AUTHOR: W. D. KLOPP

Fe
17 Cr
6.5 Mn
4.5 Ni

Type 201

1 GENERAL

The 200 series of austenitic stainless steels was developed during and after World War II to provide inexpensive, low-nickel substitutes for the 300 series stainless steels. Type 201 is a substitute for Type 301; the nickel in Type 301 is partially replaced with alternate austenite-stabilizing elements manganese and nitrogen. Mechanical properties and corrosion behaviors are very similar for the two grades. Type 201 is metastable and forms martensite on cold deformation, increasing the work-hardening rate. Type 201 is used in transit and railway cars, large truck trailers, moderately drawn utensils such as cookware lids, roll-formed and stretch bent automotive trim and wheel covers, household appliances, flat conveyor chain, architectural panels, and welded fire extinguisher tanks.

1.01 **Commercial Designation**

Type 201.

1.02 **Alternate Designations**

AISI 201, UNS S20100, and SAE 30201.

1.03 **Specifications**

AMS 5762, ASME SA412, ASTM A412, ASTM A581, ASTM A666, QQ-5-766, and SAE J405.

1.04 **Composition**

Composition, Table 1.04.

1.05 **Heat Treatment**

1.051 Annealing temperature range is 1850 to 2050 F. The alloy must be rapidly cooled or water quenched, depending on section size, in order to prevent carbide precipitation. For maximum corrosion resistance, parts should be full annealed at 1900 F or higher.

1.052 Stress relief, 800 F, 2 hours (5).

1.06 **Hardness**

1.061 The alloy is hardenable only by cold working (6).

1.062 Effect of temper on hardness, Figure 1.062.

1.07 **Forms and Conditions Available**

1.071 Sheet, strip, plate, bar, rod (7).

1.08 **Melting and Casting Practice**

1.09 **Special Considerations**

1.091 Type 201 is subject to intergranular corrosion when sensitized due to precipitation of complex chromium-rich carbides at the grain boundaries. See paragraph 2.0321.

2 PHYSICAL PROPERTIES AND ENVIRONMENTAL EFFECTS

2.01 **Thermal Properties**

2.011 Melting range is 2550 to 2650 F (9).

2.012 Phase changes.

2.0121 Time-temperature-transformation diagrams.

2.013 Thermal conductivity, 212 F, 9.4 Btu/ft/hr/ft^2/F.

2.014 Thermal expansion, Figure 2.014.

2.015 Specific heat, 32 to 212 F, 0.12 Btu/lb/F (3).

2.016 Thermal diffusivity.

2.02 **Other Physical Properties**

2.021 Density is 0.287 lb/in.^{3}, 7.94 g/cc (8).

2.022 Electrical properties.

2.0221 Electrical resistivity, 69 microhm-cm at room temperature (7).

2.023 Magnetic properties.

2.0231 Type 201 is nonmagnetic in the annealed condition and magnetic when cold worked (2).

2.0232 Effect of cold reduction on magnetic permeability, Table 2.0232.

2.024 Emissivity.

2.025 Damping capacity.

2.03 **Chemical Environments**

2.031 General corrosion.

2.0311 Type 201 has good corrosion resistance to a wide variety of media and can be used in most applications where Type 301 is used.

2.0312 The corrosion rate of Type 201 in 10 percent formic acid at room temperature is 0.4 mpy (11).

2.032 Intergranular corrosion.

2.0321 Type 201, like Type 301 and most of the unstabilized austenitic stainless steels, is subject to intergranular corrosion in the sensitized condition. Sensitization occurs when the chromium content of the matrix is reduced by precipitation of chromium-rich carbides in the grain boundary regions. Sensitization is caused by heating in the 800 to 1500 F temperature range. In particular, slow cooling through the critical temperature range after heat treating at a higher temperature or after welding can cause sensitization. Corrosion resistance can be restored by full annealing to redissolve the precipitated carbides.

2.033 Stress corrosion cracking.

2.0331 Type 201 is subject to stress corrosion cracking in chloride solutions. Cracking can be either transgranular or intergranular depending on the composition and temperature of the solution.

2.034 Oxidation.

2.0341 The oxidation resistance of Type 201 is good up to about 1550 F, comparable to that of Type 301. Above this temperature, however, Type 201 scales more rapidly due to its higher manganese content.

2.0342 Alloy is resistant to scaling up to 1550 F for continuous service and up to 1400 F for intermittent service (9).

2.0343 Effect of cold work on long time corrosion in steam at 1000 F, Figure 2.0343.

2.04 **Nuclear Environments**

3 MECHANICAL PROPERTIES

3.01 **Specified Mechanical Properties**

3.02 **Mechanical Properties at Room Temperature**

3.021 Tension – stress-strain diagrams – tension properties.

3.0211 Type 201 is hardened by the strain-induced transformation of austenite to alpha-prime martensite. As shown in Figure 3.0212, the maximum in rate of work hardening occurs simultaneously with the

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maximum rate of formation of alpha-prime martensite. The high degree of metastability of Type 201 with respect to cold deformation is indicated by the very large volume fraction, 85 percent, of martensite forming during tensile straining.

3.0212 Stress-strain curve and martensite content as a function of strain, Figure 3.0212.

3.0213 Effect of temper on mechanical properties at room temperature, Figure 3.0213.

3.0214 Effects of cold working on tensile properties, Figure 3.0214.

3.0215 Effects of cold rolling and stress relief on tensile yield strength, Figure 3.0215.

3.022 Compression – stress-strain diagrams – compression properties.

3.0221 Effect of cold work on compressive yield strength, Figure 3.0221.

3.0222 Effects of cold rolling and stress relief on compressive yield strength, Figure 3.0222.

3.023 Impact.

3.024 Bending.

3.025 Torsion and shear.

3.026 Bearing.

3.027 Stress concentration.

3.0271 Notch properties.

3.0272 Fracture toughness.

3.028 Combined properties.

3.03 **Mechanical Properties at Various Temperatures**

3.031 Tension – stress-strain diagrams – tension properties.

3.0311 Tensile properties of annealed alloy at elevated temperatures, Figure 3.0311.

3.0312 Tensile properties of full hard alloy at elevated temperatures, Figure 3.0312.

3.032 Compression – stress-strain diagrams – compression properties.

3.033 Impact.

3.0331 Effect of low and elevated temperatures on Charpy V impact strength of alloy, Figure 3.0331.

3.034 Bending.

3.035 Torsion and shear.

3.036 Bearing.

3.037 Stress concentration.

3.0371 Notch properties.

3.0372 Fracture toughness.

3.038 Combined properties.

3.04 **Creep and Creep-Rupture Properties**

3.041 Typical stress-rupture properties, Figure 3.041.

3.05 **Fatigue Properties**

3.051 The fatigue behavior of Type 201 in terms of total strain amplitude as a function of fatigue life is shown in Figure 3.052. The stress-strain hysterisis loops for this alloy progressively change with deformation and do not allow separation of total strain into plastic and elastic components. The change in behavior during fatigue life results from the continued formation of martensite. The rate of formation of martensite during cyclic straining, shown in Figure 3.053, is similar to that during monotonic straining, shown earlier in Figure 3.0212. The cyclic stress-strain curve exhibits hardening at much lower strains than the monotonic curve, as shown in Figure 3.054.

3.052 Axial fatigue behavior of smooth alloy at room temperature, Figure 3.052.

3.053 Effect of cyclic straining on martensite content of annealed alloy, Figure 3.053.

3.054 True stress-true strain curves for monotonic and cyclic deformation, Figure 3.054.

3.06 **Elastic Properties**

3.061 Poisson's ratio.

3.062 Modulus of elasticity.

3.0621 Modulus of elasticity for stress-relieved and cold rolled alloy, Figure 3.0621.

3.0622 Modulus of elasticity in compression for stress relieved and cold rolled alloy, Figure 3.0622.

3.063 Modulus of rigidity, 12,500 ksi (8).

3.064 Tangent modulus.

3.065 Secant modulus.

4 **FABRICATION**

4.01 **Forming**

4.011 Type 201 has good formability and is widely used in press-forming operations. Type 201 was developed as a less costly substitute for Type 301 but does not equal it in press forming characteristics in many applications. The true stress-true strain curves, shown in Figure 4.012, indicate high work-hardening rates for both 201 and 301, which effectively retard localized reduction, or necking, and permit significant stretching during forming operations. By holding nickel on the high side and nitrogen on the low side of the specification, the formability of Type 201 is improved to that of Type 301 (15).

4.012 Work hardening characteristics of Types 201 and 301, Figure 4.012.

4.013 General. 180-degree bending of 2 T radius of Type 201 (1/2 hard) longitudinal and transverse specimens can be successfully done without cracking (6).

4.014 Forging. Starting temperature 2100 to 2250 F, finishing temperature 1700 F or above (7).

4.02 **Machining and Grinding**

4.021 Type 201 has fair to good machinability. The machinability rating is 49 percent, based on 100 percent machinability for an AISI B1112 carbon steel. Maximum cutting speed with high-speed steel tools is 80 surface feet per minute. Cutting speed can be increased with carbide tools.

4.022 Type 201 work hardens during machining so work piece and tool must be rigid for best results. Tools must be kept sharp.

4.023 Apply good cutting fluids, such as sulfurized-chlorinated petroleum oil. This is particularly important in making heavy cuts at relatively slow feeds. Thinning the fluid with paraffin oil helps in making finishing cuts at higher speeds. The blend improves the cooling effect on the work piece and tool.

4.024 Take positive cuts and avoid dwelling to minimize work hardening and glazing (8, 16).

4.03 **Joining**

4.031 Type 201 can be welded by all conventional techniques employed for the standard 18-8 stainless steels. Shielded-arc methods, arc welding, and spot welding produce good welds with excellent mechanical properties. Weld ductility is good. Type 201 is somewhat less sensitive to intergranular corrosion in the weld heat-affected zone than 300-series compositions with comparable carbon content (8).

4.04 **Surface Treating**

4.041 Scale from heat treating operations can be removed by pickling in a bath of 20 percent hydrochloric acid at 120 to 140 F or in a solution of 10 percent sulfuric acid plus 6 to 12 percent rock salt. After pickling, rinse thoroughly, dip in a warm bath of 15 to 30 percent nitric acid, and wash in water (8).

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	Fe
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4.5	Ni

Type 201

Source	AISI (2)		(7)	
	Percent		Percent	
	Min	Max	Min	Max
Carbon	–	0.15	–	0.15
Chromium	16.0	18.0	16.0	19.0
Manganese	5.5	7.5	5.5	10.0
Nickel	3.5	5.5	3.5	6.0
Nitrogen	–	0.25	–	–
Silicon	–	1.0	–	–
Sulfur	–	0.03	–	–
Iron	Balance		Balance	

TABLE 1.04. COMPOSITION (2, 7)

	Fe
17	Cr
6.5	Mn
4.5	Ni

Type 201

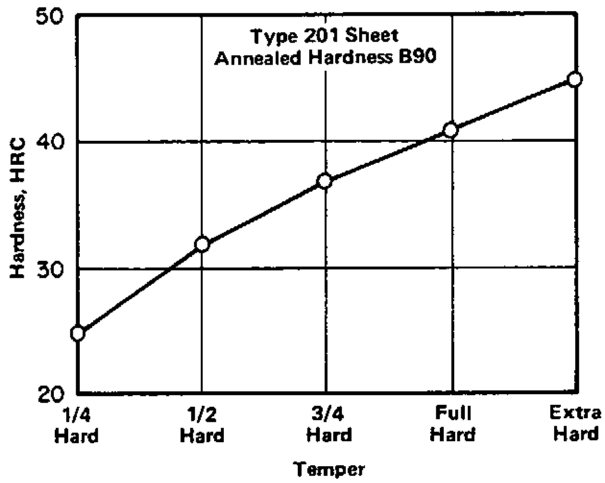

FIGURE 1.062. EFFECT OF TEMPER ON HARDNESS (8)

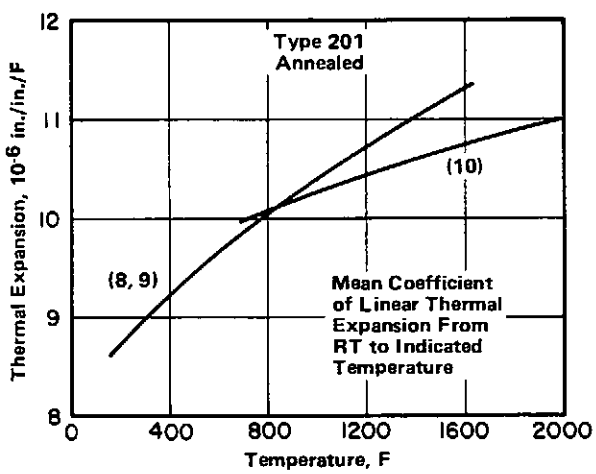

FIGURE 2.014. THERMAL EXPANSION (8, 9, 10)

Alloy	Type 201
Cold Reduction, percent	Normal Magnetic Permeability at 200 Oersteds
Anneal	1.003
5	1.016
10	1.147
20	2.738
30	7.006
50	15.395

TABLE 2.0232. EFFECT OF COLD REDUCTION ON MAGNETIC PERMEABILITY (3)

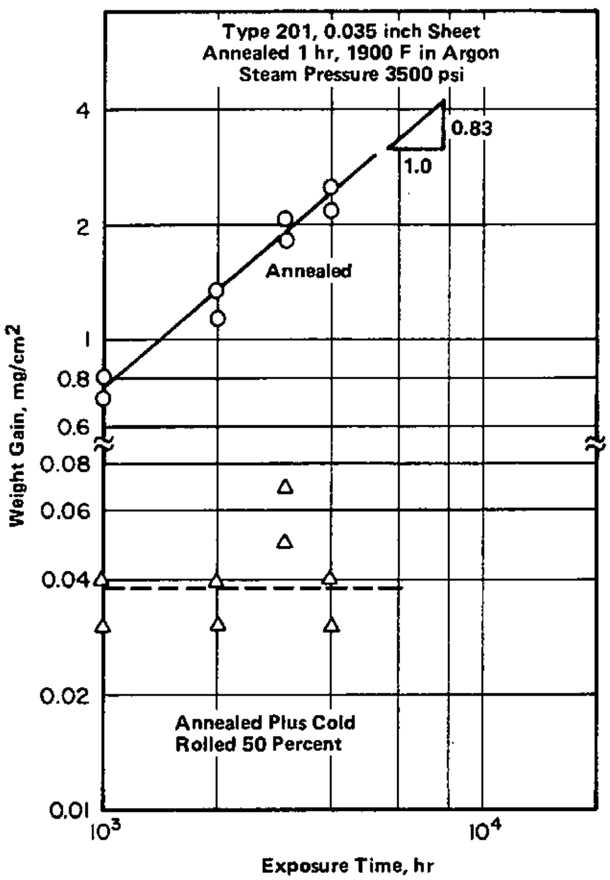

FIGURE 2.0343. EFFECT OF COLD WORK ON LONG-TIME CORROSION IN STEAM AT 1000 F (12)

	Fe
17	Cr
6.5	Mn
4.5	Ni

Type 201

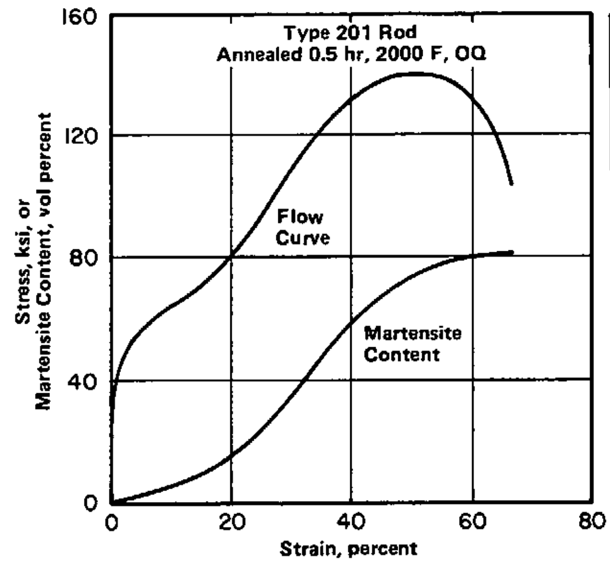

FIGURE 3.0212. STRESS-STRAIN CURVE AND MARTENSITE CONTENT AS A FUNCTION OF STRAIN (13)

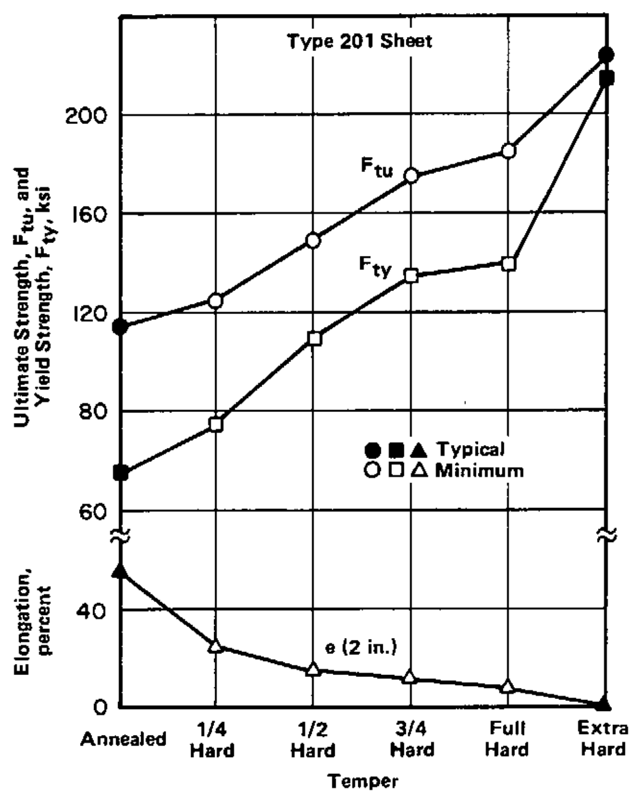

FIGURE 3.0213. EFFECT OF TEMPER ON MECHANICAL PROPERTIES AT ROOM TEMPERATURE (8)

	Fe
17	Cr
6.5	Mn
4.5	Ni

Type 201

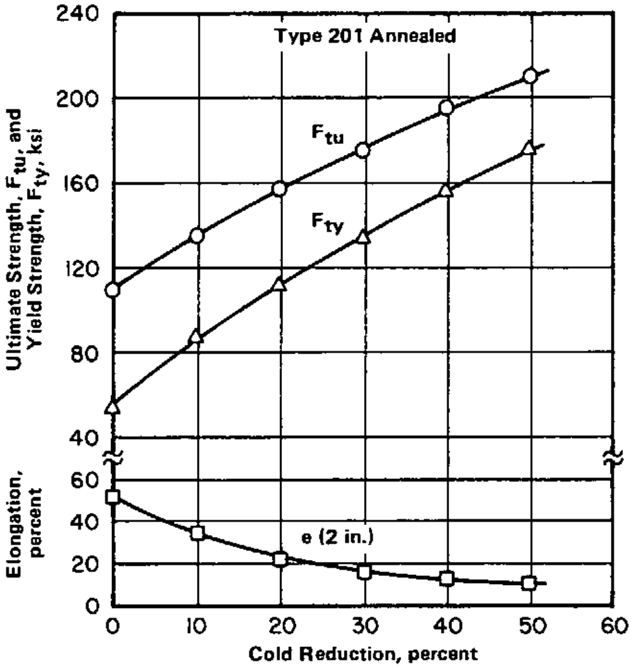

FIGURE 3.0214. EFFECTS OF COLD WORKING ON TENSILE PROPERTIES (8)

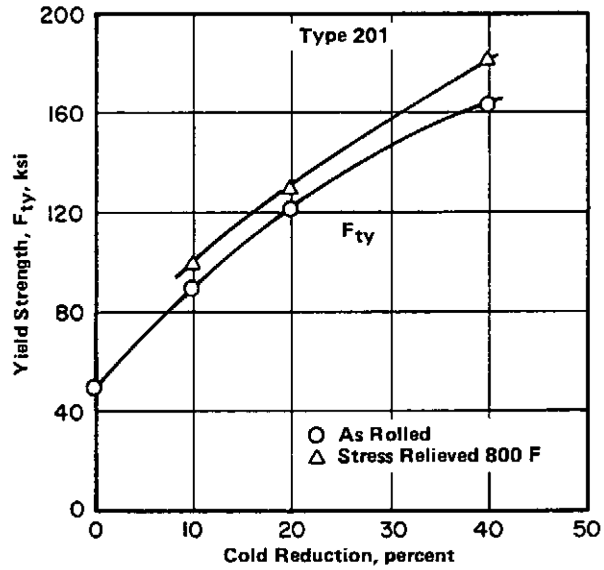

FIGURE 3.0215. EFFECTS OF COLD ROLLING AND STRESS RELIEF ON TENSILE YIELD STRENGTH (8)

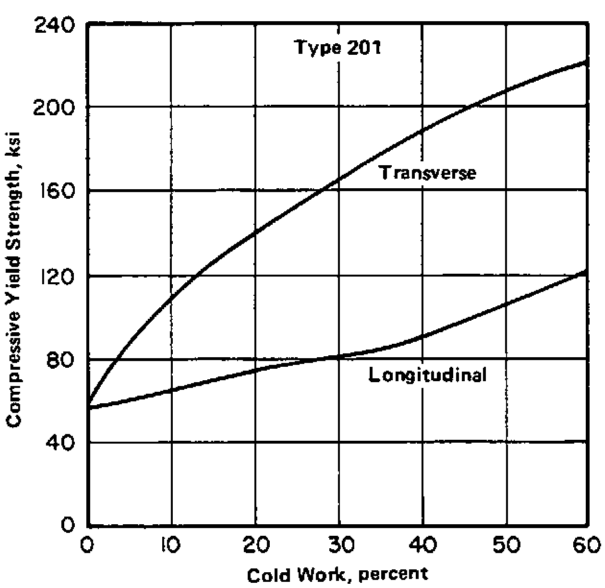

FIGURE 3.0221. EFFECT OF COLD WORK ON COMPRESSIVE YIELD STRENGTH (14)

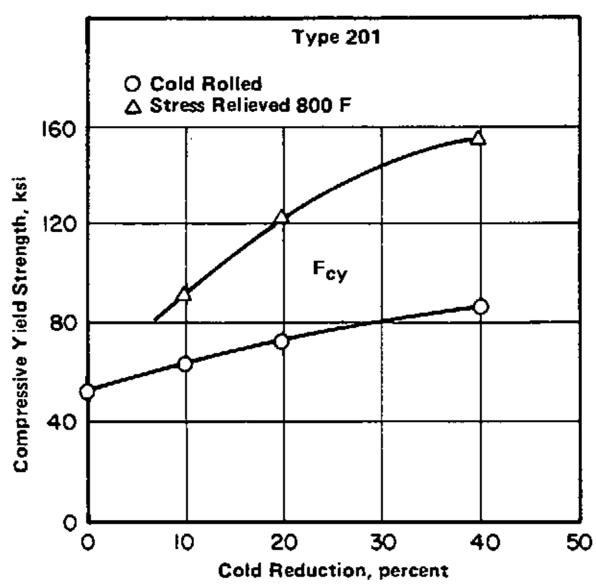

FIGURE 3.0222. EFFECTS OF COLD ROLLING AND STRESS RELIEF ON COMPRESSIVE YIELD STRENGTH (8)

	Fe
17	Cr
6.5	Mn
4.5	Ni

Type 201

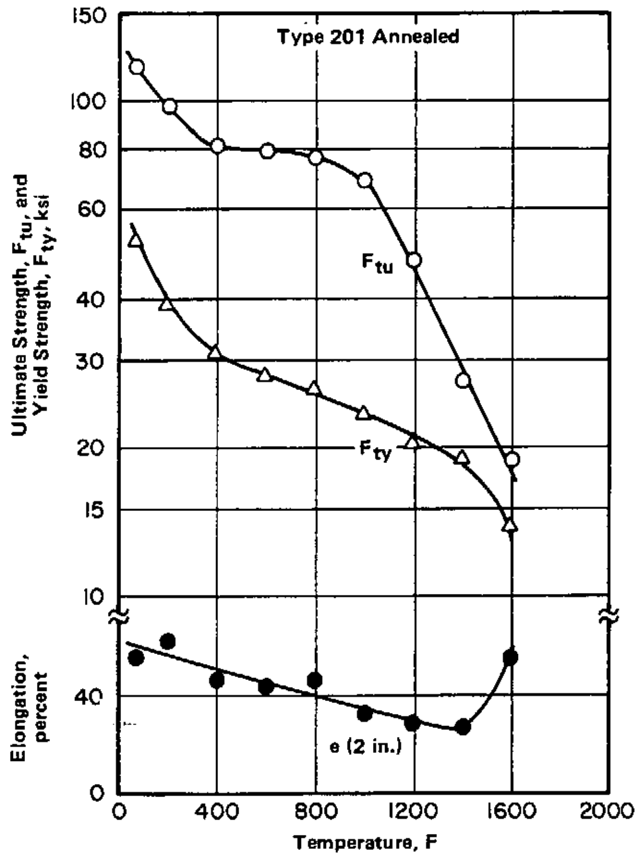

FIGURE 3.0311. TENSILE PROPERTIES OF ANNEALED ALLOY AT ELEVATED TEMPERATURES (8)

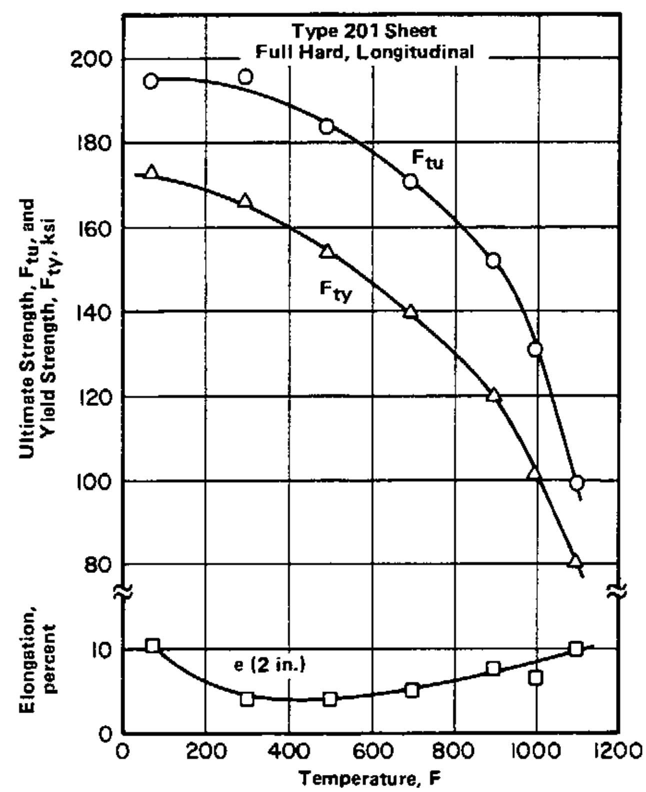

FIGURE 3.0312. TENSILE PROPERTIES OF FULL HARD ALLOY AT ELEVATED TEMPERATURES (8)

	Fe
17	Cr
6.5	Mn
4.5	Ni

Type 201

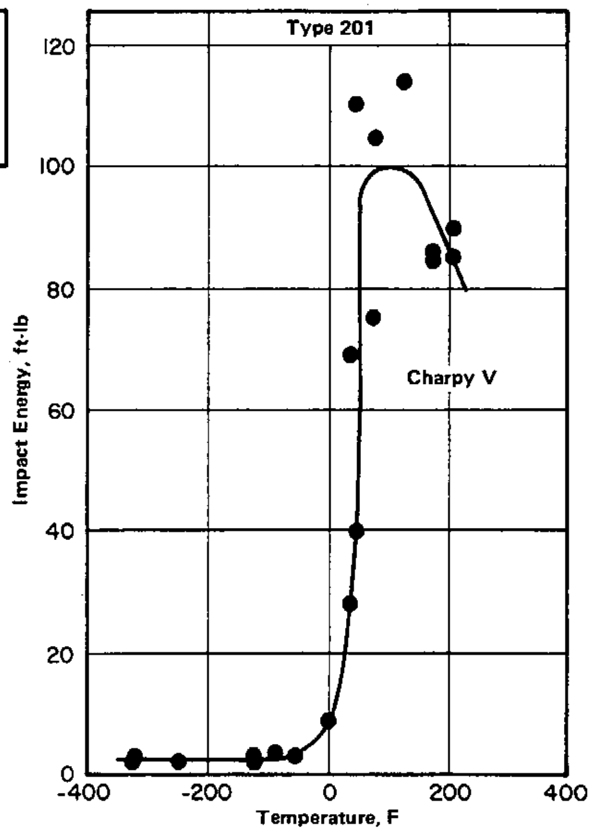

FIGURE 3.0331. EFFECT OF LOW AND ELEVATED TEMPERATURES ON CHARPY V IMPACT STRENGTH OF ALLOY (2)

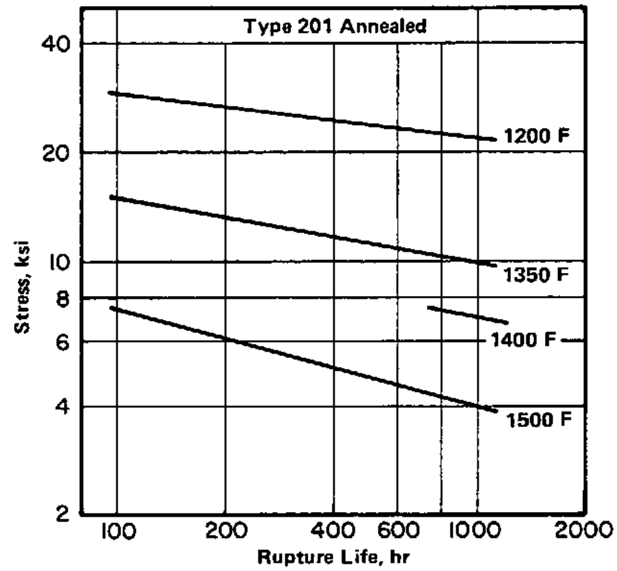

FIGURE 3.041. TYPICAL STRESS-RUPTURE PROPERTIES (8)

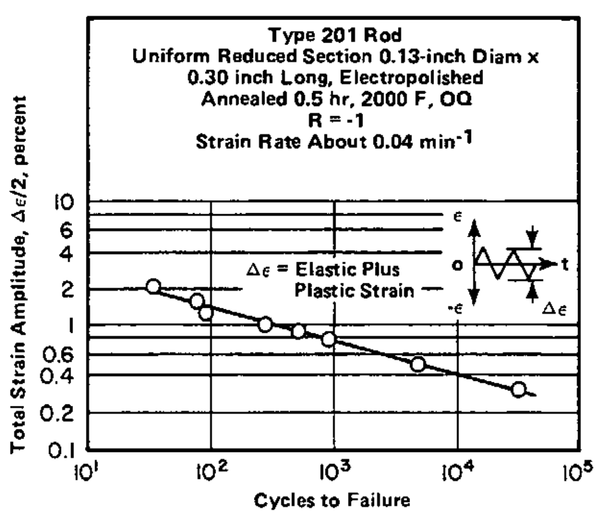

FIGURE 3.052. AXIAL FATIGUE BEHAVIOR OF SMOOTH ALLOY AT ROOM TEMPERATURE (13)

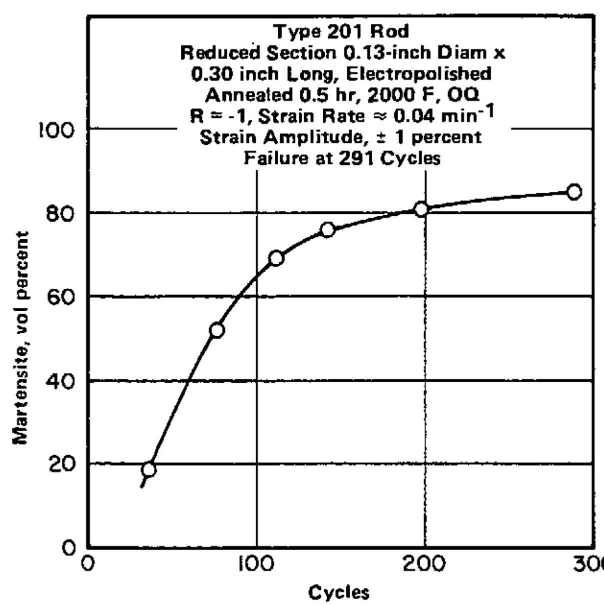

FIGURE 3.053. EFFECT OF CYCLIC STRAINING ON MARTENSITE CONTENT OF ANNEALED ALLOY (13)

	Fe
17	Cr
6.5	Mn
4.5	Ni

Type 201

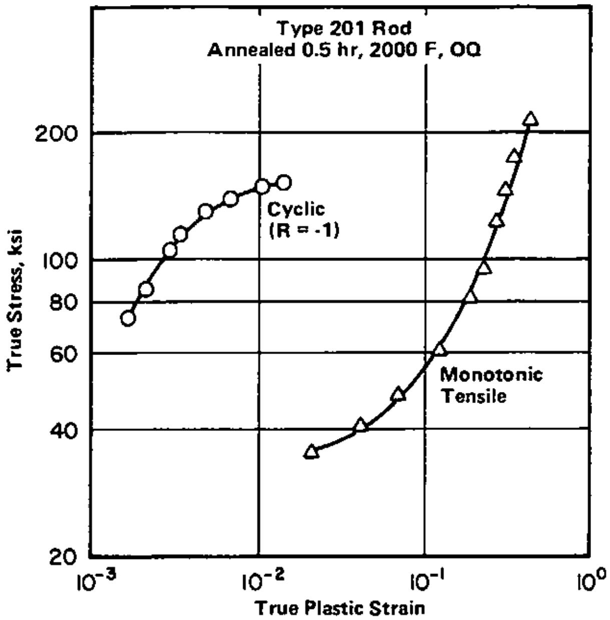

FIGURE 3.054. TRUE STRESS-TRUE STRAIN CURVES FOR MONOTONIC AND CYCLIC DEFORMATION (13)

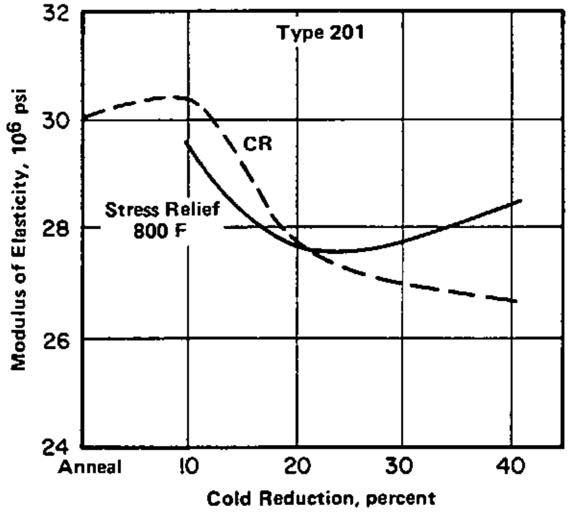

FIGURE 3.0621. MODULUS OF ELASTICITY FOR STRESS RELIEVED AND COLD ROLLED ALLOY (3)

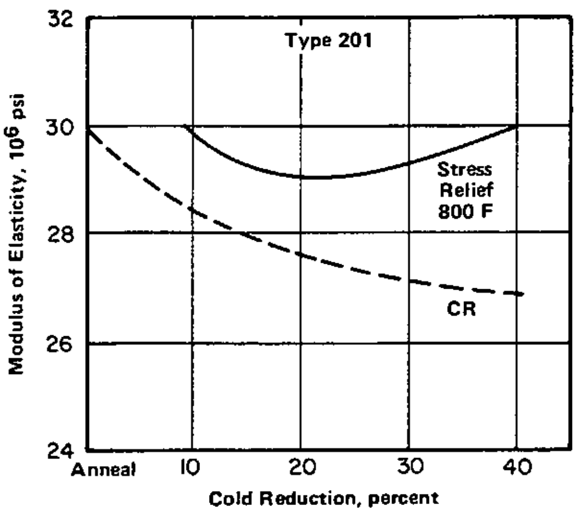

FIGURE 3.0622. MODULUS OF ELASTICITY IN COMPRESSION FOR STRESS RELIEVED AND COLD ROLLED ALLOY (3)

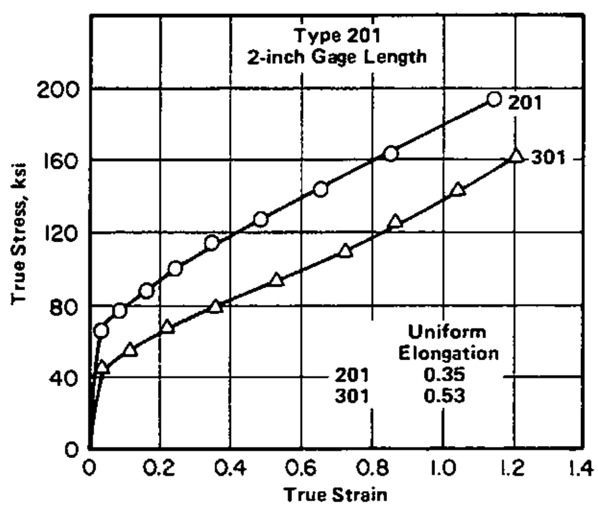

FIGURE 4.012. WORK HARDENING CHARACTERISTICS OF TYPES 201 AND 301 (15)