649)	10.73x10 ⁻⁶	(19.31x10 ⁻⁶)
73-1400	(23-760)	11.02x10 ⁻⁶	(19.84x10 ⁻⁶)
73-1600	(23-871)	11.25x10 ⁻⁶	(20.25x10 ⁻⁶)
73-1800	(23-982)	11.60x10 ⁻⁶	(20.88x10 ⁻⁶)

CORROSION RESISTANCE

Armco NITRONIC 32 stainless steel exhibits no rust or staining after 240 hours' exposure to 5% NaCl fog at 95 F (35 C) (ASTM B117-64) and is completely unaffected by exposure to 100% relative humidity at 120 F (49 C) for 240 hours. Weldments in their as-welded condition also show no corrosion in 5% NaCl fog at 95 F (35 C) for 240 hours.

The corrosion resistance of NITRONIC 32 stainless in weak acid solutions and pitting media approaches that of Type 304 stainless, as indicated by the following laboratory test results. In more aggressive media, NITRONIC 32 stainless is somewhat less corrosion resistant than Type 304.

Permic Chloride

Alloy	1/4% H ₂ SO ₄ @ 35C	1/4% HCl @ 35 C	10% FeCl ₃ @ RT
	5-48 hr pds, IPY	5-48 hr pds, IPY	50 hrs, gm/in ²
NITRONIC 32	0 — .0065*	.0073*	.477
Type 304	0 — .0003*	Nil	.312

*All specimens intentionally activated for 3rd, 4th and 5th periods.

Intergranular Attack

The results of both the boiling nitric acid and copper-accelerated copper sulfate tests (ASTM A262) characterize Armco NITRONIC 32 stainless as comparable to Type 302 with respect to intergranular attack. Due to its higher carbon content, NITRONIC 32 is not as resistant to intergranular attack as Type 304, and will not pass these tests when sensitized at 1250 F (677 C) for one hour.

Weldments in their as-welded condition exhibit only a moderate corrosive attack in the sensitized area in boiling 65% HNO₃.

Stress Corrosion Cracking

In common with most stainless steels, Armco NITRONIC 32 stainless may exhibit stress corrosion cracking in hot chloride environments under certain conditions. When tested in boiling 42% MgCl₂ solution, NITRONIC 32 stainless is slightly more resistant to cracking than Type 304 at high stress levels, and vastly superior at low stress levels. This is illustrated by the following comparative data using the direct-loaded tensile-type test method described in detail in ASTM STP 425, September 1967:

Alloy	Condition	Time to Failure, Hours, Under Stress of:		
		75 ksi (517 MPa)	50 ksi (345 MPa)	20 ksi (138 MPa)
Type 304	Annealed	0.2	0.7	3.0
NITRONIC 32	Annealed	0.3	1.0	>1000

Based on most design considerations, NITRONIC 32 stainless should exhibit better resistance to stress corrosion cracking than Type 304. Weldments in their as-welded condition did not crack on exposure to the 42% MgCl₂ solution for 250 hours.

FABRICATION

Although Armco NITRONIC 32 stainless is considerably stronger than the conventional 300 series stainless steels, the same fabricating equipment and techniques can be used. In-process annealing should be accomplished between 1900 and 2000 F (1038 and 1093 C). Cooling practices are the same as those required for the 300 series — rapid air cooling for sheet stock and water or oil quenching for heavier sections. Armco NITRONIC 32 stainless is readily forgeable at hot working temperatures of 2100-2200 F (1149-1204 C).

Welding

Armco NITRONIC 32 stainless is readily welded in all forms. Weld joints in the as-welded condition have strength equivalent to the unwelded base metal. Where weld filler metal is needed for high joint efficiencies, contact Armco's Stainless Steel Division for specific recommendations.

MACHINING

NITRONIC 32 stainless steel has machining characteristics similar to Type 304. The high strength and high work hardening of NITRONIC 32 stainless necessitate machining the alloy at lower cutting rates than used for Type 304. A suggested starting point would be one-half the cutting rate used for Type 304. Feeds should be the same or higher than those used for Type 304. The same tooling used for Type 304 can be used for machining NITRONIC 32 stainless. Tools should be kept sharp, held short and rigid as possible. Tools should not be allowed to dwell or ride on the work surface, as this will result in burnishing and work hardening.

NITRONIC 32 has a machinability rating of about 30% of AISI B1112 steel. Use a powerful machine and rigid machine setup. Select as large a tool as possible to permit maximum dissipation of heat through the tool and use a copious supply of cutting fluid directed at the tip of the tool. Use feed and depth of cut great enough to get below the work-hardened skin. Heavy feeds at reduced speeds will give a faster metal removal than light feeds at higher speeds. Keep the tool cutting and do not let it ride on the work as it glazes and work hardens the surface.

Single-point turning tools of high-speed steel should be ground to 5-10° side rake angle, 5-10° back rake, 7-10° end relief, 5-8° side relief, 8-15° cutting edge angle, 10-15° side cutting edge angle. Chip curlers or chip breakers are recommended. Circular and straight cutoff blades have about 7-10° back rake, 7-9° end relief angle, and are sometimes designed with side rake. Circular form tools also use 7-10° back rake and 7-10° clearance. Drills should have 140° included angle at the tip and 9-15° lip relief angle. Recommended cutting speeds are 60-90 sfpm for turning with 0.003-0.008" (.076-.203 mm) feed, 30-60 sfpm for drilling with a 1/2" (12.7 mm) drill and a feed of 0.003-0.007" (.076-.178 mm), 15-25 sfpm for tapping, 35-60 sfpm for milling, 8-15 sfpm for broaching, and 20-60 sfpm for reaming.

Use sulfurized cutting fluid preferably of the chlorinated type.

Armco Stainless Steel Division Box 1697 Baltimore, MD 21203

SALES OFFICES IN THE FOLLOWING CITIES:

Atlanta, Georgia 30342	875 Johnson Ferry Rd., Suite 570	404/252-9770
(Baltimore) Phoenix, Maryland 21131	13718 Princess Anne Way	301/666-9535
Baltimore, MD (Hdqtrs.) 21203	P.O. Box 1697	301/563-5500
(Boston) Franklin, MA 02038	91 Regent Circle	617/528-0330
(Boston) Salem, MA 01970	Pickering Bldg., 57 Wharf St.	617/745-8354
Buffalo, NY 14221	5820 Main St., Caldwell Bldg., Suite 503	716/634-3500
(Chicago) Oak Brook, IL 60521	2015 Spring Rd., Suite 195	312/920-8940
(Cleveland) Chagrin Falls, OH 44022	33 River Rd.	216/247-4720
(Detroit) Southfield, MI 48075	21415 Civic Center Dr., Suite 304	313/444-1144
Houston, TX 77070	15110 Rolling Oaks Dr.	713/376-5468
Houston, TX 77082	Stainless Pipe & Tubing Hdqtrs., Box 23068	713/960-5726
(Los Angeles) Carson, CA 90746	550 E. Carson Plaza Dr., Suite 222	213/516-8951
(New York) Stamford, CT 06906	34 Crescent-2D	203/357-7630
(Philadelphia) Washington Crossing, PA 18977	Bankers & Bailey Drives	215/493-2590
(Tulsa) Broken Arrow, OK 74012	1200 W. Birmingham St.	918/455-7855

