

REVISED : MARCH 1973
AUTHOR : C. F. HICKEY, JR.

FERROUS ALLOYS

1. **GENERAL**
The low carbon members of the straight 18-8 austenitic stainless steel family are produced in two grades. Type 304 with 0.08 percent maximum carbon and Type 304L with 0.03 percent maximum carbon. They have properties similar to those of Type 302 but their corrosion resistance is slightly higher because of the lower carbon and the increased chromium and nickel contents. The susceptibility of these steels to intergranular corrosion decreases considerably with decreasing carbon content, although long exposure to elevated temperatures may even sensitize Type 304L. The normal nitrogen content for Type 304 is 0.04 percent. Increasing the nitrogen to between 0.10 and 0.16 percent is a means of increasing the strength and creep rupture properties of Type 304. This higher nitrogen version is referred to as Type 304N. Types 304 and 304L are available in all common wrought forms and also as castings under the designations of CF-8 and CF-3, respectively. The wrought forms possess very good formability and the steels can be readily welded by all common methods.
- 1.01 **Commercial Designations**
Wrought: Type 304, Type 304L and Type 304N.
Cast: CF-8 and CF-3.
- 1.02 **Alternate Designations**
Low carbon 18-8S stainless steels. AISI Type 304 and Type 304L austenitic stainless steels.
- 1.03 **Specifications**
Table 1.03.
- 1.04 **Composition**
1.041 AMS compositions, Table 1.041.
1.042 AISI and ACl compositions, Table 1.042.
- 1.05 **Heat Treatment**
1.051 Anneal or solution treat. 1800 to 1950 F, 30 minutes to 1 hour per inch thickness, 2 hours minimum for plate, air cool or quench depending on section size. Cooling to 800 F maximum should be within 3 minutes.
1.0511 Sheet and tubing. 1900 to 1950 F, 10 minutes, air cool up to 0.064 inch thickness, water quench 0.065 and thicker.
1.0512 Castings (AMS 5370, 5371). 1950 to 2050 F, 30 minutes minimum, air cool.
1.052 Stress relief (see also 1.09).
1.0521 To improve elastic characteristics of cold rolled sheet or cold drawn bar. 650 to 800 F, 4 to 8 hours.
1.05211 Casting (AMS 5370). 400 to 750 F, 1/2 to 2 hours, air cool (14).
- 1.06 **Hardness**
1.061 Hardness of annealed alloy is RB 75-90 and BHN 135-185 (15).
1.062 Typical hardness for alloy of different forms and conditions (see Table 3.0212).
1.063 Effect of time and temperature of exposure on room temperature hardness of alloy, Figure 1.063.
1.064 Effect of low temperature on hardness of bar, Figure 1.064.
1.065 Effect of test temperature on hot hardness, Figure 1.065.
- 1.07 **Forms and Conditions Available**
1.071 The steel is available in the full commercial range of sizes for all wrought forms common for stainless steels.
1.072 These forms are generally available in the annealed, cold worked or cold worked and stress relieved conditions.
1.073 Sand and centrifugal castings are available up to 6000 lb in the annealed condition.
- 1.08 **Melting and Casting Practice**
Electric furnace air melts and induction vacuum melts. Castability, fluidity, shrinkage and resistance to hot tearing characteristics are excellent (14).
- 1.09 **Special Considerations**
(see also 2.03).
1.091 Intergranular corrosion after welding or heating may occur in Type 304, but usually not in Type 304L. Stress corrosion cracking may occur in hot dilute chloride solutions.
- 1.092 The normal nitrogen content for Type 304 is 0.04 percent. Increasing the nitrogen content to between 0.10 and 0.16 percent results in an increase in strength properties in the temperature range of room temperature to 1200 F (Table 3.03138).
- 1.093 The higher nitrogen material is designated as Type 304N. Higher creep and creep rupture properties are also exhibited at temperatures ranging from 1050 to 1500 F for Type 304N (Table 3.046). Ductility of Type 304N, as measured by elongation and reduction, is not adversely affected at testing temperatures up to 1100 F (43). At cryogenic temperatures the yield strength of Type 304N is superior to that of Type 304, whereas the tensile and toughness properties of Type 304N are similar to those of Type 304, see Table 1.093 for typical values. Helium reduces the rupture life of Type 304 (see Figure 3.047).
2. **PHYSICAL AND CHEMICAL PROPERTIES**
- 2.01 **Thermal Properties**
2.011 Melting range. 2550 to 2650 F.
2.012 Phase changes.
2.0121 Time-temperature-transformation diagrams.
2.0122 These steels are subject to carbide precipitation at 800 to 1600 F.
2.0123 Cold work will transform a small amount of austenite to ferrite (martensite).
2.013 Thermal conductivity, Figure 2.013.
2.014 Thermal expansion, Figure 2.014.
2.015 Specific heat, Figure 2.015.
2.016 Thermal diffusivity.
- 2.02 **Other Physical Properties**
2.021 Density. 0.287 to 0.292 lb per cu in. 7.94 to 8.07 gr per cu cm.
2.022 Electrical resistivity, Figure 2.022.
2.023 Magnetic properties. This steel is nonmagnetic in the annealed condition. Permeability of annealed materials is less than 1.02. It becomes slightly magnetic when severely cold worked, but to a lesser extent than Type 302 and particularly, Type 301.
2.0231 Effect of cold reduction on magnetic permeability, Figure 2.0231.
2.0232 The intrinsic saturation magnetization, B_s , is structure insensitive and depends only on the quantity of the ferromagnetic phase, α (28). Stress induced transformation of α to α' occurs as a function of low temperature deformation thus resulting in an increase in magnetization, Figure 2.0232.
2.024 Emittance (Black Body = 1.0) At 80 F 0.08
-320 F 0.048 (27).
- 2.025 Damping capacity.
- 2.03 **Chemical Properties**
2.031 Corrosion resistance.
2.0311 General corrosion resistance of these steels to various atmospheres, most acids, hot petroleum products and steam and combustion gases is very good.
2.0312 Intergranular corrosion in Types 304 and 304L when subjected to a nitric-dichromate solution is associated with the presence of continuous grain boundary paths of either second phase or solute-segregated regions. The susceptibility of these types to intergranular corrosion may be substantially reduced by suitable heat treatments, Table 2.0312.
2.0313 Intergranular corrosion of Type 304 may occur in certain corrosive media after it is welded or otherwise heated to temperatures between 800 and 1600 F. Type 304L will become sensitized only after prolonged heating in this temperature range, but its use over 800 F is not recommended because of its relatively low strength. Complete immunity from intergranular corrosion is obtained only in the stabilized types 321 and 347. Effect of carbon content on corrosion rate, Figure 2.0313.

	Fe
Low	C
19	Cr
10	Ni

TYPES
304, 304L

	Fe
Low	C
19	Cr
10	Ni

**TYPES
304, 304L**

- 2.0314 Type 304 is susceptible to pitting and crevice attack. In quiet sea water, cathodic protection is essential to control pitting and crevice attack (32). Deep ocean behavior of Types 304 and 304L varies, but local attack often takes place, Table 2.0314.
- 2.0315 Corrosion rate and attack depth. Results of corrosion rate and maximum depth of attack of sheet in sea water at a depth of 5600 feet in the Tongue of the Ocean (TOTO) waters, Bahama Islands, Table 2.0315.
- 2.0316 Type 304 is highly resistant to stress corrosion cracking in a moist environment containing chlorides at room temperature. Types 304 and 304L are susceptible to stress corrosion in hot dilute chloride solutions. The presence of oxygen in the solution increases the tendency to stress corrosion. Making the steels anodic accelerates stress cracking, while cathodic currents prevent it.
- 2.0317 The best corrosion resistance comes from a clean surface free of all organic and metallic contaminants. Such surfaces can be obtained by a thorough degreasing treatment and a nitric acid rinse (37).
- 2.0318 Nitriding significantly increased the resistance to stress corrosion cracking, Table 2.0318.
- 2.0319 Threshold stress (maximum stress that will not produce stress-corrosion cracking or failure in 300 hr) determined in 0.5N NaCl + 0.1N NaNO₂ boiling solution for Type 304, Table 2.0319.
- 2.03191 Mechanical properties and threshold stress values, which were determined in a boiling solution of 0.5N NaCl + 0.1N NaNO₂, for specimens of annealed sheet which were cold reduced by various amounts, Table 2.03191.
- 2.032 Oxidation resistance of these steels is good up to 1700F for continuous service and up to 1600F for intermittent service.
- 2.0321 The presence of high pressure hydrogen during loading to failure leads to a marked reduction in the tensile strength and ductility of Type 304L at room temperature. This reduction in strength is dependent upon the state of stress at the root of the notch, increasing both with increasing notch severity and with increasing hydrogen pressure (36), (see Figures 2.03211 and 2.03212).
- 2.03211 Ultimate tensile and notch strength versus hydrogen pressure for Type 304L exposed for 24 hr and then pulled to fracture in high pressure hydrogen, Figure 2.03211.
- 2.03212 Percent elongation versus hydrogen pressure for Type 304L exposed for 24 hr and then tested in high pressure hydrogen, Figure 2.03212.
- 2.04 Nuclear Properties
Austenitic stainless steels, particularly 304L, 304 and 347 are used extensively in nuclear power reactor construction.
- 2.041 Irradiation effects on austenitic stainless steels are generally the following:
- 2.0411 Magnetic susceptibility is increased depending on condition of material, irradiation variables, such as total flux and temperature, and method of measurement. At nvt = 10¹⁹ and 400 to 500 F, the susceptibility of Type 304 shows an increase in the order of 500 percent, if measured by the Guoy method.
- 2.0412 Changes in mechanical properties consist of increases in tensile strength, yield strength and hardness, decrease in elongation, development of a yield point jog and high strain rate dependence. At room temperature and about 5 x 10¹⁹ nvt, the tensile strength of annealed Type 304 is found to increase by approximately 20 percent and the yield strength by 200 percent. At 400 to 500F and 10¹⁹ nvt, effects of irradiation are small.
- 2.0413 Austenitic stainless steels retain their high impact strength after irradiation in contrast to ferritic steels which may become extremely brittle because of an increase in the transition temperature.
- 2.042 Austenitic steels exhibit good resistance to intergranular corrosion in high purity water containing oxygen at 500 to 600F. This also applies to welded parts, including intergranular corrosion between different types of the 300 series. Sensitizing of the steels does not effect this corrosion resistance.
- 2.043 Type 304L can be used in applications where it is in contact with molten sodium, even though sodium is an excel-

- lent medium for transferring carbon (37).
- 2.044 Type 304 is used with an additional content of up to 2 percent boron for such applications as control rods and thimoshields because of the high nuclear cross-section of boron. However, boron increases the susceptibility of the alloy to radiation damage.
- 2.045 Nitrogen alloyed Type 304 has the advantage of increasing the strength level by somewhat more than 10 percent without degrading the properties for reactor construction (38).
- 2.046 Effect of irradiation below 100C (212F) on yield strength, Figure 2.046.
- 2.047 Strain rate dependence of tensile properties for Type 304 at 1300F after irradiation to 3.4 nvt total, Figure 2.047.
- 2.048 S-N curve for irradiated and unirradiated smooth specimens of 304 stainless steel, Figure 2.048.

3. MECHANICAL PROPERTIES

3.01 Specified Mechanical Properties

3.011 AMS specified mechanical properties for all products except tubing, Table 3.011.

3.012 AMS specified mechanical properties for tubing, Table 3.012.

3.02 Mechanical Properties at Room Temperature

3.021 Tension.

3.0211 Stress-strain diagrams (see 3.0311).

3.0212 Typical tensile properties for various forms and conditions of alloys, Table 3.0212.

3.0213 Effect of cold rolling on tensile properties of Types 304 and 304L sheet, Figure 3.0213.

3.0214 Effect of cold rolling at -105F on tensile strength of sheet, Figure 3.0214.

3.0215 Effect of exposure to elevated temperatures on tensile properties of cold rolled sheet, Figure 3.0215.

3.0216 Effect of exposure of 10,000 hours to elevated temperatures on tensile properties of annealed alloy, Figure 3.0216.

3.0217 Effect of annealing temperature and exposure to elevated temperatures on tensile properties of bar, Figure 3.0217.

3.0218 Yield strength of Type 304 at room temperature after aging 1-1/2 hours at the temperatures shown following tensile deformation at -319F, Figure 3.0218.

3.0219 Ultimate tensile strength of Type 304 at room temperature after aging 1-1/2 hours at the temperature shown following tensile deformation at -319F, Figure 3.0219.

3.02110 Elongation of Type 304 at room temperature after aging 1-1/2 hours at the temperatures shown following tensile deformation at -319F, Figure 3.02110.

3.02111 AISI tensile strength range for various sizes of spring wire, Figure 3.02111.

3.022 Compression.

3.0221 Stress-strain diagrams.

3.023 Impact.

3.0231 Typical impact properties of annealed plate, and cold drawn bar, Table 3.0231.

3.024 Bending.

3.025 Torsion and shear.

3.026 Bearing.

3.027 Stress concentration.

3.0271 Notch properties.

3.02711 Effect of cold-rolling and test direction on notch strength of sheet, Figure 3.02711.

3.02712 Effect of stress relief temperature on sharp notch strength ratio for cold rolled 304L sheet, Figure 3.02712.

3.0272 Fracture toughness.

3.028 Combined properties.

3.03 Mechanical Properties at Various Temperatures.

3.031 Tension.

3.0311 Stress-strain diagrams.

3.03111 Stress-strain curves to failure at room and elevated temperatures, Figure 3.03111.

3.03112 Stress-strain curves at room and elevated temperatures, Figure 3.03112.

3.03113 Stress-strain curves at room and low temperatures, Figure 3.03113.

- 3.03114 True stress-strain curves at room and elevated temperatures, Figure 3.03114.
- 3.03115 True stress-strain curves at room and low temperatures, Figure 3.03115.
- 3.0312 Effect of cold reduction on tensile properties.
- 3.03121 Effect of cold rolling on tensile properties of sheet at room and low temperatures, Figure 3.03121.
- 3.03122 Effect of cold reduction on -320 F tensile properties of 304L sheet, Figure 3.03122.
- 3.0313 Effect of elevated temperatures on tensile properties.
- 3.03131 Effect of elevated test temperature on tensile properties of rolled tubing, Figure 3.03131.
- 3.03132 Range of tensile property values at elevated temperatures for annealed alloy, Figure 3.03132.
- 3.03133 Effect of elevated test temperatures on alloy, Figure 3.03133.
- 3.03134 Effect of elevated test temperature on annealed alloy, Figure 3.03134.
- 3.03135 Effect of annealing and test temperature on tensile properties of cold drawn bar, Figure 3.03135.
- 3.03136 Effect of elevated temperature on Zerolled 304 stainless, Figure 3.03136.
- 3.03137 Effect of test temperature on tensile properties of castings, Figure 3.03137.
- 3.03138 Comparison of strength properties of types 304 and 304N at room and elevated temperatures, Table 3.03138.
- 3.0314 Effect of low temperature on tensile properties.
- 3.03141 Effect of low test temperature on tensile properties of annealed alloy, Figure 3.03141.
- 3.03142 Effect of low test temperature and strain rate on tensile properties of cold drawn bar, Figure 3.03142.
- 3.03143 Effect of low test temperature on tensile properties of cold rolled sheet, Figure 3.03143.
- 3.03144 Effect of low test temperature and percent cold reduction on tensile properties of sheet, Figure 3.03144.
- 3.03145 Effect of nitrogen content and test temperature (+80 to -320 F) on the tensile properties of Type 304N, Table 3.03145.
- 3.03146 Effect of low temperatures on tensile properties of 304 cast stainless steel, Figure 3.03146.
- 3.03147 Effect of low temperature on the yield strength to density ratio, Figure 3.03147.
- 3.03148 Effect of low test temperature on true tensile properties of alloy, Figure 3.03148.
- 3.032 Compression.
- 3.0321 Stress-strain diagrams.
- 3.0322 Effect of low temperature on compressive yield strength of alloy, Figure 3.0322.
- 3.033 Impact.
- 3.0331 Probable range of Charpy impact properties of annealed Types 304 and 304L stainless steels, Figure 3.0331.
- 3.0332 Effect of low temperature on impact properties of annealed plate and bar, Figure 3.0332.
- 3.0333 Low temperature impact properties of Type 304 as a function of exposure time, Table 3.0333.
- 3.0334 Effect of sensitization heat treatment on Charpy keyhole impact properties of Types 304 and 304L, Figure 3.0334.
- 3.0335 Effect of nitrogen content and test temperature on the Charpy V-notch impact properties of Type 304N, Table 3.0335.
- 3.034 Bending.
- 3.035 Torsion and shear.
- 3.036 Bearing.
- 3.037 Stress concentration.
- 3.0371 Notch properties.
- 3.03711 Effect of low temperature on notch strength of cold rolled sheet, Figure 3.03711.
- 3.03712 Effect of low temperature on the notch and tensile strength of cold rolled sheet, Table 3.03712.
- 3.03713 Effect of test temperature on notch strength of annealed plate, Figure 3.03713.
- 3.03714 Effect of cold reduction on -320 F sharp notch strength of 304L sheet, Figure 3.03714.
- 3.03715 Effect of stress relief temperature on sharp notch strength ratio at -320 F for cold rolled 304L sheet, Figure 3.03715.
- 3.0372 Fracture toughness.
- 3.038 Combined properties.
- 3.04 Creep and Creep Rupture Properties
- 3.041 Creep rupture curves for bar at 1000 to 1800 F, Figure 3.041.
- 3.042 Creep rupture curves for bar at 1200 to 1800 F, Figure 3.042.
- 3.043 Creep rupture curves for bar at 900 to 1500 F, Figure 3.043.
- 3.044 Creep rupture curves for bar at 1050 to 1350 F, Figure 3.044.
- 3.045 Creep rupture curves for Type 304N bar at 1050 to 1500 F, Figure 3.045.
- 3.046 Comparison of rupture stress of Type 304 and Type 304N as a function to temperature and time, Table 3.046.
- 3.047 Effect of helium on creep rupture of sheet tested in vacuum at 1400 F, Figure 3.047.
- 3.048 Short time creep rupture curves for sheet at 1200 to 2000 F, Figure 3.048.
- 3.049 Isochronous stress-strain curves for Type 304 at 1000 F, Figure 3.049.
- 3.0410 Isochronous stress-strain curves for Type 304 at 1100 F, Figure 3.0410.
- 3.0411 Isochronous stress-strain curves for Type 304 at 1200 F, Figure 3.0411.
- 3.05 Fatigue Properties
(See also Figure 2.048).
- 3.051 Fatigue properties of 1 inch diameter annealed bar, Table 3.051.
- 3.052 Results of vibrating beam tests of notched and unnotched Type 304 bar, Figure 3.052.
- 3.053 S-N curves for notched and smooth sheet as a function of temperature in the annealed condition, Figure 3.053.
- 3.054 Fatigue crack propagation rate at R. T. as a function of stress intensity range for plate, Figure 3.054.
- 3.055 Fatigue crack propagation rate at 1000 F as a function of stress intensity range for plate, Figure 3.055.
- 3.056 Fatigue crack propagation rate at 1200 F as a function of stress intensity range for plate, Figure 3.056.
- 3.057 Fatigue crack growth rate as a function of stress intensity range and temperature for plate in the annealed condition, Figure 3.057.
- 3.06 Elastic Properties
- 3.061 Poisson's ratio at room and elevated temperatures, Figure 3.061.
- 3.062 Modulus of elasticity.
- 3.0621 Modulus of elasticity at room and elevated temperatures, Figure 3.0621.
- 3.0622 Modulus of elasticity at room and low temperatures, Figure 3.0622.
- 3.063 Modulus of rigidity at room and elevated temperatures, Figure 3.063.
4. FABRICATION
(See Type 301 also).
- 4.01 Formability
- 4.011 General. This steel has excellent formability in the annealed condition, although other straight 18-8 grades may be preferred for certain operations. It has a low yield strength and high strain hardening capacity and requires considerably more power than carbon steels. Severe forming operations may require intermediate anneals and a final anneal immediately after forming should be applied to prevent stress cracking.
- 4.012 Forging. Starting forging temperature 2300 F maximum, finishing temperature 1500 F minimum. Severe reductions below 1700 F should be avoided.
- 4.013 The casting characteristics of this alloy are excellent. Many of the casters use this composition as a base for making comparisons of casting characteristics. (Also see 1.08).
- 4.02 Machining and Grinding
- 4.021 General. Because of their high strain hardening, machining of austenitic stainless steels requires positive feeds,

	Fe
Low	C
19	Cr
10	Ni

TYPES
304, 304L

	Fe
Low	C
19	Cr
10	Ni

TYPES
304, 304L

- 4.022 correctly contoured and sharp tools and an ample supply of coolant. While comparison with other material varies with the operation, Type 304 is generally rated as possessing 35 to 45 percent of the machinability of Bessemer steel screw stock.
- Special measures, such as chip curlers, are required to handle the very long chips formed by these steels.
- 4.03 Welding
- 4.031 General. This steel can be welded readily by any of the common welding methods.
- 4.032 Fusion welding of sheet up to 1/8 inch thick is generally done by the inert gas tungsten arc (TIG) method. The shielded metal arc welding process is preferred for sheet over 1/8 inch thick and other products. Type 308 filler rod and electrodes are used.
- 4.033 Some sensitization on welding may occur in Type 304, particularly if the metal is over 1/8 inch thick. Type 304L will become susceptible to intergranular corrosion only if subjected to heating at about 1200F for a long time.
- 4.04 Heat Treatment
- 4.041 Furnace atmosphere should be neutral or slightly oxidizing to produce a readily removable scale and to avoid carburization. Heating with high sulfur fuels should be avoided.
- 4.042 Bright annealing is done in a dry hydrogen, cracked ammonia or argon atmosphere with a dew point of -80F maximum.
- 4.043 Prolonged heating at temperatures in the range of 800 - 1600F should be avoided because of possible embrittlement and increase in stress corrosion sensitivity.
- 4.05 Surface Treatment
- 4.051 Cleaning prior to heating and welding should include thorough removal of carbonaceous material and of any pickup of zinc or lead from dies. Contamination from these sources may reduce the corrosion resistance, cause embrittlement and susceptibility of intergranular attack during service or processing.
- 4.052 See 2.0317.

Source	AMS (1)(2)		AMS(3)(4)(5)		AMS (10)(11)	
	304L		304		304L	
	Percent		Percent		Percent	
Type	Min	Max	Min	Max	Min	Max
Carbon	-	0.050	-	0.08	-	0.030
Chromium	18.0	21.0	18.00	20.00	18.00	20.00
Copper	-	0.5	-	0.50	-	-
Manganese	1.00	2.00	-	2.00	-	2.00
Molybdenum	-	0.5	-	0.50	-	-
Nickel	8.0	11.0	8.00	11.00(c)	8.00	11.00
Phosphorus	-	0.04	-	0.040	-	0.040
Silicon	0.75(a)	1.50(a)	-	1.00(d)	0.50(e)	1.00
Sulfur	-	0.03(b)	-	0.030	-	0.030
Iron	Balance		Balance		Balance	

(a) AMS 5371 only, AMS 5370 specified 1.0 percent maximum only.
 (b) AMS 5371 gives 0.04.
 (c) AMS 5560D and 5566D gives 12.0.
 (d) AMS 5566 gives 0.75.
 (e) AMS 5647 only.

TABLE 1.041 AMS COMPOSITIONS.

Source	AISI (12)				ACI (13)			
	304		304L		CF 8		CF 3	
	Percent		Percent		Percent		Percent	
Type	Min	Max	Min	Max	Min	Max	Min	Max
Carbon	-	0.08	-	0.03	-	0.08	-	0.03
Chromium	18.00	20.00	18.00	20.00	18.0	21.0	18.0	21.0
Manganese	-	2.00	-	2.00	-	1.50	-	1.50
Nickel	8.00	12.00	8.00	12.00	8.0	11.0	8.0	11.0
Phosphorus	-	0.045	-	0.045	-	0.04	-	0.04
Silicon	-	1.00	-	1.00	-	2.00	-	2.00
Sulfur	-	0.030	-	0.030	-	0.04	-	0.04
Iron	Balance		Balance		Balance		Balance	

TABLE 1.042 AISI AND ACI COMPOSITIONS

AMS	Type	Form	Military
5370	304L	Castings, prec. invest.	—
5371	304L	Castings, sand	—
5513	304	Sheet, strip, plate (ST)	MIL-S-5059
5560D	304	Tubing, seamless (ST)	MIL-T-8506
5565D	304	Tubing, welded (ST)	MIL-T-8506
5566D	304	Tubing, hydraulic (CD)	MIL-T-6845
5567	304	Tubing, seamless or welded, hydraulic (ST)	MIL-T-8504
5639A	304	Bar, forgings, tubing (ST)	QQ-S-763 (a)
5697	304	Wire (ST) (CD)	QQ-S-423 (a)
5511A	304L	Sheet, strip, plate (ST)	MIL-S-4043
5647B	304L	Bar, forging stock, forgings, tubing (ST)	QQ-S-763 (a)

(a) Federal Specifications

TABLE 1.03 SPECIFICATIONS

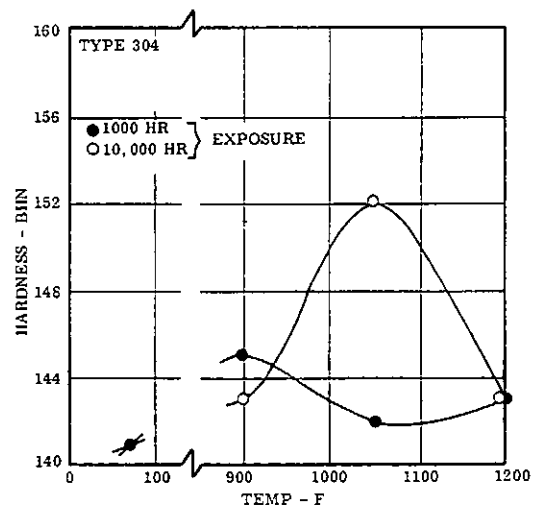


FIG 1.063 EFFECT OF TIME AND TEMPERATURE OF EXPOSURE ON ROOM TEMPERATURE HARDNESS OF ALLOY (17)

FERROUS ALLOYS

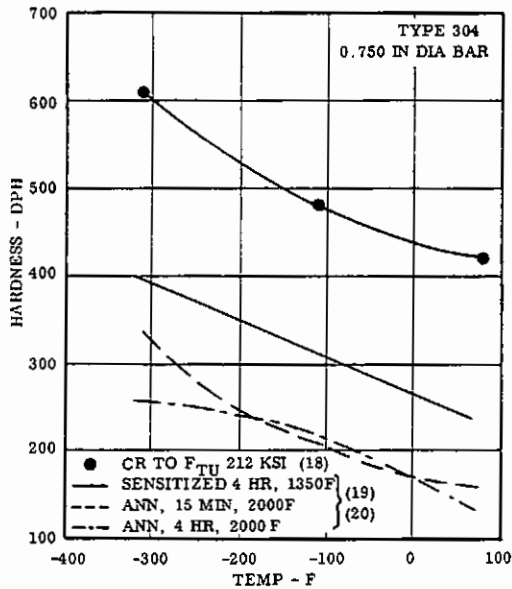


FIG 1.064 EFFECT OF LOW TEMPERATURES ON HARDNESS OF BAR (18)(19)(20)

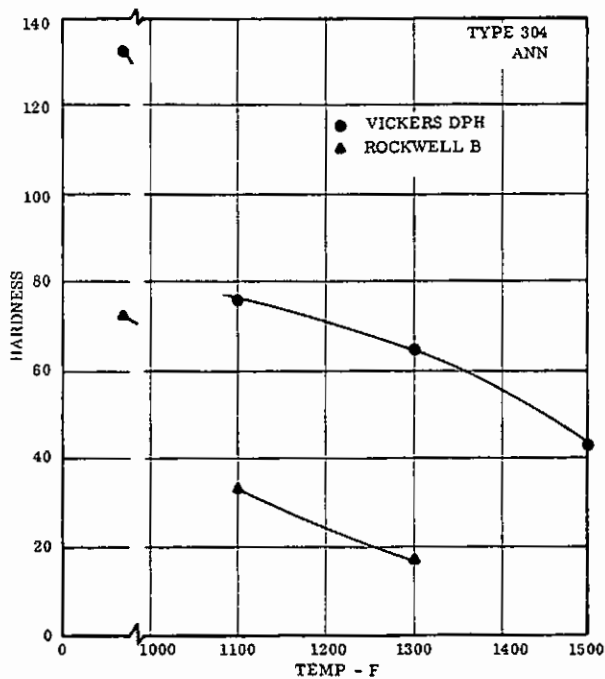


FIG 1.065 EFFECT OF TEST TEMPERATURE ON HOT HARDNESS (21)

Source	(27) (43)		
Form	Bar		
Condition	Annealed		
Test temp	-320F	F_{ty} - ksi	F_{tu} - ksi
Type 304	57	220	115(a)
Type 304L	98	220	125
(a) Ref. 27 (b) IE charpy V-notch			

TABLE 1.093 TYPICAL VALUES OF TENSILE AND TOUGHNESS PROPERTIES AT CRYOGENIC TEMPERATURES.

Low	Fe
19	C
10	Cr
	Ni

TYPES
304, 304L

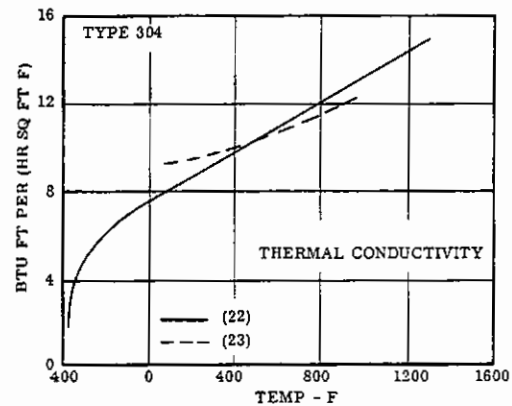


FIG 2.013 THERMAL CONDUCTIVITY (22)(23)

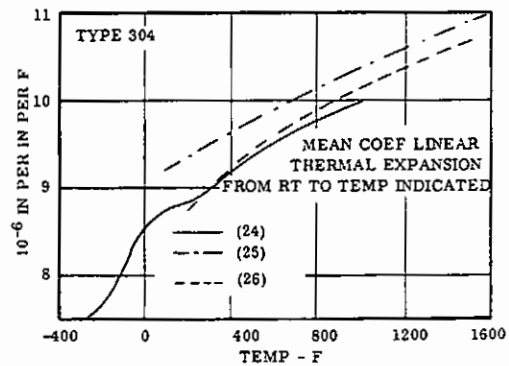


FIG 2.014 THERMAL EXPANSION (21, p. 22)(24)(25, p. 6)(26)

Fe
Low C
19 Cr
10 Ni
**TYPES
304, 304L**

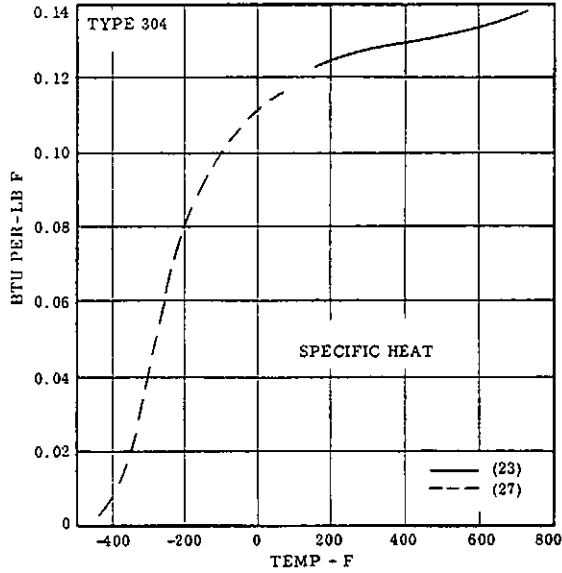


FIG 2. 015 SPECIFIC HEAT (23)(27)

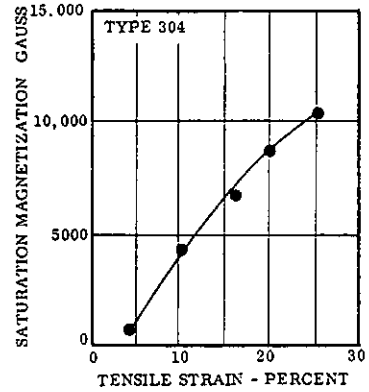


FIG 2. 0232 VARIATION IN THE SATURATION MAGNETIZATION AT ROOM TEMPERATURE AFTER TENSILE DEFORMATION IN LIQUID NITROGEN (28)

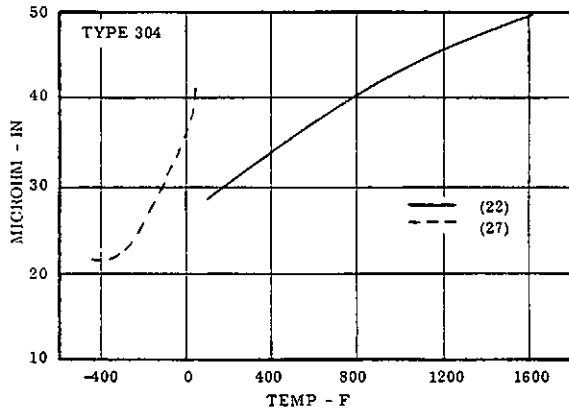


FIG 2. 022 ELECTRICAL RESISTIVITY (22)(27)

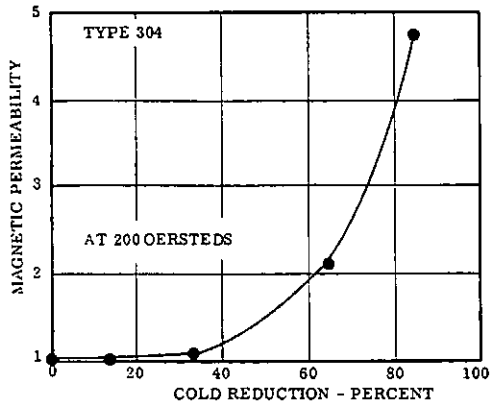


FIG 2. 0231 EFFECT OF COLD REDUCTION ON MAGNETIC PERMEABILITY (30)

Source		(31)
Form		0.015 Inch Sheet
Corrosion Medium		Nitric-Dichromate (after heat treatment)
Type	Heat Treatment	Corrosion Rate mg/cm ² /hr
304	1920F-2 hrs-WQ	6.2
	1920F-2 hrs-WQ, 1650F-2 hrs-WQ	1.9
	1920F-2 hrs, cooled to 1650F within 20 min, 1650F-2 hrs-WQ	6.2
	2370F-4 hrs, cool to 1110F at approx. 36F per min, 1110F-1 hr-WQ	6.1
	2370F-4 hrs, cool to 1650F at approx. 36F per min, 1650F-1 hr-WQ	6.1
304L	1920F-2 hrs-WQ	5.3
	1920F-2 hrs-WQ, 1650F-2 hrs-WQ	7.7
	1920F-2 hrs-WQ, 1470F-2 hrs-WQ	3.3
	1920F-2 hrs-WQ, 1110F-2 hrs-WQ	8.9

TABLE 2. 0312 INTERGRANULAR CORROSION IN TYPES 304 AND 304L WHEN SUBJECTED TO A NITRIC-DICHROMATE SOLUTION.

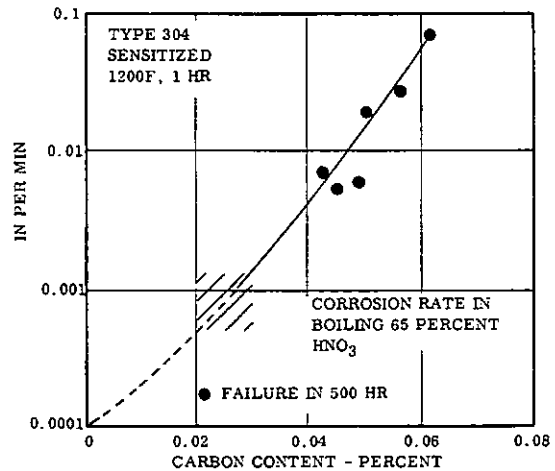


FIG 2. 0313 EFFECT OF CARBON CONTENT ON CORROSION RATE (25, p. 273)

REVISED : MARCH 1973

FERROUS ALLOYS

Source (32, p. 26)					
Alloy	Depth(a) ft.	Exposure time, days	Crevice attack, mils		Local Corrosion
			Water	Mud	
304	2,340	197	11	slight	Edge, tunnel
	5,300	1,064	21	29	None in water tunnel in mud
304L	2,340	197	8	18	Tunnel
	5,300	1,064	27, per- forated	0	Severe tunnel

(a) Oxygen level at 2,340 feet is 0.60 ppm; that at 5,300 feet is about 1.70 ppm.

TABLE 2.0314 CREVICE ATTACK IN QUIET SEA WATER

Source (35, p.141)					
Alloy Type 304					
Corrosion Environment 0.5N NaCl + 0.1N NaNO ₂ boiling solution					
Cold reduction percent	Final sheet thickness, in	F _{ty} (ksi)	F _{TU} (ksi)	Threshold stress (a) (ksi)	
0 (b)	0.031	40	91	26	
14.5(c)	0.027	85	113	66(d)	
26 (c)	0.023	114	143	93	
35 (c)	0.020	134	163	74	

(a) See Table 2.0319 for definition.
 (b) Values are average of two specimens.
 (c) Values are average of four specimens.
 (d) Approximate value.

Fe
 Low C
 19 Cr
 10 Ni
**TYPES
 304, 304L**

TABLE 2.03191 MECHANICAL PROPERTIES AND THRESHOLD STRESS VALUES.

Source (33, p.13)				
Alloy Type 304				
Form 0.063 inch sheet				
Condition	Avg. corrosion rate Mils per year (MPY)		Maximum Depth of attack (MILS)	
	111 days	1050 days	111 days	1050 days
Annealed	0	0.24	27	63(a)

(a) Localized penetration by corrosion

TABLE 2.0315 CORROSION RATE AND ATTACK DEPTH

Source (34, p.8)		
Alloy Type 304		
Form 0.047 in dia wire		
Testing Condition Boiling MgCl ₂ (42 percent-310 F) at 60,000 psi		
Heat Treatment	Specimen No.	Time of Test
A) Annealed in argon 1 hr. at 1832F	1	Failed after 6.5 hours
	2	Failed after 14.0 hours
	3	Failed after 9.3 hours
B) Treated as in (A) then annealed in hydrogen 3 hr at 1380 F	4	Failed after 5.0 hours
	5	Failed after 8.7 hours
C) Treated as in (A) then nitrided in 5 percent NH ₃ -H ₂ 3 hr at 1380 F	6	Failed after 6.5 hours
	7	Unbroken after 85 hours
	8	Unbroken after 95 hours
	9	Unbroken after 93 hours

TABLE 2.0318 NITRIDING SIGNIFICANTLY INCREASED THE RESISTANCE TO STRESS CORROSION CRACKING

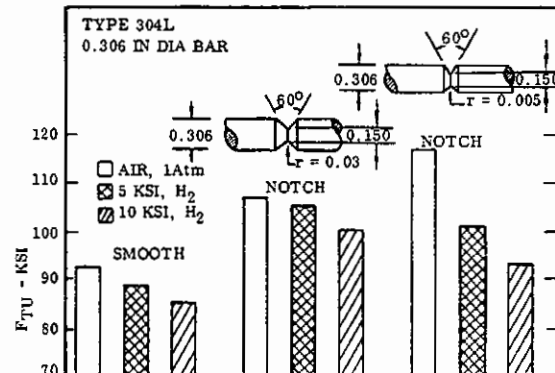


FIG 2.03211 ULTIMATE TENSILE AND NOTCH STRENGTH VERSUS HYDROGEN PRESSURE FOR TYPE 304L EXPOSED FOR 24HR AND THEN PULLED TO FRACTURE IN HIGH PRESSURE HYDROGEN (36, p244)

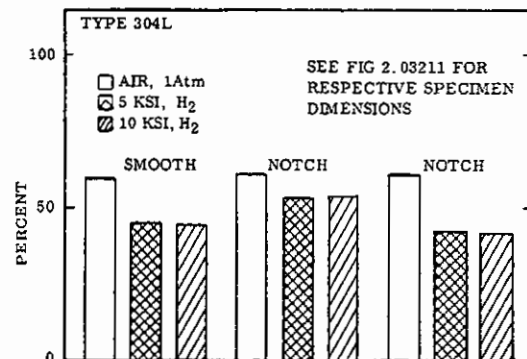


FIG 2.03212 PERCENT ELONGATION VERSUS HYDROGEN PRESSURE FOR TYPE 304L EXPOSED FOR 24HR AND THEN TESTED IN HIGH PRESSURE HYDROGEN (36, p244)

Source (35, p.141)					
Alloy Type 304					
Corrosion Environment 0.5N NaCl + 0.1N NaNO ₂ Boiling Solution					
Condition	Sheet Thickness in.	F _{ty} ksi	F _{TU} ksi	Threshold Stress (a)	
				ksi	Percent of F _{ty}
Cold rolled(b)	0.044	149	166	83	56
Cold rolled(b)	0.030	135	157	149	111
Annealed(b)	0.031	40	91	26	65(c)

(a) Threshold stress is the maximum stress that will not produce stress corrosion cracking or failure in 300 hrs.
 (b) As received condition, values average of two specimens.
 (c) Approximate value.

TABLE 2.0319 THRESHOLD STRESS DETERMINED IN 0.5N NaCl + 0.1N NaNO₂ BOILING SOLUTION FOR TYPE 304.

Fe
Low C
19 Cr
10 Ni
TYPES
304, 304L

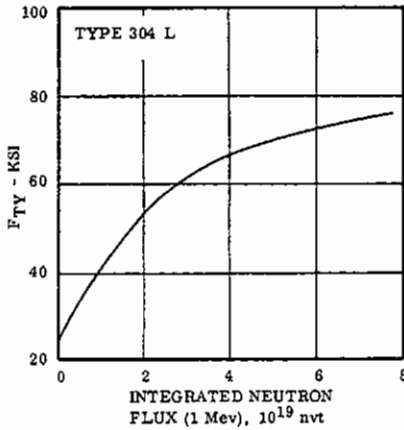


FIG 2.046 EFFECT OF IRRADIATION BELOW 100C (212F) ON YIELD STRENGTH (39)

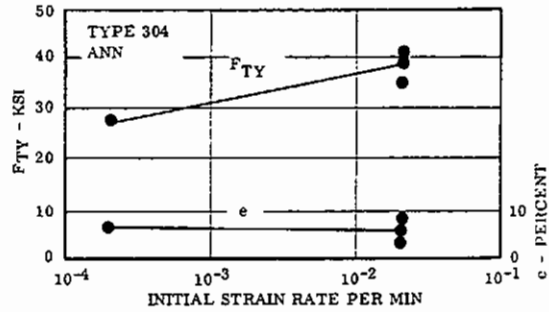


FIG 2.047 STRAIN RATE DEPENDENCE OF TENSILE PROPERTIES FOR TYPE 304 AT 1300F AFTER IRRADIATION TO 3.4×10^{22} NVT TOTAL (40, p10)

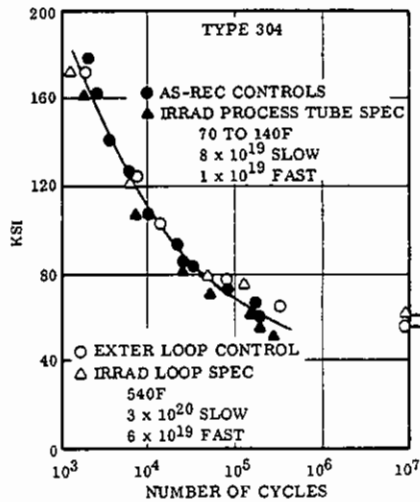


FIG. 2.048 S-N CURVE FOR IRRADIATED AND UNIRRADIATED SMOOTH SPECIMENS OF STAINLESS STEEL. (39)

Source	AMS (3)	AMS (8)		AMS(9)	AMS(1)	AMS(2)	AMS(10)	AMS (11)	
Alloy	Type 304 / Type 304L								
Form	Sheet, strip, plate	Bar	Tube	Wire	Castings, invest.	Castings, sand	Sheet, strip, plate	Bar	
Condition	ST	ST		ST	ST	ST	ST	ST	
Thickness - in	-	< 0.75	> 0.75	-	-	-	-	< 0.75	> 0.75
F _{tu} - min - ksi	-	-	-	90	-	-	-	-	-
F _{tu} - max - ksi	100	-	-	125	-	-	100	-	-
e(2 in)-min-percent	40	-	-	35	-	-	40	-	-
Hardness									
BHN-min	-	170	140	-	-	-	-	170	140
BHN-max	-	255	241	-	-	170	-	255	241
RB - min	-	-	-	-	-	-	-	-	-
RB - max	-	-	-	-	86	-	-	-	-

TABLE 3.011 AMS SPECIFIED MECHANICAL PROPERTIES

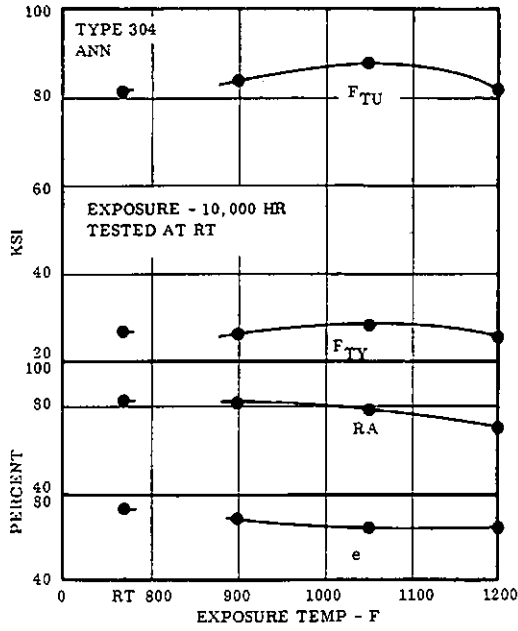


FIG 3.0216 EFFECT OF EXPOSURE OF 10,000 HOURS TO ELEVATED TEMPERATURES ON TENSILE PROPERTIES OF ANNEALED ALLOY (17)

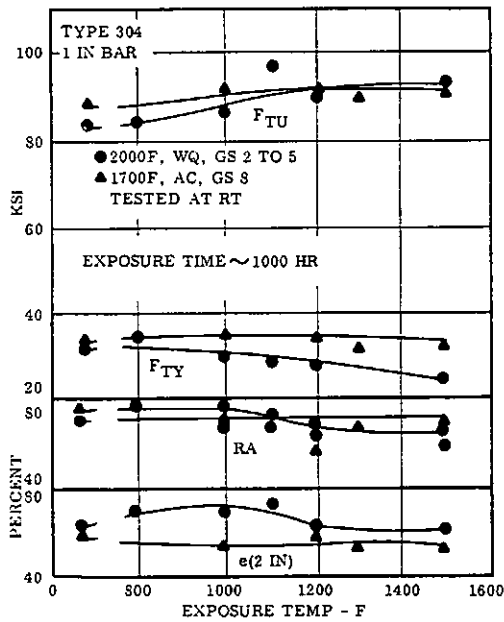


FIG. 3.0217 EFFECT OF ANNEALING TEMPERATURE AND EXPOSURE TO ELEVATED TEMPERATURES ON TENSILE PROPERTIES OF BAR. (26)

	Fe
Low	C
19	Cr
10	Ni

TYPES 304, 304L

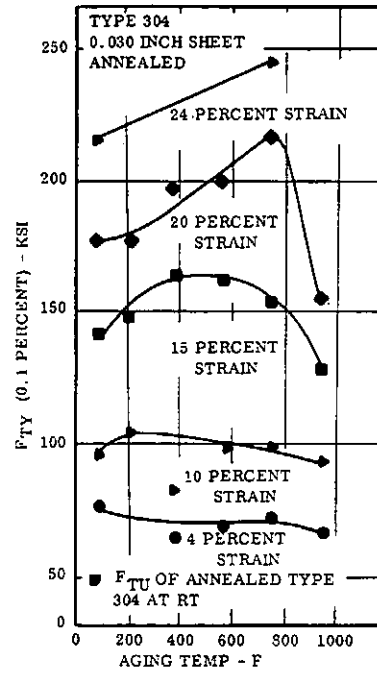


FIG 3.0218 YIELD STRENGTH OF TYPE 304 AT ROOM TEMPERATURE AFTER AGING 1 1/2 HOURS AT THE TEMPERATURES SHOWN FOLLOWING TENSILE DEFORMATION AT -319F. (29, p 1588)

NOTE: ALL SPECIMENS STRAINED 10 AND 20 PERCENT (EXCEPT 932F SPECIMEN FOR 20 PERCENT STRAIN) BROKE OUTSIDE OF 2 INCH GAGE MARKS. THIS APPLIES FOR THE TENSILE DATA IN FIGS. 3.0218 AND 3.0219, AND ACCOUNTS FOR THE ABSENCE OF 10 AND 20 PERCENT ELONG. CURVES IN FIG. 3.02110.

Fe
Low C
19 Cr
10 Ni

**TYPES
304, 304L**

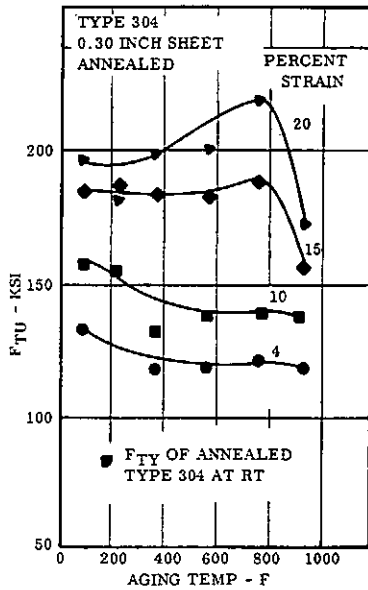


FIG 3.0219 ULTIMATE TENSILE STRENGTH OF TYPE 304 AT ROOM TEMPERATURE AFTER AGING 1 1/2 HOURS AT THE TEMPERATURES SHOWN FOLLOWING TENSILE DEFORMATION AT -319F. (29, p 1588) SEE NOTE ON FIG 3.0218

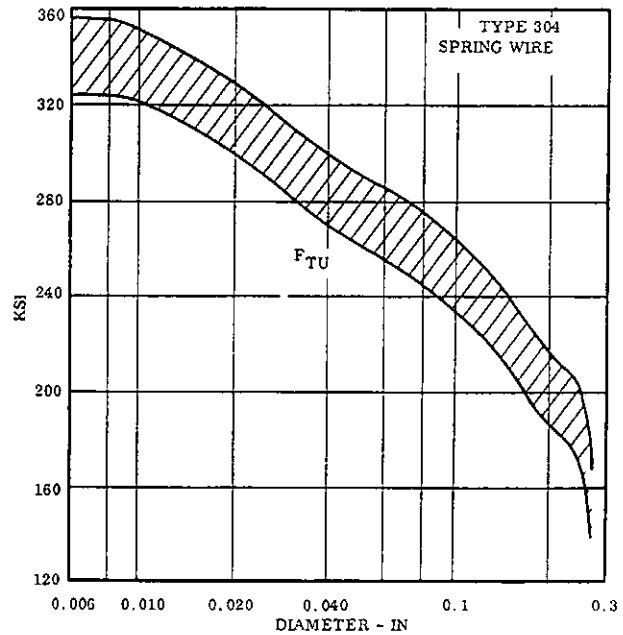


FIG 3.02111 AISI TENSILE STRENGTH RANGE FOR VARIOUS SIZES OF SPRING WIRE (12)

Source	(12)	
Alloy	Type 304	
Form	Plate, bar	Bar
Condition	Ann	CD to high tensile strength
Thickness - in	-	1-1/2
Impact Strength Izod-ft-lb	110	90

TABLE 3.0231 TYPICAL IMPACT PROPERTIES OF ANNEALED PLATE AND COLD DRAWN BAR.

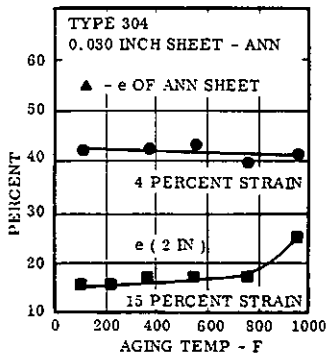


FIG 3.02110 ELONGATION OF TYPE 304 AT ROOM TEMPERATURE AFTER AGING 1 1/2 HOURS AT THE TEMPERATURES SHOWN FOLLOWING TENSILE DEFORMATION AT -319F. (29, p1588) SEE NOTE ON FIG 3.0218

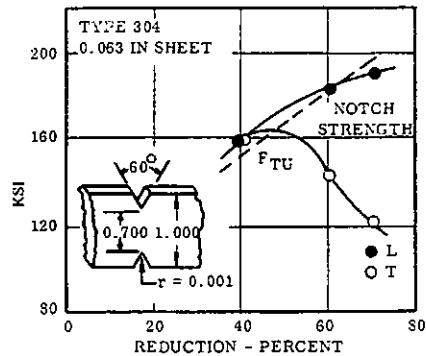


FIG 3.02711 EFFECT OF COLD ROLLING AND TEST DIRECTION ON NOTCH STRENGTH OF SHEET (42)

REVISED : MARCH 1973

FERROUS ALLOYS

Low	Fe
19	C
10	Cr
	Ni

TYPES
304, 304L

Source	AMS (4)(5)(7)						AMS (6)		AMS (8)	AMS (11)
Alloy	Type 304									
Form	Tubing, seamless or welded						Tubing, hydraulic		Tubing, mechanical	
Condition	ST						CD		ST	
Outside dia - in	≤ 0.188		> 0.188 to 0.500		> 0.500		0.188	≥ 0.250	-	-
Wall thickness-in	≤ 0.016	> 0.016	≤ 0.010	> 0.010	≤ 0.010(a)	> 0.010	≥ 0.016	All	-	-
F _{tu} - min - ksi	-	-	-	-	-	-	95	105	-	-
F _{tu} - max - ksi	115	100	110	100	100	100	130	140	-	-
F _{ty} - min - ksi	30(b)(c)	30(b)	-	30(b)	-	30(b)	60	75	-	-
F _{ty} - max - ksi	-	-	-	-	-	-	90	110	-	-
e(2in)-min-percent	-	-	-	-	-	-	-	-	-	-
Tube	35	40	37	40	32	35(d)	25	20	-	-
Strip	-	-	32(a)	35(a)	27	30(e)	-	-	-	-
Hardness	-	-	-	-	-	-	-	-	-	-
RB-min	-	-	-	-	-	-	-	-	-	75
max	-	-	-	-	-	-	-	-	≤ 90	90

(a) AMS 5567 not included.
 (b) AMS 5567 only.
 (c) Tubes having a wall thickness 0.010 inch and under, the yield strength need not to be determined.
 (d) 40 ksi for AMS 5567.
 (e) 35 ksi for AMS 5567.

TABLE 3.012 AMS SPECIFIED MECHANICAL PROPERTIES FOR TUBING

Source	(16)				(12)									
Alloy	Type 304													
Form	Sheet(a)		Sheet, strip	Plate, bar	Bar			Wire				Sheet Strip	Ann	
Condition	Ann		Ann	Ann	Ann + CD	CD to high tensile	Ann	Soft temper	Hard temper	Spring temper	Ann	Ann		
Thickness - in	< 0.118	> 0.118	-	-	1	7/8	1-1.2	0.062 to 0.500				0.062 to 0.307	-	-
F _{tu} - ksi	78	78	85	85	100	125	110	105 to 90	125 to 100	160 to 140	260 to 170	75	75	
F _{ty} - ksi	29	26	35	30	60	95	75	35	90 to 60	125 to 105	-	28	28	
e (2 in) - percent	-	-	50	60	45	25	60	55 to 60	40 to 45	20 to 25	-	50	50	
RA - percent	55	55	-	70	-	-	-	65	65	55	-	-	-	
Hardness	-	-	-	150	212	277	240	-	-	-	-	-	140	
BHN	-	-	-	-	-	-	-	83	95	-	-	70	-	
RB	90	90	80	-	-	-	-	-	-	33	-	-	-	
RC	-	-	-	-	-	-	-	-	-	-	-	-	-	
Impact strength izod ft-lb	-	90 max	-	110	-	-	90	-	-	-	-	-	-	

(a) Minimum values

TABLE 3.0212 TYPICAL TENSILE PROPERTIES FOR VARIOUS FORMS AND CONDITIONS OF ALLOYS.

	Fe
Low	C
19	Cr
10	Ni

TYPES
304, 304L

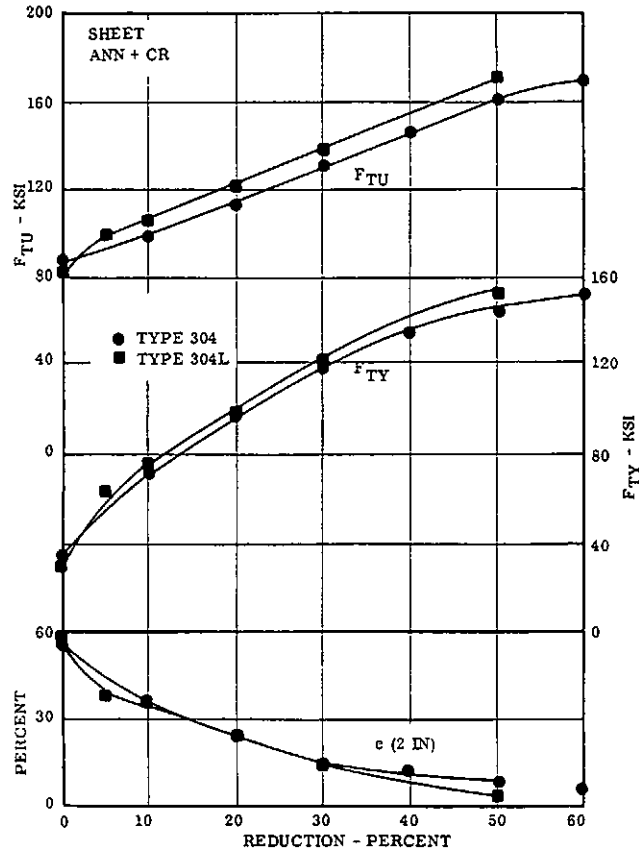


FIG 3.0213 EFFECT OF COLD ROLLING ON TENSILE PROPERTIES OF TYPES 304 AND 304L SHEET (41)

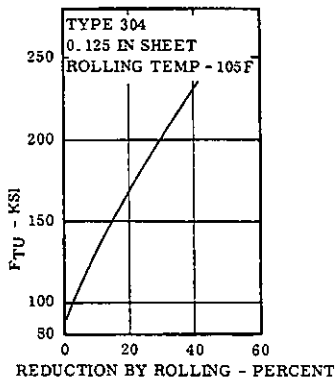


FIG. 3.0214 EFFECT OF COLD ROLLING AT -105F ON TENSILE STRENGTH OF SHEET. (47)

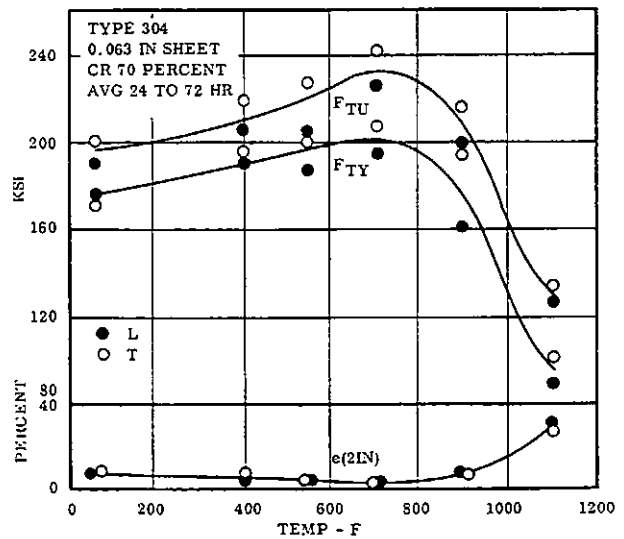


FIG 3.0215 EFFECT OF EXPOSURE TO ELEVATED TEMPERATURES ON TENSILE PROPERTIES OF COLD ROLLED SHEET (42)

FERROUS ALLOYS

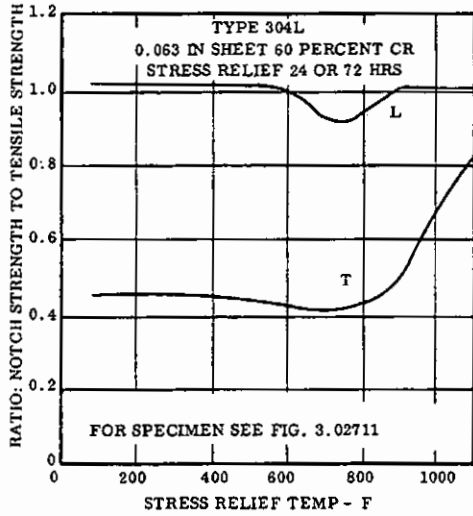


FIG. 3.02712 EFFECT OF STRESS RELIEF TEMPERATURE ON SHARP NOTCH STRENGTH RATIO FOR COLD ROLLED 304L SHEET. (73, fig. 14)

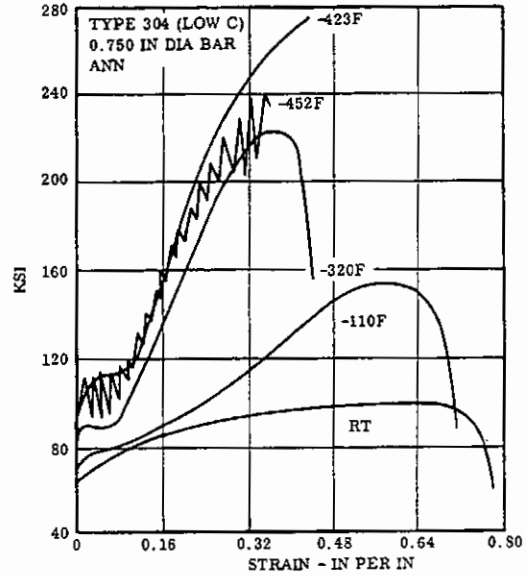


FIG 3.03113 STRESS - STRAIN CURVES AT ROOM AND LOW TEMPERATURES (44)

Fe
Low C
19 Cr
10 Ni

TYPES
304, 304L

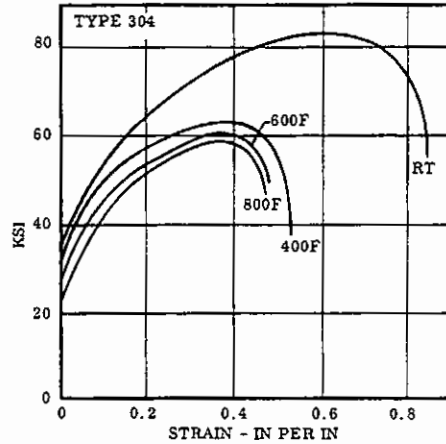


FIG 3.03111 STRESS - STRAIN CURVES TO FAILURE AT ROOM AND ELEVATED TEMPERATURES (23)

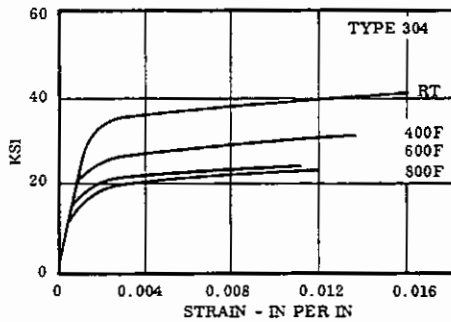


FIG 3.03112 STRESS - STRAIN CURVES AT ROOM AND ELEVATED TEMPERATURES (23)

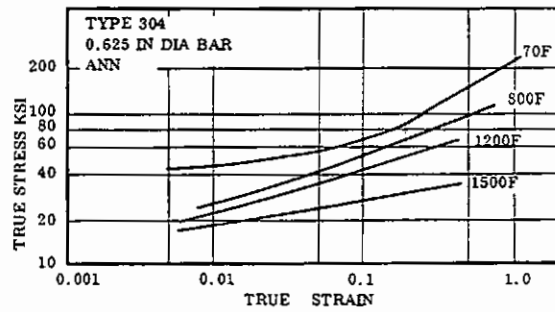


FIG 3.03114 TRUE STRESS - STRAIN CURVES AT ROOM AND ELEVATED TEMPERATURES (45)

Fe	
Low C	
19 Cr	
10 Ni	
TYPES 304, 304L	

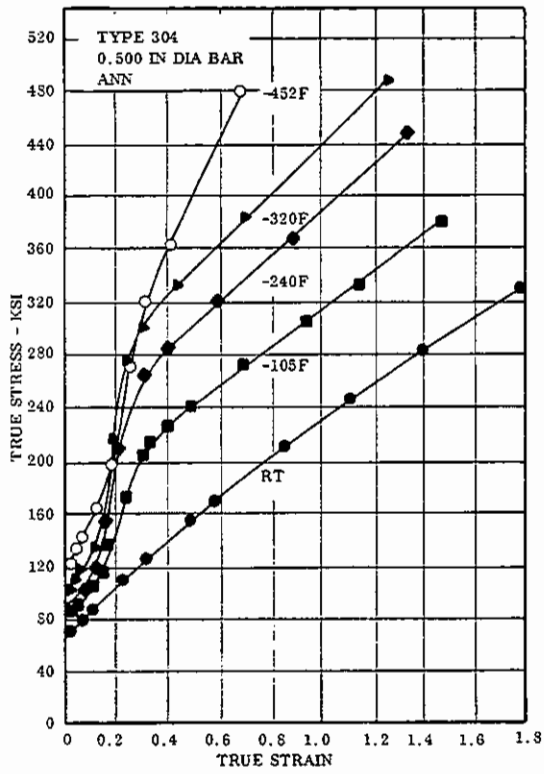


FIG 3.03115 TRUE STRESS - STRAIN CURVES AT ROOM AND LOW TEMPERATURES (46)

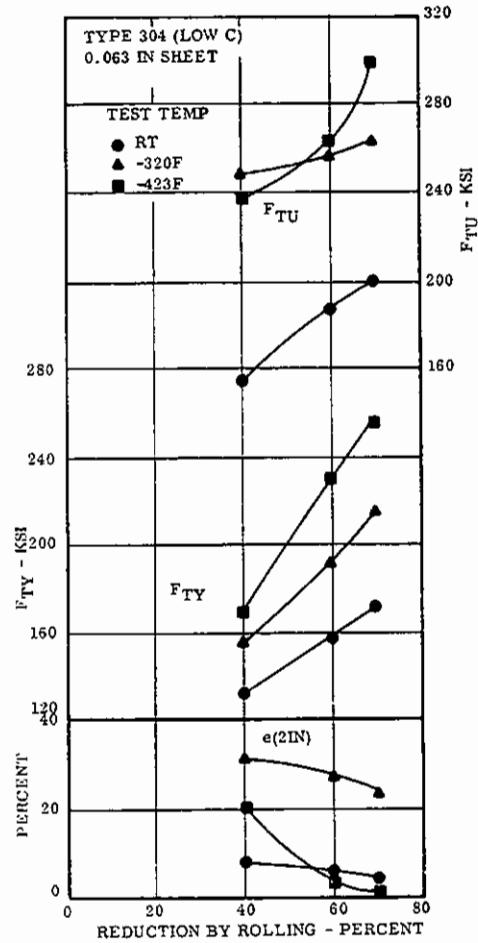


FIG 3.03121 EFFECT OF COLD ROLLING ON TENSILE PROPERTIES OF SHEET AT ROOM AND LOW TEMPERATURES (48)

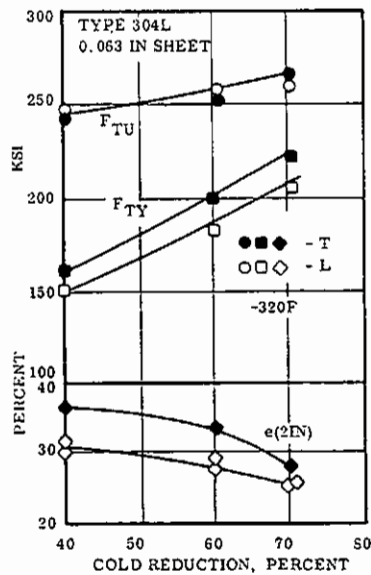


FIG 3.03122 EFFECT OF COLD REDUCTION ON -320F TENSILE PROPERTIES OF 304L SHEET (73)

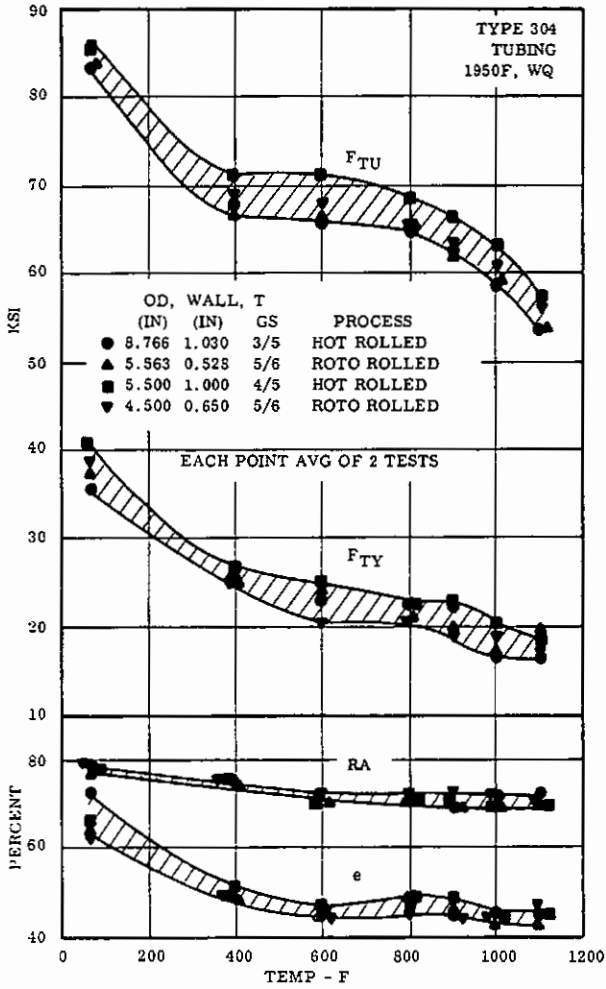


FIG 3.03131 EFFECT OF ELEVATED TEST TEMPERATURE ON TENSILE PROPERTIES OF ROLLED TUBING (49)

Fe
Low C
19 Cr
10 Ni

TYPES 304, 304L

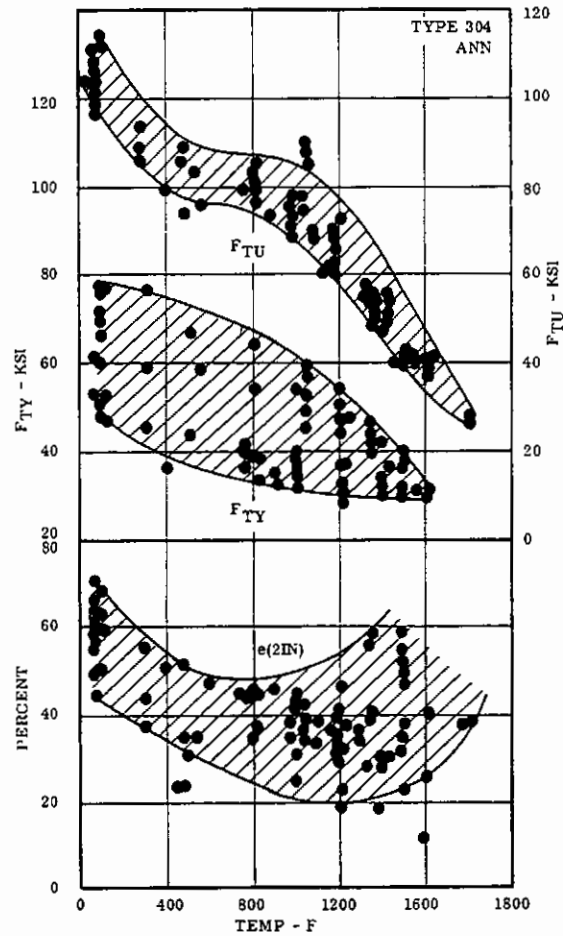


FIG 3.03132 RANGE OF TENSILE PROPERTY VALUES AT ELEVATED TEMPERATURES FOR ANNEALED ALLOY (50)

Fe
Low C
19 Cr
10 Ni

TYPES
304, 304L

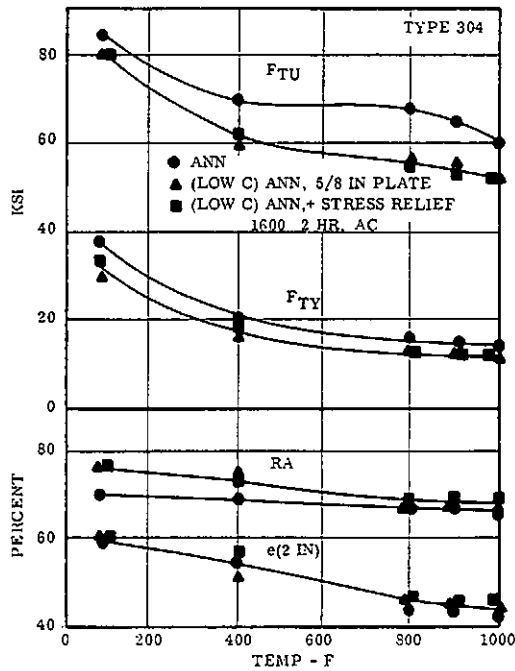


FIG 3.03133 EFFECT OF ELEVATED TEST TEMPERATURE ON ALLOY (51)

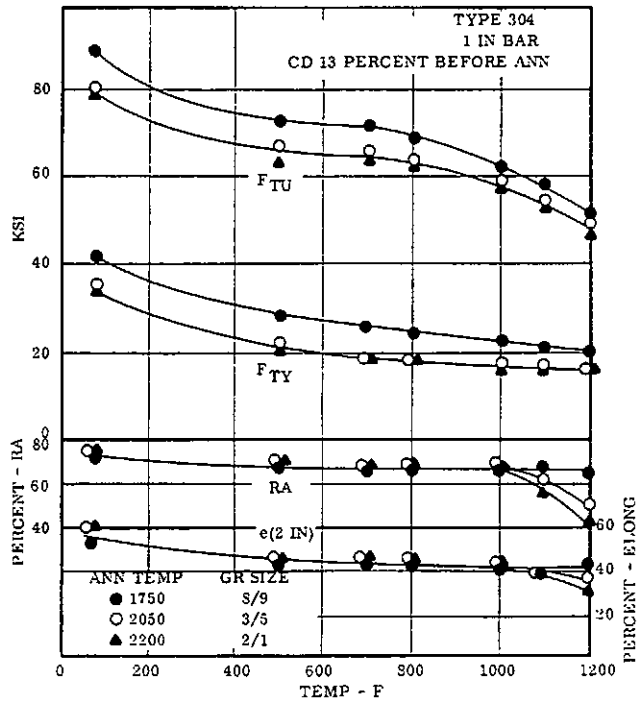


FIG 3.03135 EFFECT OF ANNEALING AND TEST TEMPERATURE ON TENSILE PROPERTIES OF COLD DRAWN BAR (53)

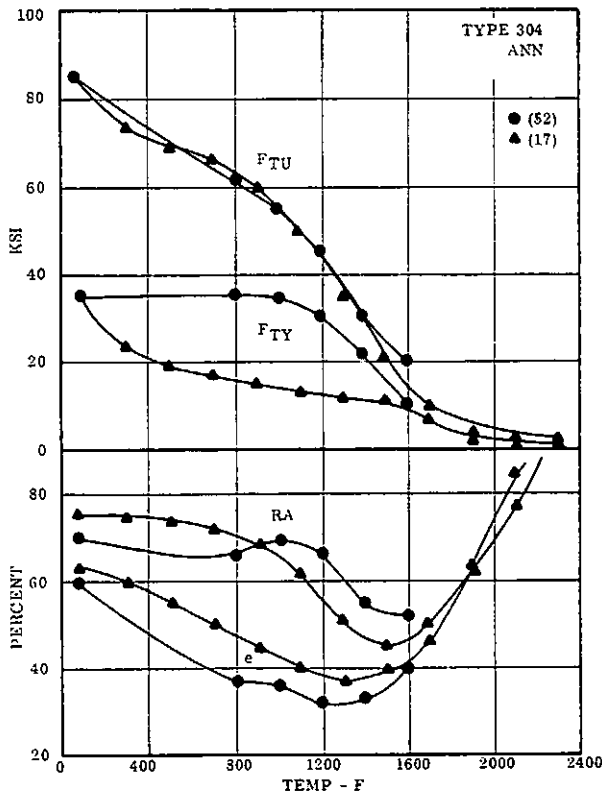


FIG 3.03134 EFFECT OF ELEVATED TEST TEMPERATURE ON ANNEALED ALLOY (17)(52)

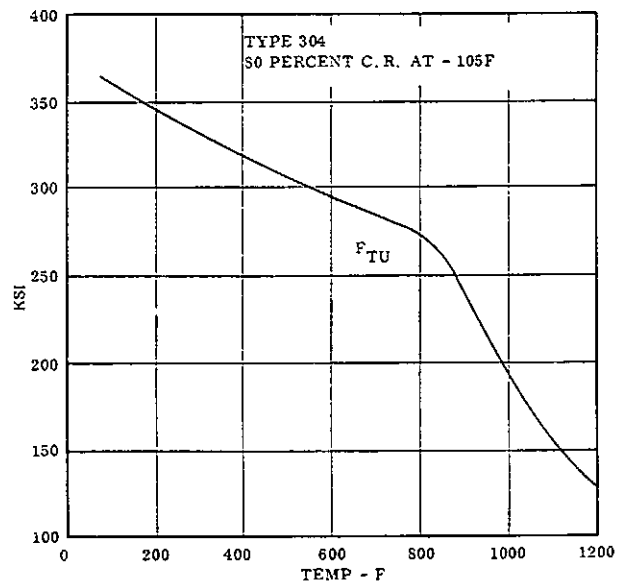


FIG. 3.03136 EFFECT OF ELEVATED TEMPERATURES ON ZEROLLED 304 STAINLESS. (54)

REVISED : MARCH 1973

FERROUS ALLOYS

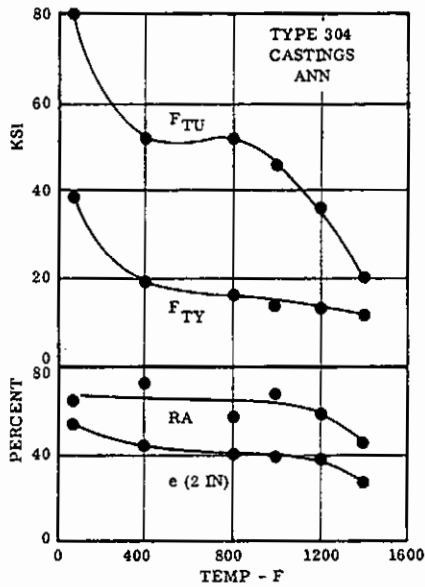


FIG. 3.03137 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF CASTINGS (55)

Source (43)				
Form 3 in sq bar (a)				
Condition Annealed 1975 F - 1 hr - WQ(a)				
Type	304(b)		304N(c)	
Test Temp F	F _{ty} - ksi	F _{tu} - ksi	F _{ty} - ksi	F _{tu} - ksi
RT	31.0 - 34.5	80.5 - 86.0	40.1 - 43.3	86.7 - 90.7
200	28.5 - 33.1	69.1 - 72.1	33.2 - 34.4	77.6 - 80.1
400	23.5 - 28.0	61.9 - 65.0	26.2 - 28.4	69.4 - 73.0
600	21.0 - 24.1	61.0 - 64.5	22.4 - 24.5	66.5 - 71.0
800	18.5 - 22.1	59.0 - 64.0	21.0 - 24.6	66.0 - 68.8
1000	18.1 - 19.7	54.2 - 64.1	19.6 - 20.2	60.2 - 63.8
1200	17.5 - 18.1	42.8 - 51.1	17.9 - 18.9	51.6 - 54.5

(a) Specimens annealed in blank form and finish machined to 0.250 in dia tension bars.
 (b) Range of strength values for a nitrogen range of 0.004 - 0.006 percent.
 (c) Range of strength values for a nitrogen range of 0.12 - 0.16 percent.

TABLE 3.03138 COMPARISON OF STRENGTH PROPERTIES OF TYPES 304 AND 304N AT ROOM AND ELEVATED TEMPERATURES.

Low	Fe
19	C
10	Cr
	Ni

TYPES 304, 304L

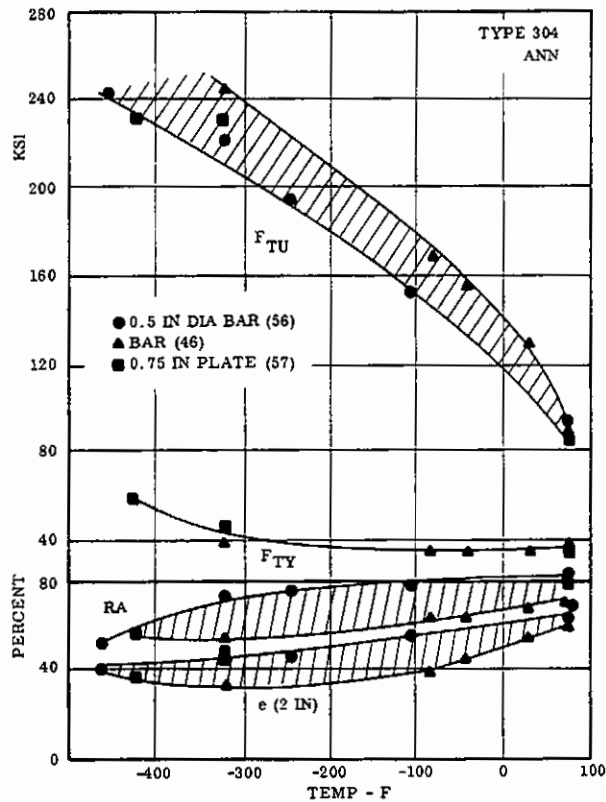


FIG 3.03141 EFFECT OF LOW TEST TEMPERATURE ON TENSILE PROPERTIES OF ANNEALED ALLOY (46)(56)(57)

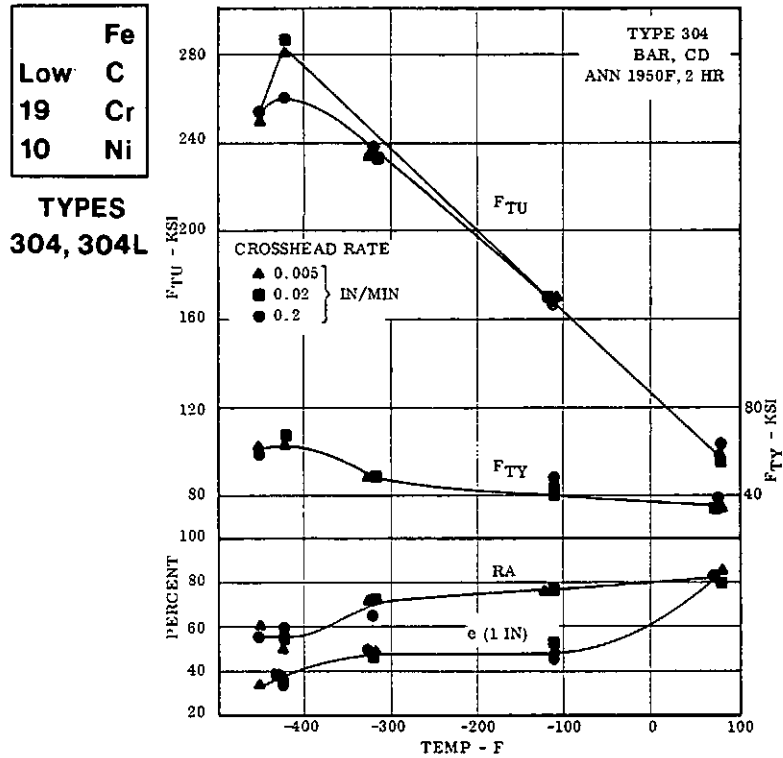


FIG 3.03142 EFFECT OF LOW TEST TEMPERATURE AND STRAIN RATE ON TENSILE PROPERTIES OF COLD DRAWN BAR (58)

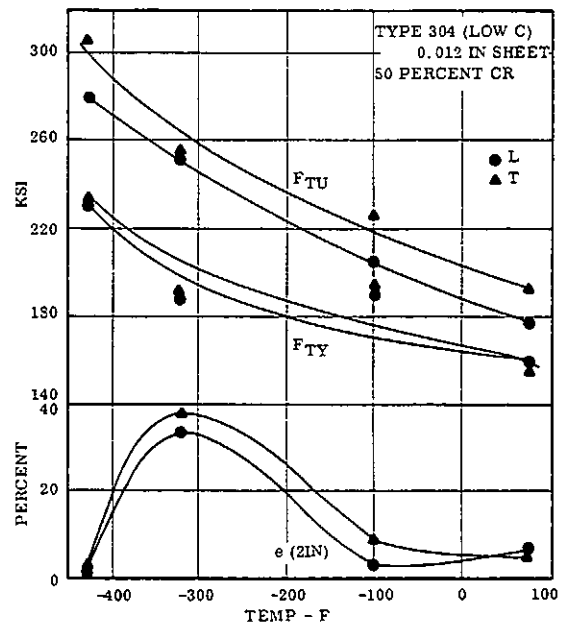


FIG 3.03143 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF COLD ROLLED SHEET (59)

FERROUS ALLOYS

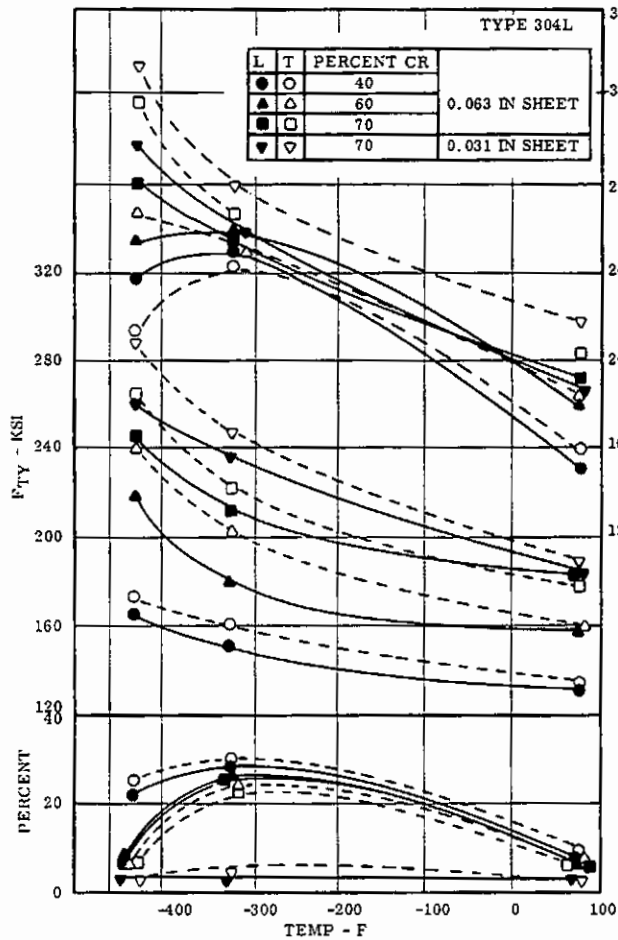
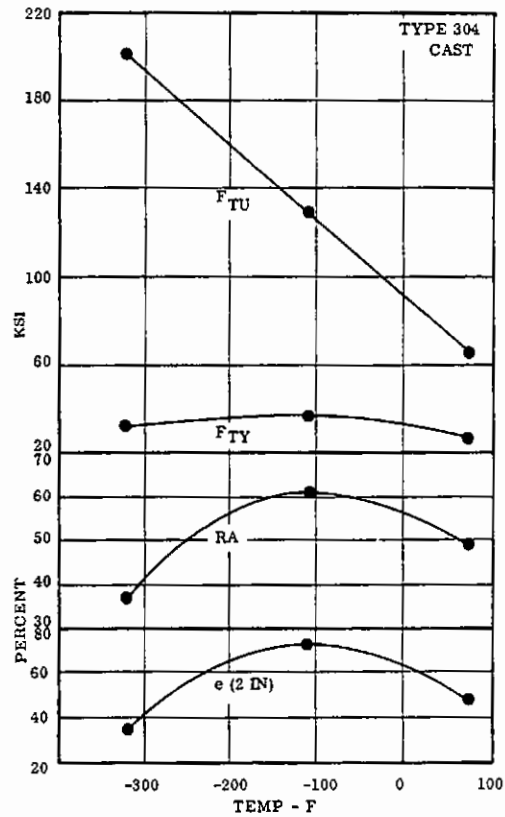


FIG 3.03144 EFFECT OF LOW TEST TEMPERATURE AND PERCENT COLD REDUCTION ON TENSILE PROPERTIES OF SHEET (48)



Fe
Low C
19 Cr
10 Ni
TYPES 304, 304L

FIG 3.03146 EFFECT OF LOW TEMPERATURES ON TENSILE PROPERTIES OF 304 CAST STAINLESS STEEL (60)

Source	(43)				
Alloy	304N				
Form	3 in sq. bar (a)				
Condition	Annealed - 1975 F - 1 hr - WQ(a)				
Nitrogen Content wt. percent	Test Temp F	F _{ty} ksi	F _{tu} ksi	e (1 in) percent	RA percent
0.12	80	40.1	86.7	57	76
	-100	63.4	147.1	66	75
	-320	94.2	220.8	49	66
0.13	80	40.8	87.9	55	75
	-100	64.4	150.8	64	75
	-320	95.6	227.8	47	64
0.14	80	43.3	87.6	57	78
	-100	66.2	144.0	71	77
	-320	100.0	223.0	50	66
0.16	80	43.6	90.7	51	75
	-100	66.6	145.4	66	75
	-320	101.5	225.8	47	63

(a) Specimens annealed in blank form and finish machined to 0.250 in dia tension bars.
Data are the average of two tests.

TABLE 3.03145 EFFECT OF NITROGEN CONTENT AND TEST TEMPERATURE (+80 to -320F) ON THE TENSILE PROPERTIES OF TYPE 304N.

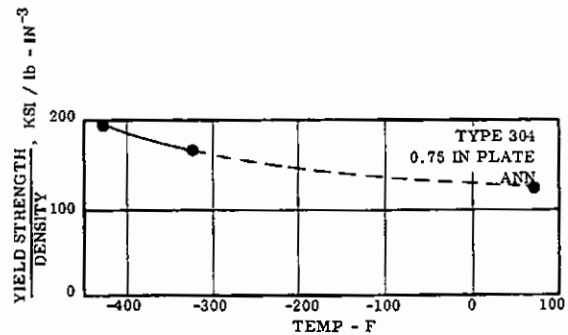


FIG 3.03147 EFFECT OF LOW TEMPERATURE ON THE YIELD STRENGTH - DENSITY RATIO (57)

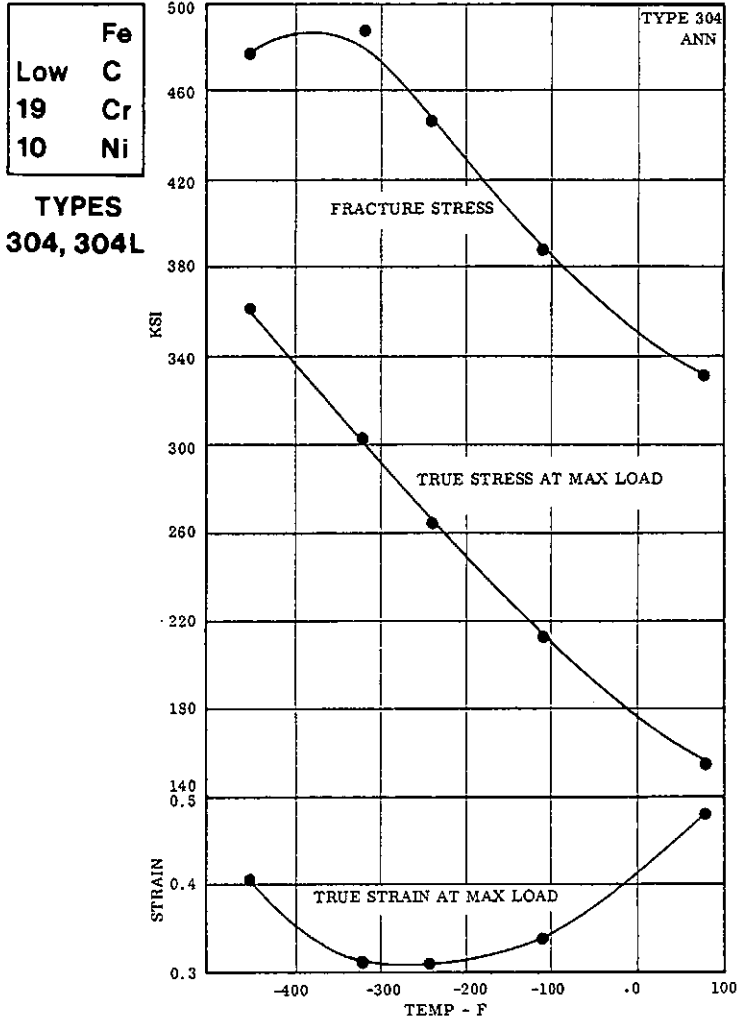


FIG 3.03148 EFFECT OF LOW TEST TEMPERATURE ON TRUE TENSILE PROPERTIES OF ALLOY (46)

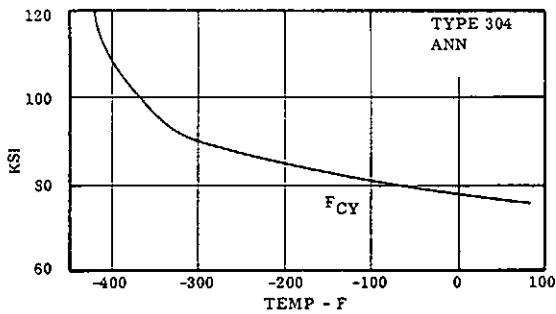


FIG 3.0322 EFFECT OF LOW TEMPERATURE ON COMPRESSIVE YIELD STRENGTH OF ALLOY (44)

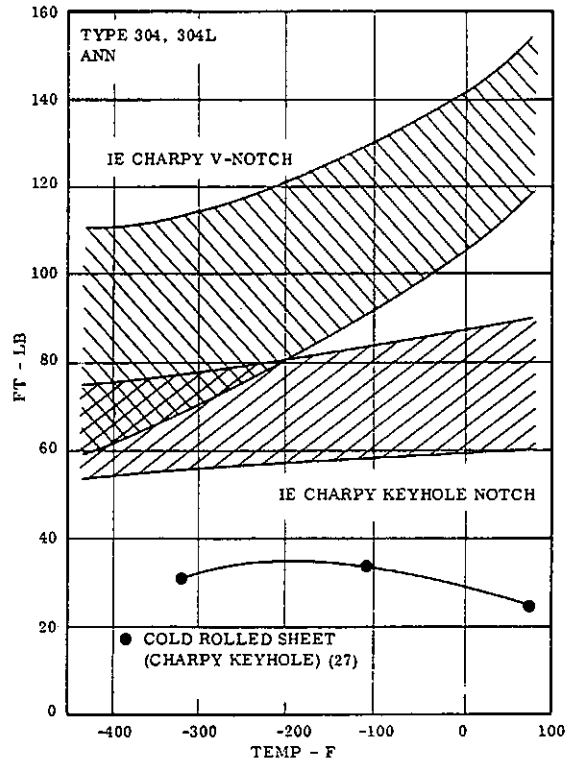


FIG 3.0331 PROBABLE RANGE OF CHARPY IMPACT PROPERTIES OF ANNEALED TYPES 304 AND 304L STAINLESS STEELS (27)(51)

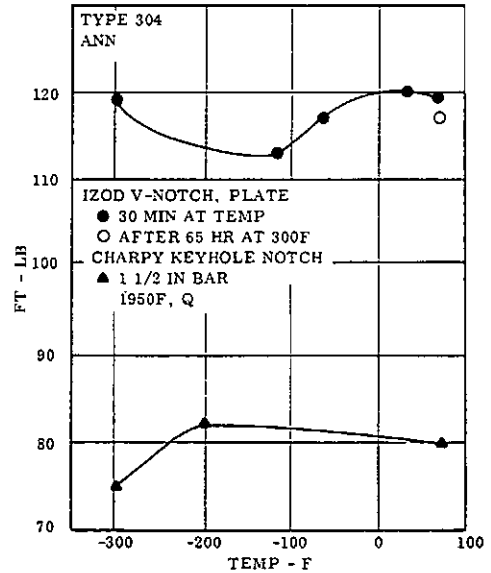


FIG 3.0332 EFFECT OF LOW TEMPERATURE ON IMPACT PROPERTIES OF ANNEALED PLATE AND BAR (61)

REVISED : MARCH 1973

FERROUS ALLOYS

Source	(62)	
Alloy	304	
Form	Plate	
Condition	Annealed	
Exposure time to test temp.	Test temp - F	Charpy keyhole notch impact strength - ft-lb
0	-320	85
30 min	-320	72
6 mo	-320	73
12 mo	-320	75

TABLE 3.0333 LOW TEMPERATURE IMPACT PROPERTIES OF TYPE 304 AS A FUNCTION OF EXPOSURE TIME

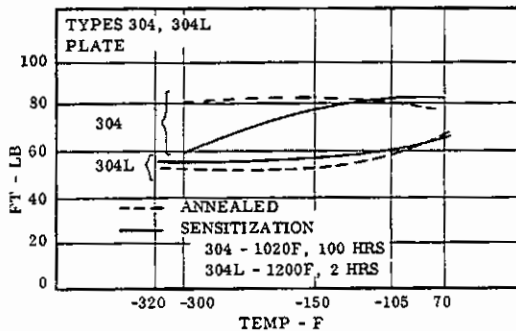


FIG. 3.0334 EFFECT OF SENSITIZATION HEAT TREATMENT ON CHARPY KEYHOLE IMPACT PROPERTIES OF TYPES 304 AND 304L. (62)

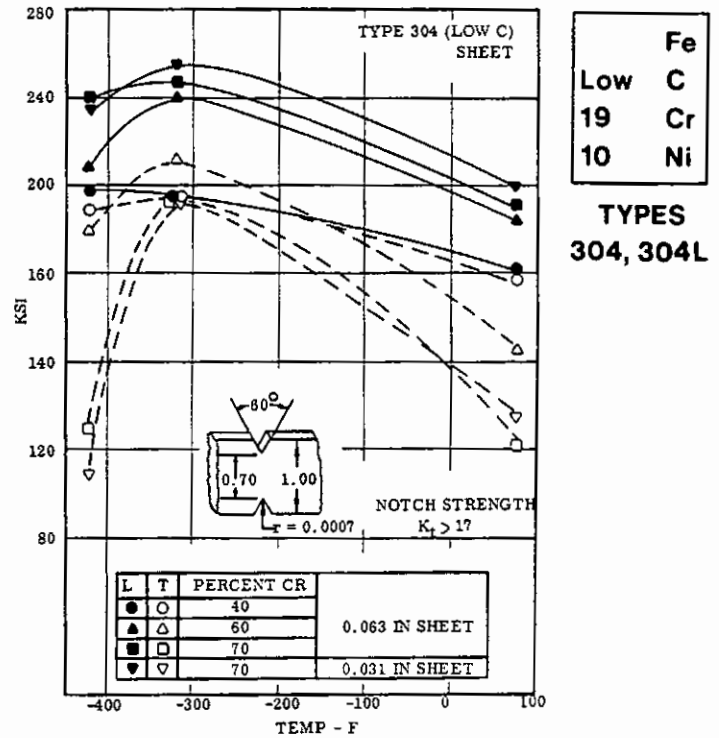


FIG 3.03711 EFFECT OF LOW TEMPERATURES ON NOTCH STRENGTH OF COLD ROLLED SHEET (48)

Source	(43)		
Alloy	304N		
Form	3 in sq bar (a)		
Condition	Annealed 1975 F - 1 hr - WQ(a)		
Nitrogen Content wt. percent	Test Temp	Charpy V-notch Impact Energy ft-lb	
	F	Longitudinal	Transverse
0.12	80	240(b)	105
	-100	240(b)	82
	-320	141	66
0.13	80	240(b)	90
	-100	240(b)	71
	-320	152	61
0.14	80	240(b)	55
	-100	230	62
	-320	125	52
0.16	80	240(b)	102
	-100	240(b)	80
	-320	158	58

(a) Specimens annealed in blank form and finish machined to standard 0.394 Charpy V-notch impact bars.
 (b) Specimens did not break.
 Data are average of two tests

TABLE 3.0335 EFFECT OF NITROGEN CONTENT AND TEST TEMPERATURE ON THE CHARPY V-NOTCH IMPACT PROPERTIES OF TYPE 304N.

Source	(62)		
Form	0.012 in sheet		
Condition	50 percent CR		
Type	304L		
Test Temp (F)	F _y (ksi)	F _{tu} (ksi)	Notch F _{tu} (a) (ksi)
78	158	176	192
-100	186	198	217
-320	187	251	262
-423	231	279	304

TABLE 3.03712 EFFECT OF LOW TEMPERATURE ON THE NOTCH AND TENSILE STRENGTH OF COLD ROLLED SHEET.

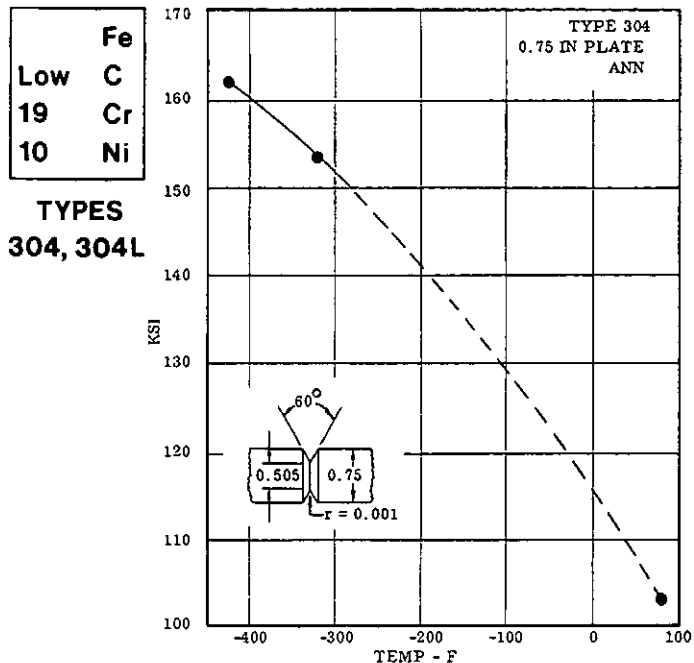


FIG 3.03713 EFFECT OF TEST TEMPERATURE ON NOTCH STRENGTH OF ANNEALED PLATE (57)

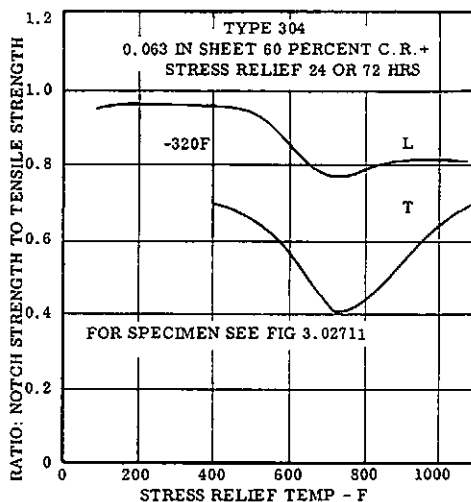


FIG 3.03715 EFFECT OF STRESS RELIEF TEMPERATURE ON SHARP NOTCH STRENGTH RATIO AT -320F FOR COLD ROLLED 304L SHEET (73, fig 14)

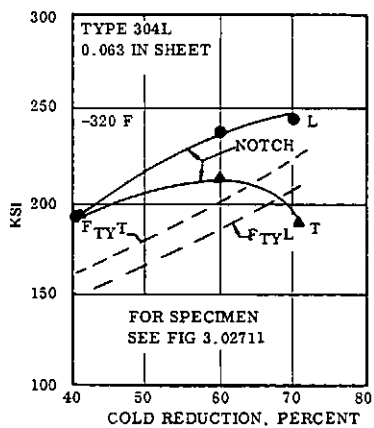


FIG 3.03714 EFFECT OF COLD REDUCTION ON -320F SHARP NOTCH STRENGTH OF 304L SHEET (73) FIG 3

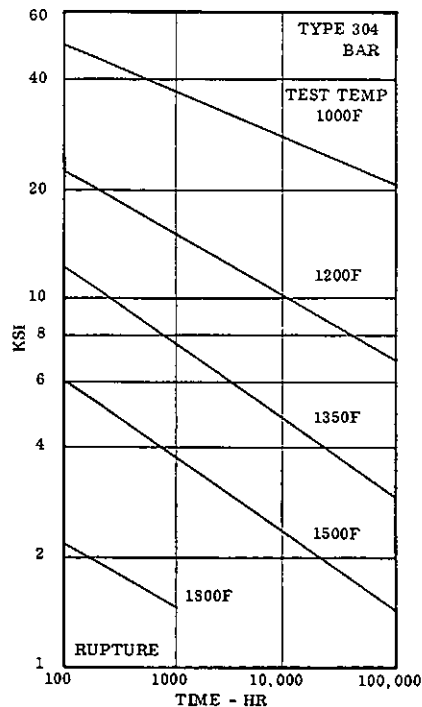


FIG 3.041 CREEP RUPTURE CURVES FOR BAR AT 1000F TO 1800F (64)

FERROUS ALLOYS

	Fe
Low	C
19	Cr
10	Ni

TYPES
304, 304L

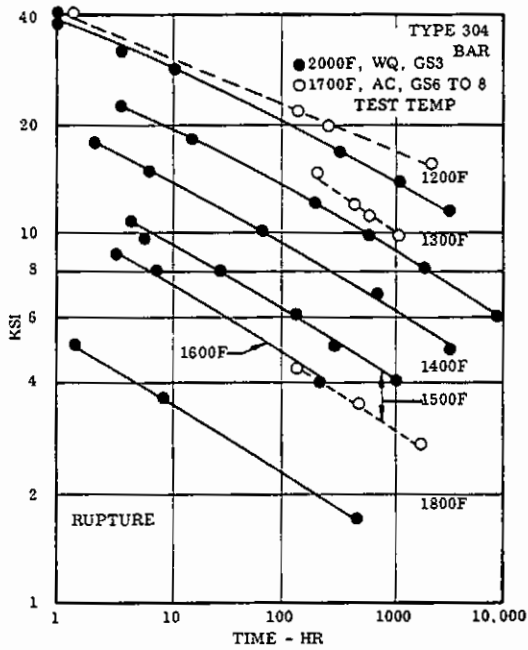


FIG 3.042 CREEP RUPTURE CURVES FOR BAR AT 1200 TO 1800F (26)

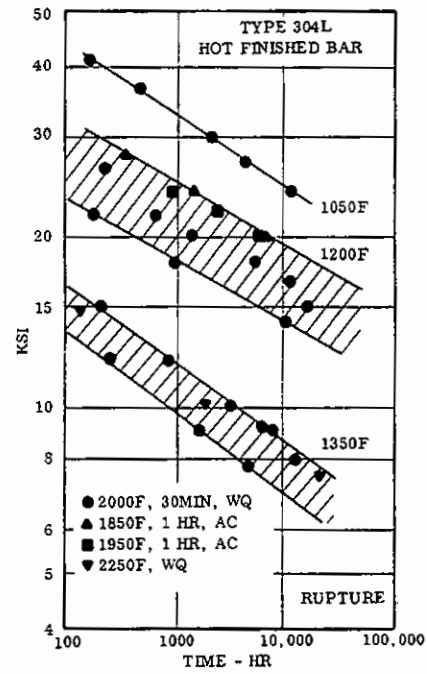


FIG 3.044 CREEP RUPTURE CURVES FOR BAR AT 1050F TO 1350F (65)

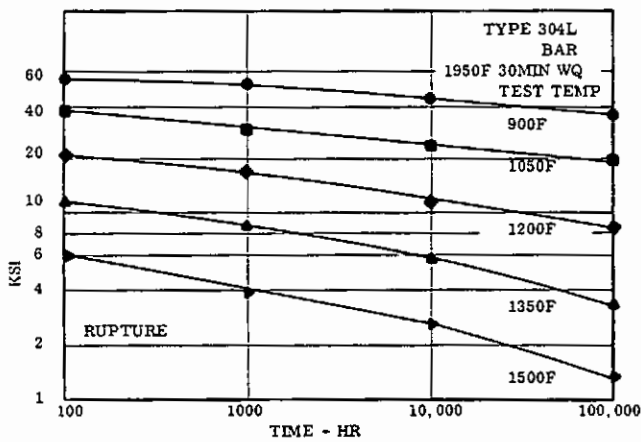


FIG 3.043 CREEP RUPTURE CURVES FOR BAR AT 900 TO 1500F (64)

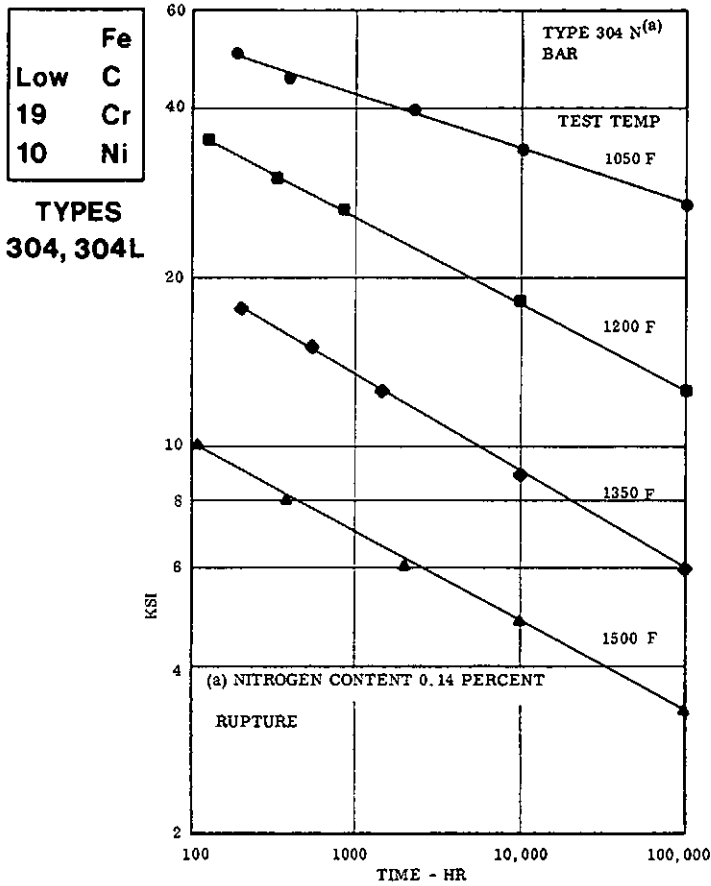


FIG 3.045 CREEP RUPTURE CURVES FOR TYPE 304N BAR AT 1050 TO 1500F (66)

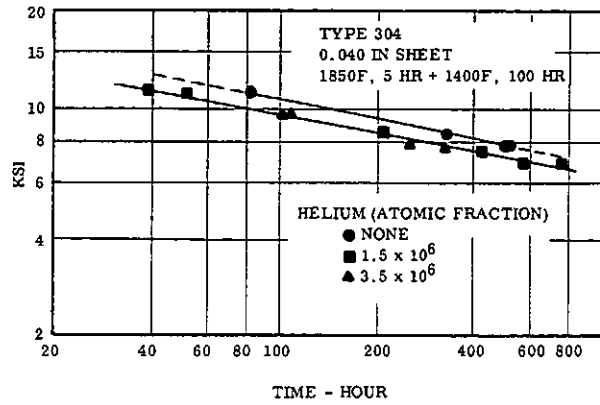


FIG. 3.047 EFFECT OF HELIUM ON CREEP RUPTURE OF SHEET TESTED IN VACUUM AT 1400F. (67)

Source	(66)			
Form	Bar			
Type	304		304N(a)	
Test Temp (F)	Rupture stress - ksi			
	10,000 Hr.	100,000 Hr.	10,000 Hr.	100,000 Hr.
1050	28.0	20.0	34.0	27.0
1200	13.8	9.8	18.0	12.5
1350	6.7	4.7	8.8	6.0
1500	3.25	2.3	3.3	4.0

(a) Nitrogen content 0.14 percent.

TABLE 3.046 COMPARISON OF RUPTURE STRESS OF TYPE 304 AND TYPE 304N AS A FUNCTION TO TEMPERATURE AND TIME.

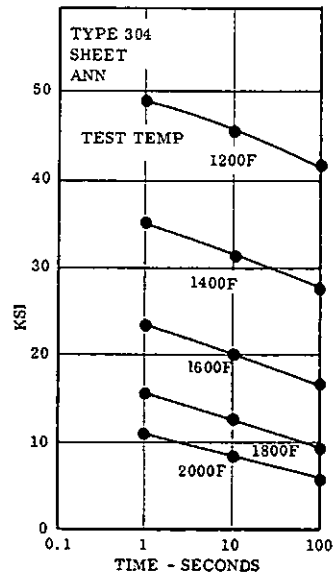


FIG. 3.048 SHORT TIME CREEP RUPTURE CURVES FOR SHEET AT 1200 TO 2000F. (68)

Fe
Low C
19 Cr
10 Ni

TYPES
304, 304L

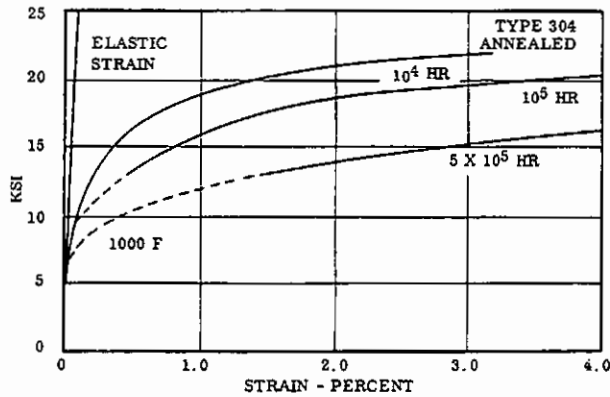


FIG. 3.049 ISOCHRONOUS STRESS - STRAIN CURVES FOR TYPE 304 AT 1000 F (69)

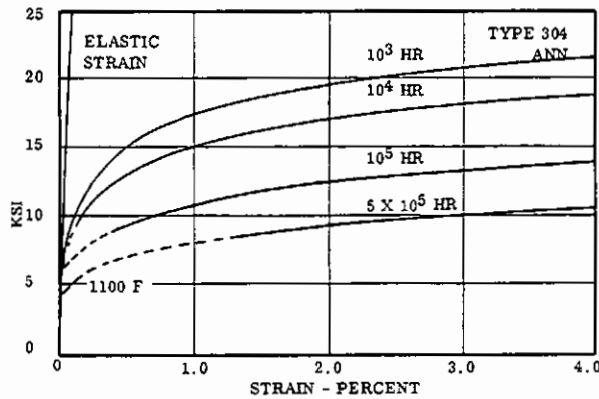


FIG. 3.0410 ISOCHRONOUS STRESS - STRAIN CURVES FOR TYPE 304 AT 1100 F (69)

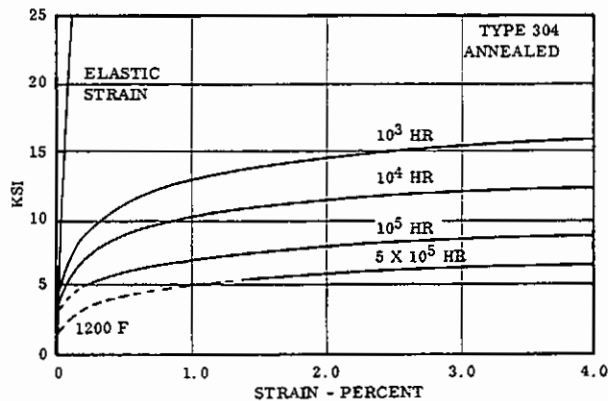


FIG. 3.0411 ISOCHRONOUS STRESS - STRAIN CURVES FOR TYPE 304 AT 1200 F (69)

Source (70)							
Alloy Type 304							
Form 1 in bar							
Condition Ann							
Temp - F	Method	Stress Ratio		Stress Concentration	Fatigue strength-ksi at cycles		
		A	R		10 ⁵	10 ⁶	10 ⁷
RT	Rot Beam	∞	-1	Smooth K = 1	45	41	40
800					32	31	31
1000					34	32	31
1200					31	29	29

TABLE 3.051 FATIGUE PROPERTIES OF 1 INCH DIAMETER ANNEALED BAR.

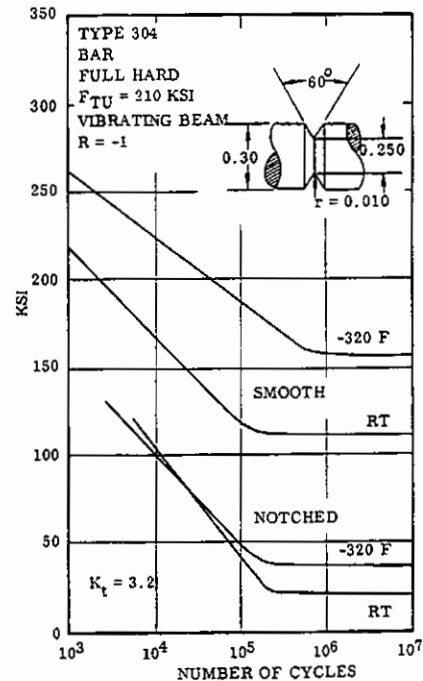


FIG. 3.052 RESULTS OF VIBRATING BEAM TESTS OF NOTCHED AND SMOOTH TYPE 304 BAR (18)

Fe
Low C
19 Cr
10 Ni
**TYPES
304, 304L**

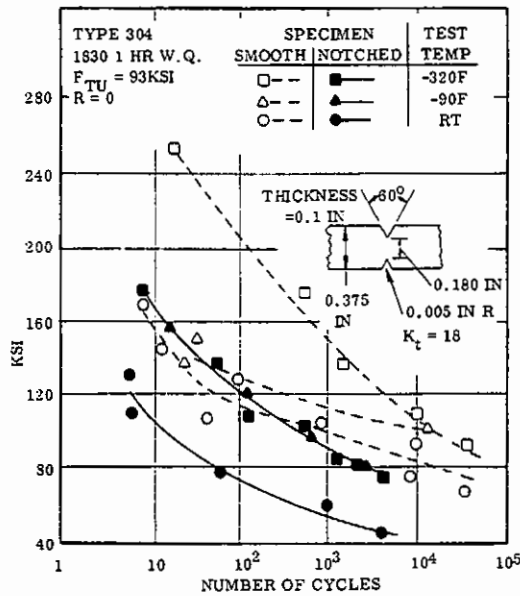


FIG 3.053 S-N CURVES FOR NOTCHED AND SMOOTH SHEET AS A FUNCTION OF TEMPERATURE IN THE ANNEALED CONDITION (75)

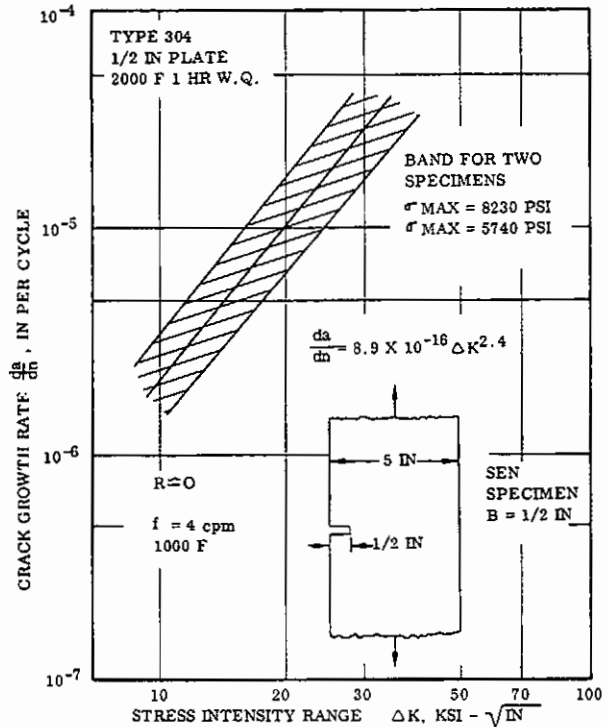


FIG 3.055 FATIGUE CRACK PROPAGATION RATE AT 1000 F AS A FUNCTION OF STRESS INTENSITY RANGE FOR PLATE (73, Fig 5)

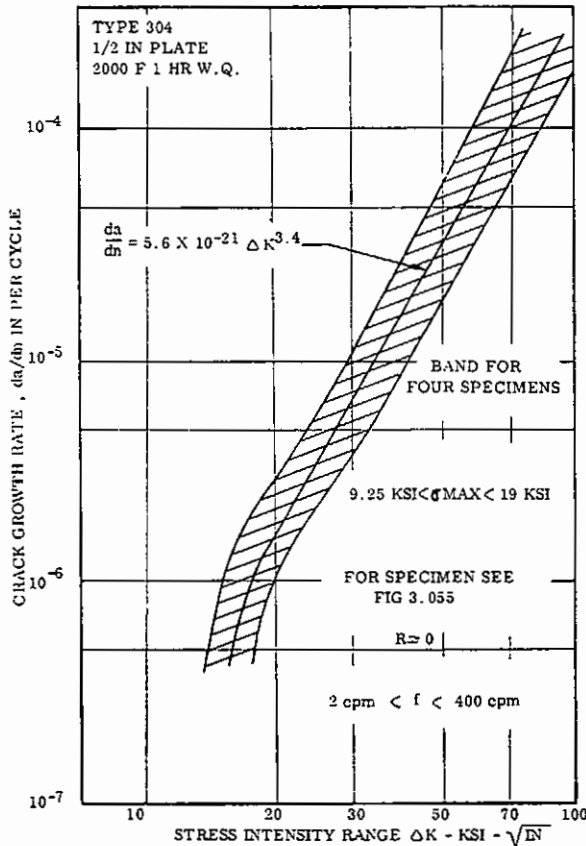


FIG 3.054 FATIGUE CRACK PROPAGATION RATE AT R.T. AS A FUNCTION OF STRESS INTENSITY RANGE FOR PLATE (73, fig 3)

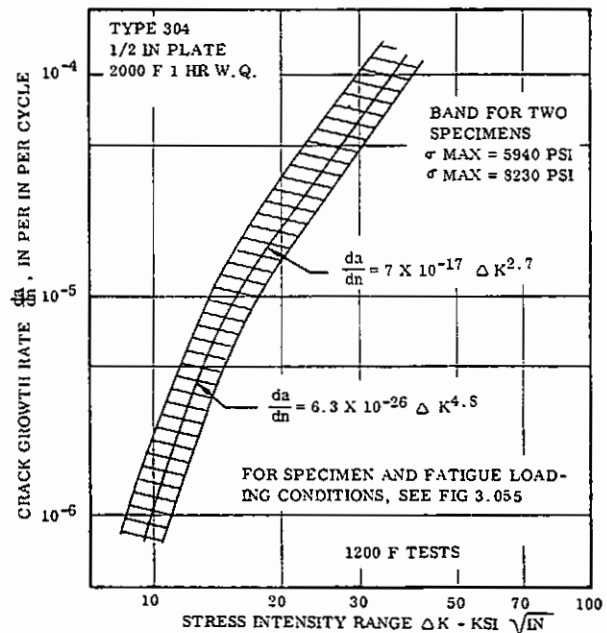


FIG 3.056 FATIGUE CRACK PROPAGATION RATE AT 1200F AS A FUNCTION OF STRESS INTENSITY RANGE FOR PLATE (73, fig 6)

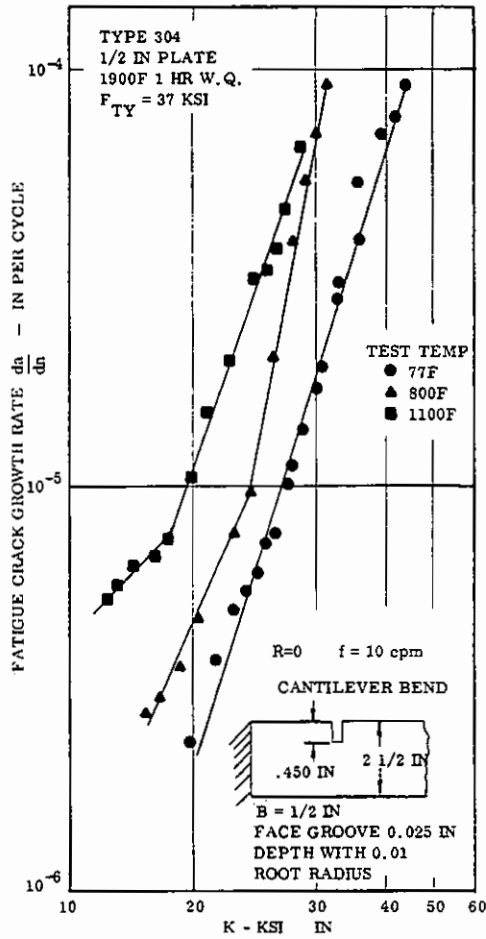


FIG 3.057 FATIGUE CRACK GROWTH RATE AS A FUNCTION OF STRESS INTENSITY RANGE AND TEMPERATURE FOR PLATE IN THE ANNEALED CONDITION (76)

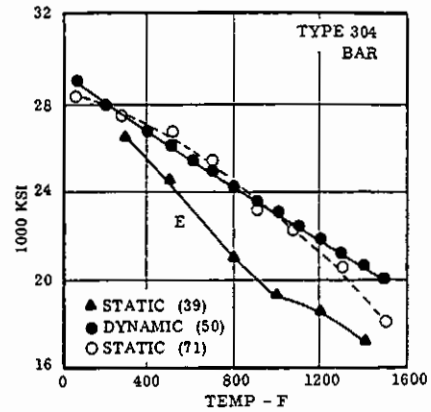


FIG 3.0621 MODULUS OF ELASTICITY AT ROOM AND ELEVATED TEMPERATURES (39)(50,p.82)(71)

Fe
Low C
19 Cr
10 Ni
TYPES 304, 304L

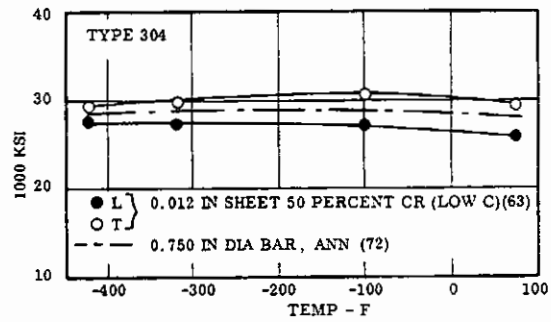


FIG 3.0622 MODULUS OF ELASTICITY AT ROOM AND LOW TEMPERATURES (63) (72)

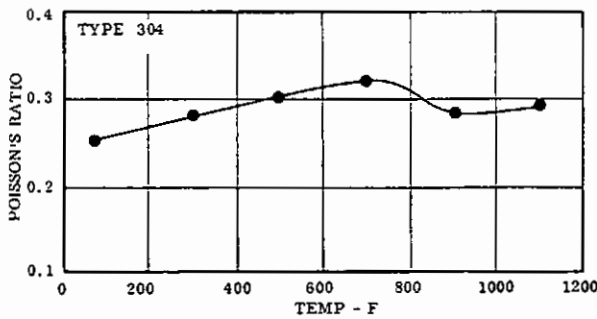


FIG 3.061 POISSON'S RATIO AT ROOM AND ELEVATED TEMPERATURES (21)

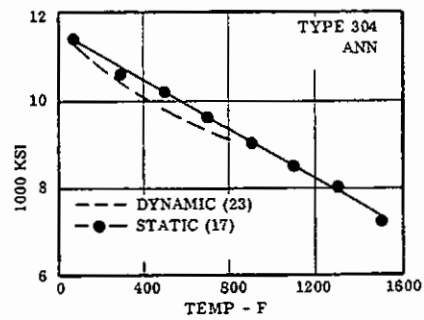


FIG 3.063 MODULUS OF RIGIDITY AT ROOM AND ELEVATED TEMPERATURES (17)(23)

	Fe
Low	C
19	Cr
10	Ni

TYPES
304, 304L

REFERENCES

1. AMS 5370, Castings - Precision Investment 19.5 Cr - 10 Ni (Low Carbon)(March 1, 1955).
2. AMS 5371, Castings - Sand 19.5 Cr - 10 Ni (Low Carbon) (March 1, 1955).
3. AMS 5513, Plate, Sheet and Strip 19 Cr - 9 Ni (June 15, 1958).
4. AMS 5560D, Tubing, Seamless 19 Cr - 10 Ni (January 15, 1958).
5. AMS 5563D, Tubing, Welded 19 Cr - 9 Ni (January 15, 1958).
6. AMS 5566D, Tubing, Seamless or Welded-Hydraulic 19 Cr-10 Ni High Pressure (July 15, 1963).
7. ASM 5567, Tubing, Hydraulic - Seamless or Welded 19 Cr-10 Ni Solution Treated (January 31, 1964).
8. AMS 5639A, Bars, Forgings, Mech. Tubing and Rings 19 Cr - 9 Ni (June 15, 1959).
9. AMS 5697, Wire 19 Cr - 9 Ni Solution Treated (November 1, 1954).
10. AMS 5511A, Plate, Sheet and Strip 18 Cr - 8 Ni Extra Low Carbon (June 15, 1952).
11. AMS 5647B, Bars, Forgings, Mech. Tubing and Rings 18 Cr - 8 Ni (March 15, 1966).
12. American Iron and Steel Institute, "Type 304 and 304L Stainless and Heat Resisting Steels" (June 1957).
13. American Casting Institute, "Corrosion Resistant Type CF-8", Data Sheet (June 1954).
14. Morykwas, S., "304 and 304L Alloy Data", Cannon-Muskegon Corporation (August 1967).
15. United States Steel, "Data on USS-18-8S, Type 304 and USS 18-8L Stainless Steel" (April 1962).
16. Alloy Digest, "Fagersta - R350 (Stainless Steel - Type 304)" (October 1968).
17. National Tube Division, United States Steel Corp., "Pipe and Tubes for Elevated Temperature Service", Bulletin No. 26 (1956).
18. Spretnak, J. W., et. al., "Notched and Unnotched Tensile and Fatigue Properties of Ten Engineering Alloys at 25°C and 196°K", Trans. American Society for Metals, Vol. 43 (1951).
19. Fontana, M. G., "Investigation of Mechanical Properties and Physical Metallurgy of Aircraft Alloys at Very Low Temperatures", WADC-TR-5662, Part II, Ohio State Foundation (October 1958).
20. Zambrow, J. L. and Fontana, M. G., "Impact Strength and Hardness of Aircraft Alloys Down to -423°F", Metals Progress, Vol. 53 (1948).
21. Universal Cyclops Steel Corporation, "High Temperature Metals Unloy 18-8S (AISI Type 304)", p. 22 (1959).
22. North American Aviation, Inc., "Stainless Steel - Type 304", Data Sheet (1957).
23. Westinghouse Electric Corporation, Standards Engineering Section, "Bettis Plant Materials Manual" (May 1957).
24. Furman, T., AIME (1950).
25. Allegheny Ludlum Steel Corporation, "Stainless Steel Fabrication", p. 273 (1958).
26. The Timken Roller Bearing Company, Steel and Tube Division, "Digest of Steels", p. 56-57 (1957).
27. The International Nickel Co. Inc., "Low Temperature Data Sheet Type 304 and 304L Stainless Steel" (February 1963).
28. Hoselitz, K., "Ferromagnetic Properties of Metals and Alloys", Oxford Clarendon Press, Oxford (1952).
29. Mangonon, P. L. Jr. and Thomas, G., "Structure and Properties of Thermal-Mechanically Treated 304 Stainless Steel", Metallurgical Trans., Vol. 1 (June 1970).
30. The International Nickel Co., Inc., "Heat Treatment and Physical Properties of the Austenitic Chromium - Nickel Stainless Steels", Nickel Alloy Steels, Section 7, Data Sheet A (1947).
31. Aust, K. T. et. al., "Intergranular Corrosion and Electron Microscopic Studies of Austenitic Stainless Steels", Trans. American Society for Metals, Vol. 60 (1967).
32. Fink, F. W. and Boyd, W. K., "The Corrosion of Metals in Marine Environments", DMIC Report 245 (May 1970).
33. Lennox, T. J. Jr., Peterson, M. H. and Groover, R. E., "Marine Corrosion Studies", NRL Report 1948 (November 1963).
34. Mannheimer, W. A. and Paxton, H. W., "Some Effects of Nitrogen on the Resistance to Stress Corrosion Cracking of Type 304 Stainless Steel Wires", Carnegie Institute of Technology, Contract Nonr 760 (14) NR 036-029 (June 15, 1966).
35. Logan, H. L. and McBee, M. J., "Stress-Corrosion Cracking of Cold Reduced Austenitic Stainless Steel", MR&S, ASTM, Vol. 7, No. 4 (April 1967).
36. Vennett, R. M. and Ansell, G. S., "The Effect of High-Pressure Hydrogen Upon the Tensile Properties and Fracture Behavior of 304L Stainless Steel", Trans. ASM, Vol. 60 (1967).
37. Personal Communication, Lovejoy, P. T., Allegheny Ludlum Industries, Inc. to C. F. Hickey, Jr. (September 22, 1970).
38. Guinia, R. B. and Woodrow, G. R., "Nitrogen Improves Engineering Properties of Chromium-Nickel Stainless Steels", Journal of Mats., ASTM, Vol. 5, No. 2 (1970).
39. Tipton, C. R., Jr., Editor, "Reactor Handbook", 2nd Edition Interscience Publishers, New York (1960).
40. Comprelli, F. A., Busboom, H. J. and Gebhardt, M. F., "Mechanical Properties of Irradiated Type 304 and Type 316 Stainless Steel in Fast Reactors", GEAP-10062, AEC Research and Development Report (June 1969).
41. Allegheny Ludlum Steel Corp., "Types 302, 304, 304L and 305", Allegheny Ludlum Blue Sheet (October 1963).
42. NASA (E-502) (1959).
43. Spaeder, C. E. and Domis, W. F., "Cryogenic and Elevated Temperature Mechanical Properties of a High-Nitrogen Type 304 Stainless Steel", Applied Research Laboratory, United States Steel, Proj. No. 44.012-062(2) (April 30, 1969).
44. "Cryogenic Materials Data Handbook", ML-TRD-64-280, Martin Co., Denver (August 1964).
45. Conway, J. B., "Evaluation of Plastic Fatigue Properties of Heat-Resistant Alloys", GEMP-740, General Electric Co., - NSP (December 1969).
46. DeSisto, T. S. and Carr, F. L., "Low Temperature Mechanical Properties of 300 Series Stainless Steels and Titanium" WAL TR 323.4/1 (December 1961).
47. Krivobok, V. N. and Tolbot, A. M., "Effect of Temperature on the Mechanical Properties, Characteristics and Processing of Austenitic Stainless Steels", ASTM, Vol. 50 (1950).
48. Hanson, M. P., "Smooth and Sharp-Notch Tensile Properties of Cold-Reduced AISI 301 and 304L Stainless Steel Sheet at 75 F and -423 F", NASA TN D-592 (February 1961).
49. The Timken Roller Bearing Company, Steel and Tube Division, "Resume of High Temperature Investigations Conducted During 1948 to 1950", p. 32 (1950).
50. American Society for Metals, "Metals Handbook", Vol. 1, 8th Edition (1961).
51. Engineering Alloys Digest, Inc., "Alloy Digest Filing Code: SS-5S Stainless Steel" (May 1957).
52. The Carpenter Steel Corporation, "Working Data - Carpenter Stainless and Heat Resisting Steels" (1962).
53. Timken Roller Bearing Co., Data Sheet (1959).
54. McDowell, D. W., Jr and Mihalisin, J. L., "Zerolling Boosts Strength of Stainless Sheet", Materials in Design Engineering, Vol. 53, No. 5 (May 1961).
55. Allegheny Ludlum Steel Corporation, "Allegheny Metal 18-8", Allegheny Ludlum Blue Sheet (1958).
56. Allegheny Ludlum Steel Corporation, "Stainless Steel Handbook", p. 66 (1956).
57. Rice, L. P., Campbell, J. E. and Simmons, W. F., "Tensile Behavior of Parent Metals and Welded 5000 Series Aluminum Alloy Plate at Room and Cryogenic Temperatures", Cryogenic Engineering Conference, Ann Arbor, Michigan (August 1961).
58. Gunter, C. F. and Reed, R. P., "The Effect of Experimental Variables Including the Martensitic Transformation on the Low Temperature Properties of Austenitic Stainless Steel", Trans. ASM, Vol. 55 (1962).
59. ASTM STP 287, "Symposium on Low Temperature Properties of High Strength Aircraft Missile Materials" (1960).
60. ASTM STP 302, "Symposium on Evaluation of Metallic Materials in Design for Low Temperature Service" (1961).
61. Republic Steel Corporation, "Republic Enduro Stainless Steel, Chromium Nickel Type 300 Series" (1964).

REVISED: MARCH 1973

FERROUS ALLOYS

62. United States Steel, "Low Temperature and Cryogenic Steels Materials Manual" (1966).
63. Christian, J. L., "Physical and Mechanical Properties of Pressure Vessel Materials for Applications in a Cryogenic Environment", ASD TDR 62-258, General Dynamics/Astronautics (March 1962).
64. ASTM Data Series D55 Report on the Elevated Temperature Properties of Stainless Steels; D55-S1 Supplement; and D5 5-S2 Strength of Wrought 304, 316, 321 and 347 of Elevated Temperatures(1969).
65. The Babcock and Wilcox Company, "The Long Time Creep Rupture Strength of Croloy 304".
66. Domis, W. F., "Creep and Creep Rupture Properties of Types 304N and 316N Stainless Steels", ASME, Pet-34(1971)
67. Garr, K. R., Kramer, D. and Rhodes, C. G., "Effect of Helium on Stress-Rupture Behavior of Types 304 and 316 Stainless Steels", AI-AEC-12932 (April 15, 1970).
68. Moon, D. P. and Simmons, W. F., "Selected Short-Time Tensile and Creep Data Obtained Under Conditions of Rapid Heating", DMIC Report 130 (June 17, 1960).
69. "Isochronous Stress-Strain Curves for 2-1/4 Cr-1Mo, Type 304-304H, and Type 316-316H Steels", TR 2012-Part 1, Prepared for U. S. Atomic Energy Commission, Contract No. AT(04-3)-781, Braun Project 4122-W, United Nuclear Project 2351 (October 16, 1970).
70. Cross, T., ASME (1934).
71. ASTM STP 129, Symposium on Determination of Elastic Constants (1952).
72. Warren, K. A. and Reed, R. P., "Tensile and Impact Properties of Selected Materials from 70 to 300°K", Monograph 63, National Bureau of Standards (June 1963).
73. Espey, G. B., Repko, A. J. and Brown, W. F., Jr., "Effect of Cold Rolling and Stress Relief on Sharp Edge Notch Tensile Characteristics of Austenitic Stainless Sheet Alloys", Proc. ASTM Vol. 59, 159, p. 816.
74. James, L. A., "Fatigue Crack Propagation Behavior of Type 304 Stainless Steel at Elevated Temperatures", 4th National Symposium on Fracture Mechanics, Carnegie Mellon Univ. (August 1970).
75. Reed, R. P., Durcholz, R. L., Schramm, R. E. and Patrician, T. J., "Study of Cryogenic Tank Fatigue Life", Technical Note 609, National Bureau of Standards (August 1971).
76. Steele, L. E. et. al., "Irradiation Effects on Structural Materials", Memorandum Report 2398, Naval Research Laboratory (February 1972).

	Fe
Low	C
19	Cr
10	Ni

TYPES
304, 304L

