

REVISED: MARCH 1970
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FERROUS ALLOYS

1. GENERAL
AFC-77 is a martensitic stainless steel which has been modified by the addition of substantial amounts of Co and Mo. It is still under development, both in regard to heat treatment and mechanical processing. It is subject to a very strong secondary hardening reaction and tensile strengths up to 260 ksi, and yield strengths of 210 ksi can be obtained by quenching and tempering in the range of 700-1100F, depending on composition and austenitizing temperature. The Mo and Co promote high temperature strength, and yield strengths above 150 ksi at 1000F can be achieved by tempering between 1000 and 1100F. By combinations of heavy cold work and tempering, wires with tensile strengths of 500 ksi can be produced.

Unfortunately, like other martensitic stainless steels, this alloy is subject to embrittlement when tempered in the range of secondary hardening. In this case, the embrittlement is quite severe, and in terms of tempering temperature, extends from about 700F to well beyond the secondary hardening peak. For this reason the high strength conditions are not suitable for critical applications where resistance to crack propagation is a consideration. When tempered in the range between 400 and 700F, the yield strength is between 160 and 170 ksi, but the fracture toughness is greatly improved. However, alloys tempered at low temperatures are unstable and embrittle when exposed to even moderately elevated temperatures for extended times. Attempts have been made to achieve high strength without embrittlement by combinations of tempering and cold work. However, the data available on such treatments are as yet inadequate to permit judgement of their practical value.

1.01 Commercial Designation
AFC-77

1.02 Alternate Designations

1.03 Specifications

1.04 Composition
Table 1.04.

TABLE 1.04

Source	(1) (2)			
	Percent			
	Nominal	(a)	(b)	(c)
Carbon	0.15	0.173	0.164	0.147
Chromium	14.5	14.34	14.36	14.22
Cobalt	13.5	13.61	13.73	12.93
Copper	-	0.016	0.013	0.07
Manganese	-	0.01	0.02	0.10
Molybdenum	5.0	4.93	4.90	4.62
Nickel	-	0.05	0.10	0.08
Nitrogen	0.05	0.02	0.02	0.03
Phosphorus	-	0.006	0.004	0.010
Silicon	-	0.20	0.19	0.07
Sulfur	-	0.011	0.008	0.008
Tungsten	-	0.02	-	-
Vanadium	0.5	0.52	0.51	0.30
Iron	Balance			

(a) Measured (one-ton heat air-induction melted).
(b) Measured (vacuum arc-remelted heat).
(c) Measured (15-ton heat air-induction melted).

1.05 Heat Treatment
1.051 Austenitize. 1800 to 2000F, 1 hour, oil quench or air cool.
1.052 Refrigerate. -100F, 30 minutes.
1.053 Temper. 400 to 1100F, 2 + 2 hours.
1.06 Hardness
1.061 After austenitizing at 2000F, oil quenching and refrigerating at -100F for 30 minutes. Rockwell hardness is RC 48-50.
1.062 Effect of austenitizing and tempering temperature on Rockwell hardness, Figure 1.062.

1.063 Effect of refrigeration and tempering conditions on hardness of alloy austenitized at 1900F, Figure 1.063.
1.064 Effect of tempering temperature on hardness of sheet, Figure 1.064.

1.07 Forms and Conditions Available
A variety of products have been successfully produced from a 15-ton air-induction heat which included wire (to 1/8 inch diameter), bar (to 3 inch diameter), hot rolled sheet and strip (0.033 to 0.125 inch thick) and billets (7 1/2 inch square).

1.08 Melting and Casting Practice
Conventional air-arc melting and vacuum-arc remelting. The alloy has been produced in one-ton, two-ton, and fifteen-ton heats.

1.09 Special Considerations
In common with other martensitic stainless steels, this alloy is subject to a severe embrittlement when tempered above about 700F. The tempering temperature range over which this embrittlement occurs is much more extensive than in other martensitic stainless steels and extends to nearly 1400F (e.g. Figure 3.02712 and Figure 3.0331). It is interesting to note that no substantial recovery in the embrittlement is noted for 1200F tempering even though this temperature is well beyond the secondary hardening peak. Cold rolling preceding tempering in the brittle range can substantially increase the strength but also increases the embrittlement (see Figure 3.03711). The alloy is not stable during elevated temperature exposure and long time exposures to moderately elevated temperatures can substantially increase the embrittlement (see Figure 3.03714). As might be expected, the low temperature crack and notch strength are very poor for conditions tempered in the brittle range (see Figure 3.03711, 3.03713 and 3.03714).

If tempering is confined to temperatures below about 700F, the yield strength is below about 170 ksi and the room temperature fracture toughness is high (e.g. Figure 3.02712). No valid values of K_{Ic} are available for these tempered conditions. It would be expected that the low tempered conditions would not be stable during elevated temperature exposure, and that a time-temperature dependent embrittlement would develop.

Attempts have been made by Webster to improve the toughness of the high strength conditions by increasing the amount of retained austenite by austenitizing at high temperatures (about 2000F) and tempering at low temperatures where the retained austenite is stable (12). High strength is produced by introducing cold work following a low temperature temper (500F) and then re-tempering. Tensile yield strengths of about 270 ksi can be produced by moderate amounts of cold work. Unfortunately, Webster does not describe his fracture toughness tests in sufficient detail to permit judgement of the practical value of the proposed treatments. However, it would be expected that retained austenite would increase the toughness, particularly if it produced a layered structure that would cause crack branching. Such a structure might be produced by cold work following tempering at a low temperature but could be quite directional in its fracture properties.

2. PHYSICAL AND CHEMICAL PROPERTIES

2.01 Thermal Properties
2.011 Melting range.
2.012 Phase changes.
2.0121 Time-temperature-transformation diagrams.
2.013 Thermal conductivity.
2.014 Thermal expansion, Figure 2.014.
2.0141 Effect of tempering temperature on dimensional change of alloy austenitized at 2000F, Figure 2.0141.
2.015 Specific heat.
2.016 Thermal diffusivity.

Fe
0.15 C
14.5 Cr
13.5 Co
5 Mo
0.5 V
0.05 N ₂

AFC-77

Fe
0.15 C
14.5 Cr
13.5 Co
5 Mo
0.5 V
0.05 N ₂

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- 2.02 Other Physical Properties
- 2.021 Density.
- 2.022 Electrical properties.
- 2.023 Magnetic properties.
- 2.024 Emissivity.
- 2.025 Damping capacity.
- 2.03 Chemical Properties
In general, the oxidation and corrosion resistance are characteristic of martensitic stainless steels. However, when tempered to its highest strength conditions, it is very susceptible to stress corrosion. This susceptibility develops in the same range of tempering temperatures as does the temper embrittlement (compare Figure 2.031 and Figure 3.02712).
- 2.031 Effect of tempering temperature on time to failure of statically stressed fatigue-cracked tensile specimens exposed to salt solution, Figure 2.031.
- 2.04 Nuclear Properties
- 3. MECHANICAL PROPERTIES
- 3.01 Specified Mechanical Properties
- 3.02 Mechanical Properties at Room Temperature
- 3.021 Tension.
- 3.0211 Stress-strain diagrams. (see also 3.03111 and 3.03112)
- 3.032111 Typical stress-strain curve at room temperature for cold-drawn fine wire, Figure 3.02111.
- 3.0212 Sheet.
- 3.02121 Effect of tempering temperature on tensile properties of sheet cold reduced 55 percent, Figure 3.02121.
- 3.02122 Effect of tempering temperature on tensile properties of sheet, Figure 3.02122.
- 3.02123 Effect of cold reduction and tempering temperature on sheet austenitized at 2000F, Figure 3.02123.
- 3.02124 Effect of austenitizing and tempering temperature on tensile and yield strength of sheet, Figure 3.02124.
- 3.0213 Bar.
- 3.02131 Effect of austenitizing and tempering temperature on tensile properties of bar, Figure 3.02131.
- 3.0214 Wire.
- 3.02141 Effect of cold reduction on tensile properties of wire, Figure 3.02141.
- 3.02142 Effect of cold reduction on tensile strength of rod, Figure 3.02142.
- 3.02143 Effect of exposure for 18 hours at various temperatures on tensile strength of fine wire, Figure 3.02143.
- 3.02144 Effect of short exposure to elevated temperatures on tensile strength of fine wire, Figure 3.02144.
- 3.02145 Tensile strengths achievable by combinations of cold reduction and tempering in successive stages, Figure 3.02145.

- 3.024 Bending.
- 3.025 Torsion and shear.
- 3.0251 Double shear strength of pins, Table 3.0251.

TABLE 3.0251

Source	(4)	
Alloy	Fe-(0.15C)-14.5Cr-13.5Co-5Mo-0.5V	
Form	(0.506 in round bar)	
Property	Double Shear Test	
Condition	1800, 1 hr, OQ+(-100F), 30 minutes, +1050F, 2 + 2 hours, AC	1900F, 1 hr, OQ + (-100F) 30 minutes, +1000F, 2 + 2 hours, AC
Double shear strength, lb	58.9	65.8
Shear stress - ksi (a)	149.9	167.5

(a) Stress calculated at twice the area corresponding to nominal diameter of shear pin, (0.3927 square inches).

- 3.026 Bearing.
- 3.027 Stress concentration.
- 3.0271 Notch properties.
- 3.02711 Effect of cold reduction on crack strength of sheet, Figure 3.02711.
- 3.02712 Effect of tempering temperature on yield strength, crack strength, and plane strain fracture toughness of sheet, Figure 3.02712.
- 3.0272 Fracture toughness.
- 3.02721 General. While only a very limited amount of meaningful plane strain fracture toughness data is available, tests on sharply notched or cracked specimens definitely indicate that very low fracture toughness is to be expected for tempering above about 700F, where high tensile and yield strengths can be obtained. Low tempering temperatures produce much tougher conditions, but these have relatively low strength (see also 1.09).
- 3.02722 Effect of tempering temperature on plane strain fracture toughness of sheet, Figure 3.02722. This figure is shown to indicate qualitatively that fracture toughness is substantially increased if tempering temperature is kept below 700F. The K_{IC} values (tempering temperature less than 800F) are from specimens not meeting ASTM size requirements (5).
- 3.028 Combined properties.
- 3.03 Mechanical Properties at Various Temperatures
- 3.031 Tension (see also 3.037).
- 3.0311 Stress-strain diagrams.
- 3.03111 Stress-strain curves in tension for sheet tempered at 700F, Figure 3.03111.
- 3.03112 Stress-strain curves in tension for sheet tempered at 1100F, Figure 3.03112.
- 3.0312 Bar.
- 3.03121 Effect of test temperature on tensile properties of bar after austenitizing at 2000F, Figure 3.03121.
- 3.03122 Tensile properties at room temperature, 900F and 1200F, Table 3.03122.

TABLE 3.03122

Source	(4)											
Alloy	AFC-77 (0.506 in round bar)											
Condition	1800F, 1 hr, OQ + (-100F), 30 min +1050F, 2 + 2 hr, AC			1900F, 1 hr, OQ + (-100F), 30 min, +1000F, 2+2 hr, AC			1800F, 1 hr, OQ + (-100F), 30 min, +1000F, 2+2 hr, AC			1900F, 1 hr, OQ + (-100F), 30 min, +1000F, 2+2 hr, AC		
Form	0.357 inch specimen			1/2 x 20 Bolt *			0.357 inch specimen			1/2 x 20 Bolt *		
Temperature - F	RT	900	1200	RT	900	1200	RT	900	1200	RT	900	1200
F _{tu} , (avg) - ksi	259	217	101	262	222	117	285	209	101	294	246	127
F _{ty} , (avg) - ksi	213	184	94	187	153	76	208	165	93	181	176	82
e, (avg) - percent	8.2	10.6	11.4	-	-	-	13.5	3.5	10.7	-	-	-
RA, (avg) - percent	26.7	38.8	52.2	-	-	-	48.5	31.3	52.3	-	-	-
Hardness, RC												
As received	37.0	-	-	-	-	-	37	-	-	-	-	-
HT	48.5	-	-	-	-	-	52.5	-	-	-	-	-

* Stress for bolts based on Basic Pitch Diameter area of 0.1716 square inch. All bolt threads were rolled.

- 3.022 Compression.
- 3.0221 Stress-strain diagrams (see 3.03113 and 3.03114).
- 3.0222 Effect of austenitizing and tempering temperatures on compressive yield strength, Figure 3.0222.
- 3.023 Impact (see also 3.0331 and 3.0332).
- 3.0231 Effect of austenitizing temperature on Charpy impact energy of bar tempered at 500 and 700F, Figure 3.0231.
- 3.03123 Effect of test temperature on tensile properties of smooth and notched bar for alloy austenitized at 2000F and tempered at 1100F, Figure 3.03123.
- 3.0313 Sheet.
- 3.03131 Effect of test temperature on tensile properties of .010 inch sheet tempered at 700F, Figure 3.03131.
- 3.03132 Effect of test temperature on tensile properties of .010

- 3.03133 inch sheet tempered at 1100F, Figure 3.03132.
- 3.03133 Effect of test temperature on tensile properties of .050 inch sheet tempered at various temperatures, Figure 3.03133.
- 3.03134 Effect of test temperature, prior exposure to stress and temperature, on yield strength of sheet in as-heat treated condition and after 10 percent cold roll, Figure 3.03134.
- 3.0314 Wire.
- 3.03141 Effect of test temperature on tensile strength of .006 inch diameter wire, Figure 3.03141.
- 3.03142 Effect of elevated temperatures on tensile strength of .006 inch wire thermomechanically processed to a room temperature tensile strength of 530 ksi, Figure 3.03142.
- 3.032 Compression.
- 3.0321 Stress-strain curves in compression for sheet tempered at 700F, Figure 3.0321.
- 3.0322 Stress-strain curves in compression for sheet tempered at 1100F, Figure 3.0322.
- 3.033 Impact.
- 3.0331 Effect of tempering temperature on Charpy-V impact properties at room temperature and 500F test temperatures, Figure 3.0331.
- 3.0332 Effect of tempering temperature on impact energy of subsized Charpy specimen at room and elevated temperatures, Figure 3.0332.
- 3.034 Bending. Specimens tempered at 1400F, 2 + 2 hours permitted. 180° bend for R/T = 4.5 at temperatures of 50, 25, 0, -25, and -50F (6, p. 132).
- 3.035 Torsion and shear. Average shear strength of sheet in longitudinal and transverse direction 170 ksi (6, p. 138).
- 3.036 Bearing.
- 3.037 Stress concentration.
- 3.0371 Notch properties.
- 3.03711 Effect of test temperature on tensile properties of smooth and notched sheet in as-heat treated condition and after 10 percent cold roll, Figure 3.03711.
- 3.03712 Effect of test temperature and prior exposure to stress and temperature on tensile properties of smooth and notched sheet tempered at 750F, Figure 3.03712.
- 3.03713 Effect of test temperature and prior exposure to stress and temperature on tensile strength and elongations of smooth and notched sheet in as-heat treated condition and after 10 percent cold roll, Figure 3.03713.
- 3.03714 Effect of test temperature on crack strength of sheet tempered at 900 and 1100F, Figure 3.03714.
- 3.0372 Fracture toughness.
- 3.03721 General. While no plane strain fracture toughness values are available at various temperatures, tests on sharply notched or cracked specimens indicate that fracture toughness would be poor at subzero temperatures (e.g. Figure 3.03711). Fracture toughness at moderately elevated temperatures is considerably improved over that at room temperature; however, the alloy is not stable for long time exposures to moderately elevated temperatures if tempered to give high strength (e.g. Figure 3.03712).
- 3.038 Combined properties.
- 3.04 Creep and Creep Rupture Properties
- 3.041 Bar.
- 3.0411 Creep rupture curves at 1000F and 1050F for smooth and notched bar tempered at 1400F, Figure 3.0411.
- 3.0412 Effect of austenitizing temperature on creep rupture life and ductility at 90 ksi and 1000F for smooth bar and on rupture life for notched bar, Figure 3.0412.
- 3.042 Sheet.
- 3.0421 Curves for 0.2 and 0.5 percent deformation and for rupture of sheet tempered at 1100F, Figure 3.0421.
- 3.043 Wire.
- 3.0431 Creep-rupture properties of .006 inch diameter wire drawn to room temperature tensile strength of 550 ksi and tested at temperatures from 800 to 1100F, Figure 3.0431.
- 3.05 Fatigue Properties
- 3.051 Axial fatigue of sheet tempered at 700F and tested at room and elevated temperatures, Figure 3.051.
- 3.052 Axial fatigue of sheet tempered at 1100F and tested at

room and elevated temperatures, Figure 3.052.

- 3.06 Elastic Properties
- 3.061 Poisson's ratio.
- 3.062 Modulus of elasticity.
- 3.0621 Elastic modulus at room and elevated temperatures for sheet tempered at 700F, Figure 3.0621.
- 3.0622 Elastic modulus at room and elevated temperatures for sheet tempered at 1100F, Figure 3.0622.

4. FABRICATION

- 4.01 Formability
- 4.011 Although experience is limited, this alloy appears to be readily formable by conventional methods.
- 4.012 Forming has been accomplished by heating to temperatures from 2000 to 2300F, and forging from 2300 to 1600F minimum without difficulty. Upper limit temperature of workability determined by soaking furnace available and by the tendency of a given heat to form free ferrite. (Contents of free ferrite above 5 percent may cause cracking.) Lower limit temperature of workability is determined by the capacity of available forging or rolling equipment. The high strength of this alloy implies need of high working forces, as temperature is lowered. In general, the hot workability of this alloy may be regarded as similar to that of Type 316 Stainless Steel.
- 4.013 For alloy austenitized at temperatures between 2000 and 2200F and water quenched, reduction by cold rolling is limited to approximately 25 percent before reannealing becomes necessary as a result of rapid strain hardening. If alloy is austenitized between 1600 and 2000F, air cooled, and tempered at 1400F for 2 + 2 + 2 hours, reductions of 75 percent can be accomplished, although high roll separating forces are required.

- 4.02 Machining and Grinding
- Machining is best accomplished after tempering at 1400F.

- 4.03 Welding

- 4.04 Heat Treatment

- 4.05 Surface Treatment

Fe
0.15 C
14.5 Cr
13.5 Co
5 Mo
0.5 V
0.05 N ₂

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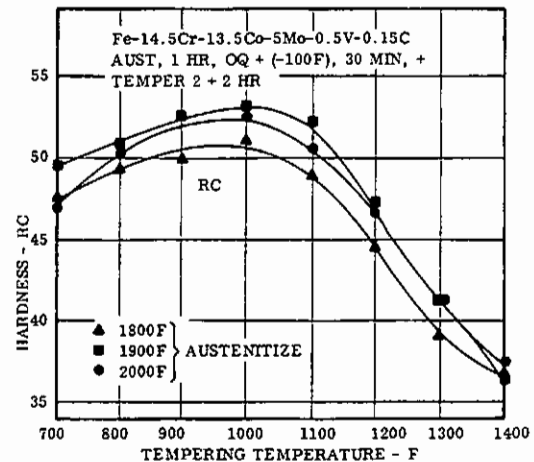


FIG. 1.062 EFFECT OF AUSTENITIZING AND TEMPERING TEMPERATURE ON ROCKWELL HARDNESS. (1, p. 112)

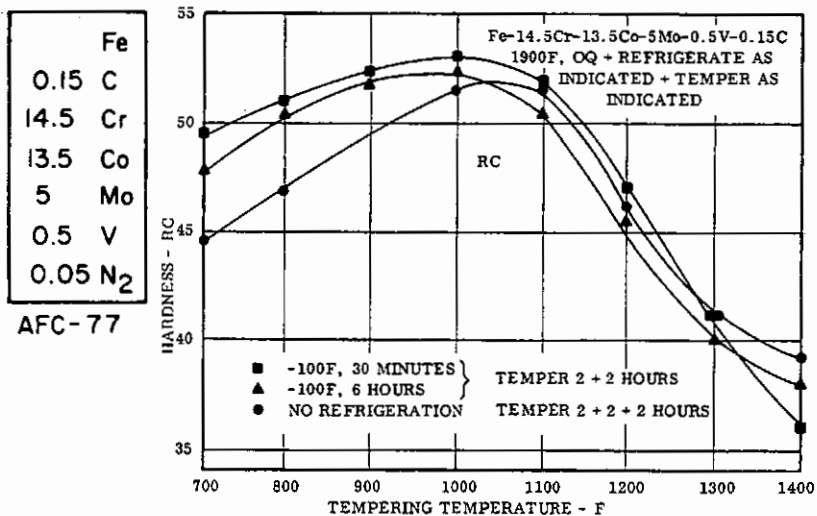


FIG. 1.063 EFFECT OF REFRIGERATION AND TEMPERING CONDITIONS ON HARDNESS OF ALLOY AUSTENITIZED AT 1900F. (1, p. 113)

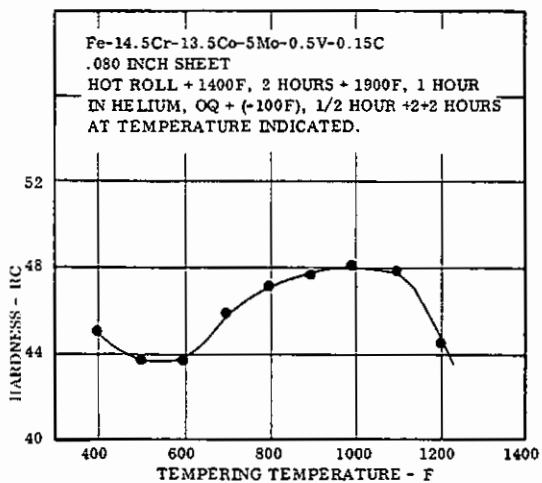


FIG. 1.064 EFFECT OF TEMPERING TEMPERATURE ON HARDNESS OF SHEET. (7, p. 77)

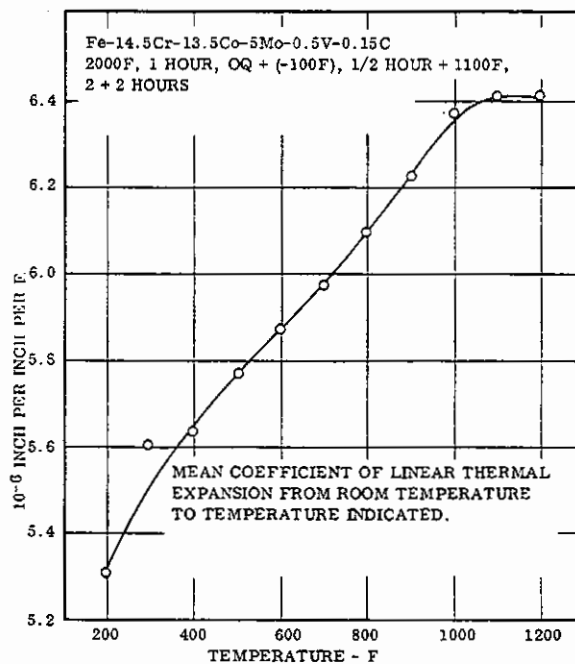


FIG. 2.014 THERMAL EXPANSION. (11, p. 37)

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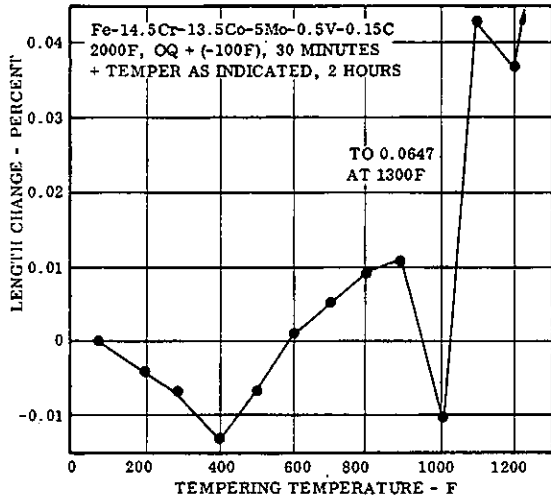


FIG. 2.0141 EFFECT OF TEMPERING TEMPERATURE ON DIMENSIONAL CHANGE OF ALLOY AUSTENITIZED AT 2000F. (1, p. 97)

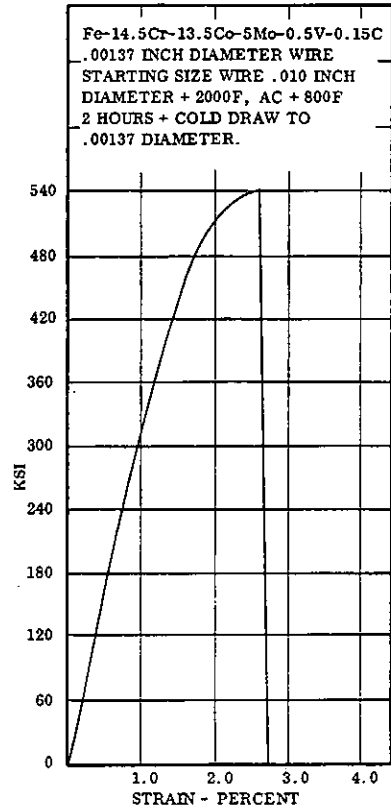


FIG. 3.02111 TYPICAL STRESS-STRAIN CURVE FOR COLD-DRAWN FINE WIRE. (9, p. 33)

	Fe
0.15	C
14.5	Cr
13.5	Co
5	Mo
0.5	V
0.05	N ₂

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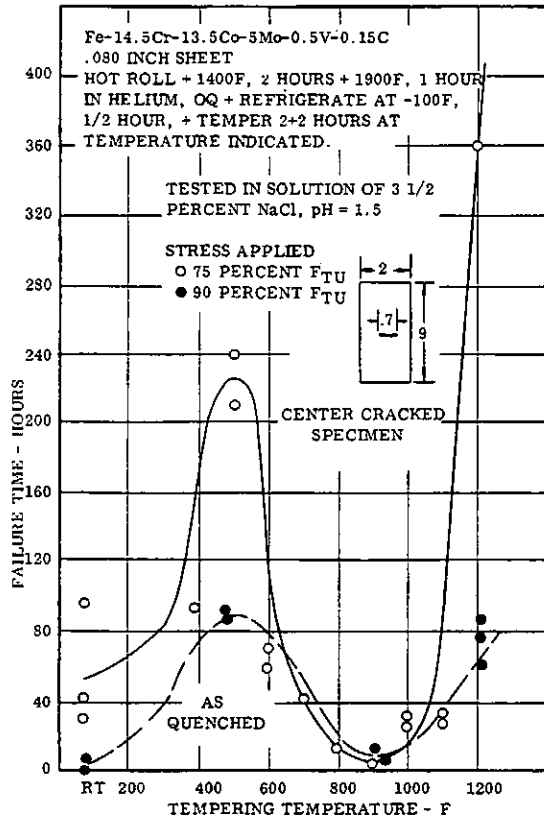


FIG. 2.031 EFFECT OF TEMPERING TEMPERATURE ON TIME TO FAILURE OF STATICALLY STRESSED FATIGUE CRACKED TENSILE SPECIMENS EXPOSED TO SALT SOLUTION. (7, p. 79)

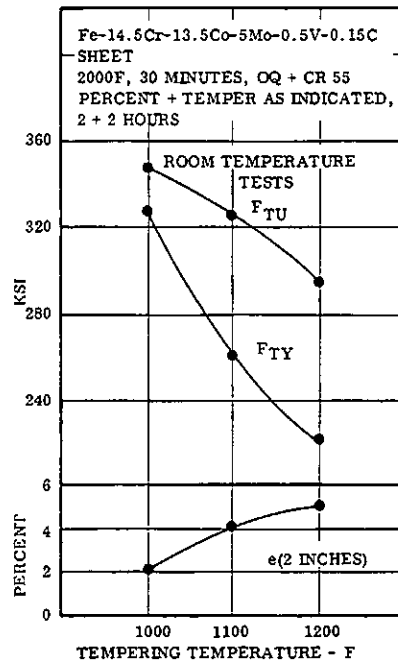


FIG. 3.02121 EFFECT OF TEMPERING TEMPERATURE ON TENSILE PROPERTIES OF SHEET COLD REDUCED 55 PERCENT. (2, p. 130)

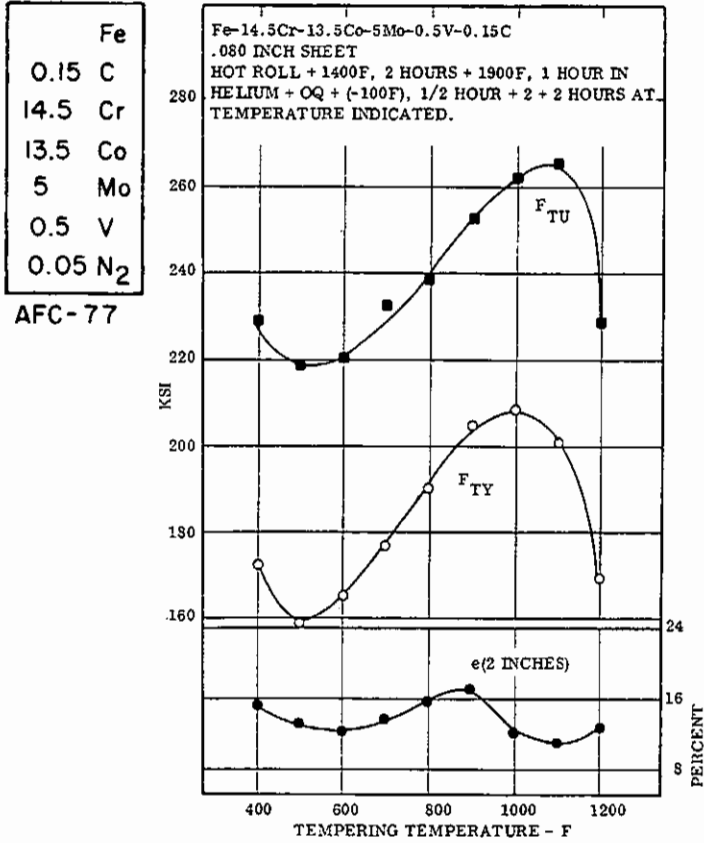


FIG. 3.02122 EFFECT OF TEMPERING TEMPERATURE ON TENSILE PROPERTIES OF SHEET. (7, p. 77)

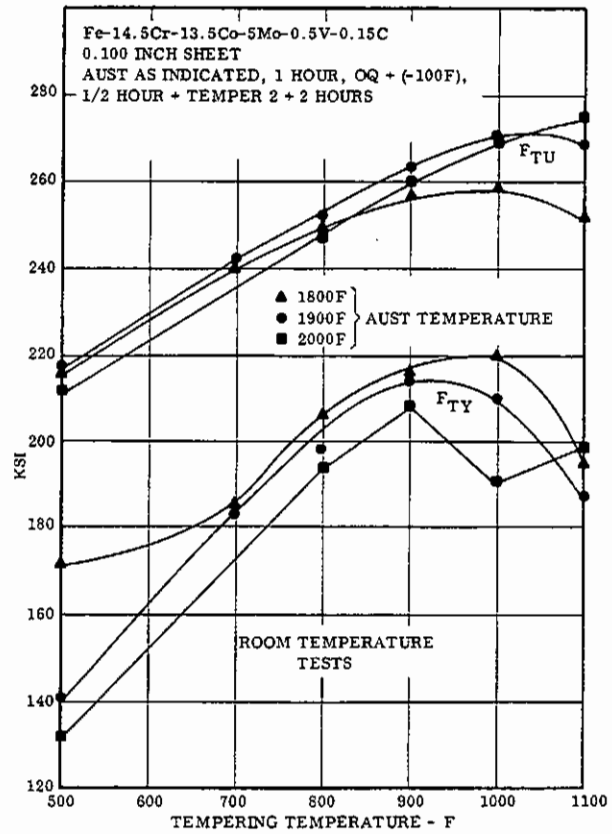


FIG. 3.02124 EFFECT OF AUSTENITIZING AND TEMPERING TEMPERATURE ON TENSILE AND YIELD STRENGTH OF SHEET AT ROOM TEMPERATURE. (1, p. 114)(11, p. 34)

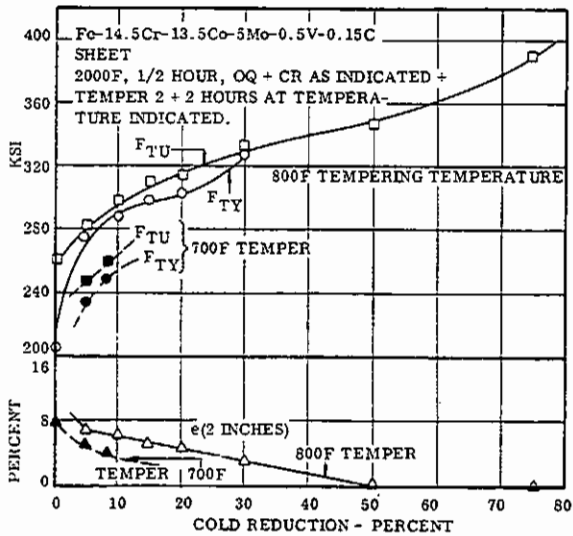


FIG. 3.02123 EFFECT OF COLD REDUCTION AND TEMPERING TEMPERATURE ON SHEET AUSTENITIZED AT 2000F. (11, p. 33)

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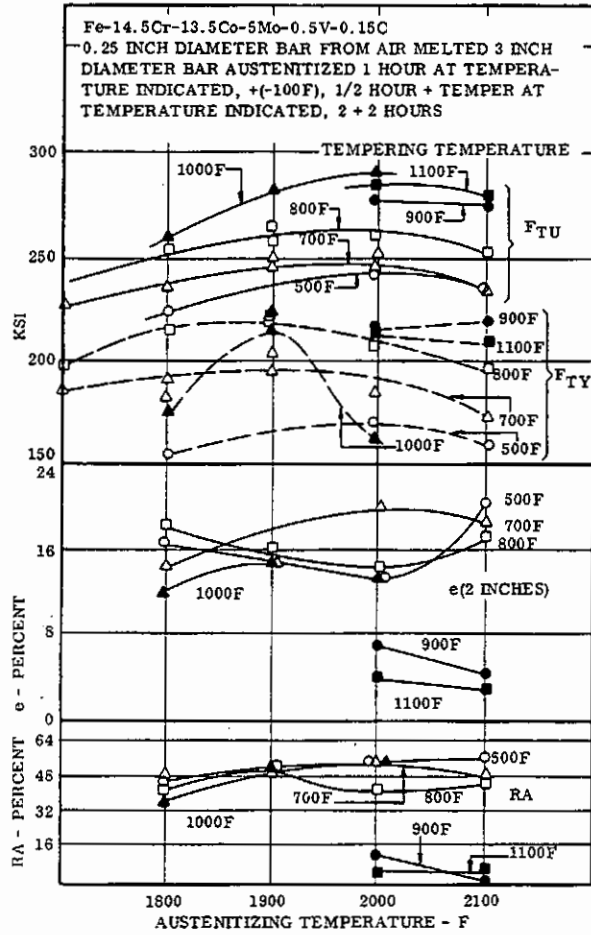


FIG. 3.02131 EFFECT OF AUSTENITIZING AND TEMPERING TEMPERATURE ON TENSILE PROPERTIES OF BAR. (12, pp. 820, 821)

Fe
0.15 C
14.5 Cr
13.5 Co
5 Mo
0.5 V
0.05 N ₂

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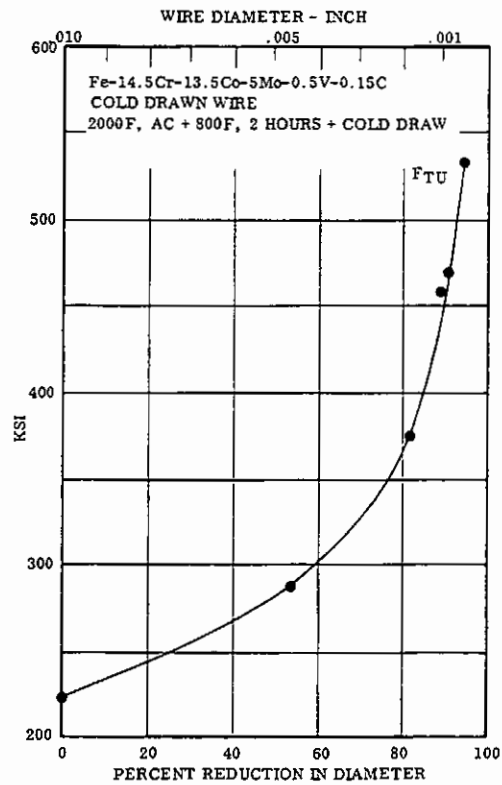


FIG. 3.02141 EFFECT OF COLD REDUCTION ON TENSILE STRENGTH OF WIRE. (9, p. 32)

Fe
0.15 C
14.5 Cr
13.5 Co
5 Mo
0.5 V
0.05 N ₂
AFC-77

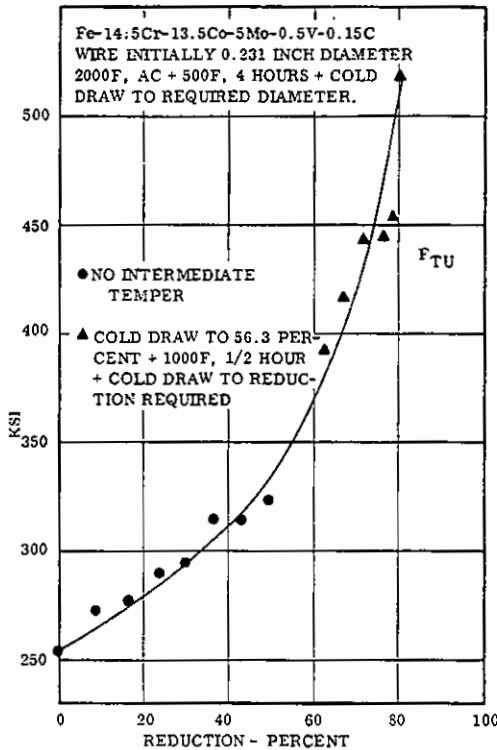


FIG. 3.02142 EFFECT OF COLD REDUCTION ON TENSILE STRENGTH OF ROD. (9, p. 37)

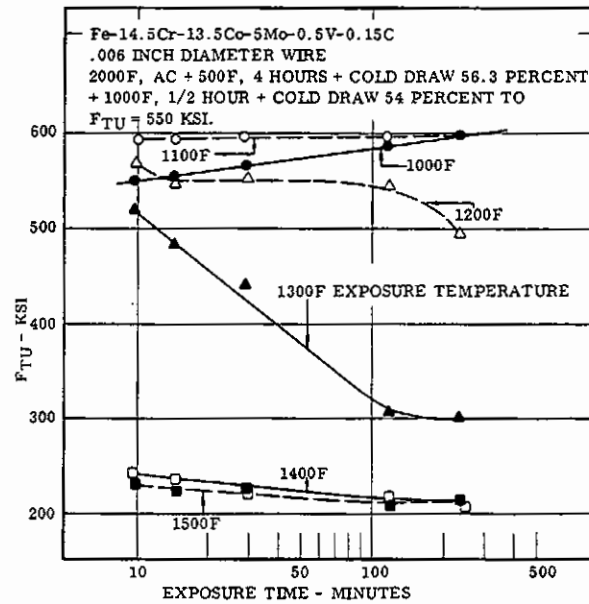


FIG. 3.02144 EFFECT OF SHORT EXPOSURE TO ELEVATED TEMPERATURES ON TENSILE STRENGTH OF FINE WIRE. (9, p. 34)

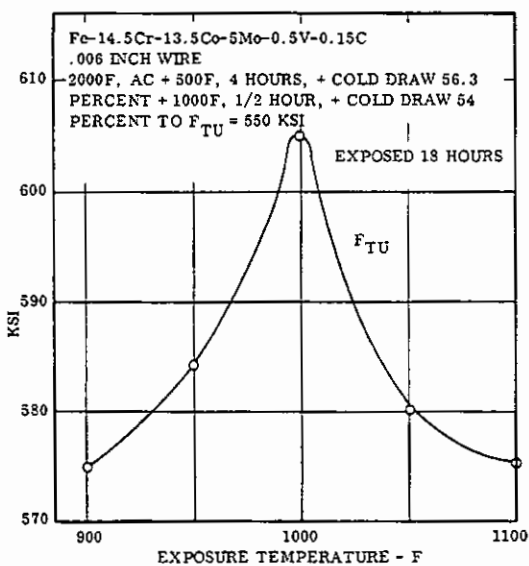


FIG. 3.02143 EFFECT OF EXPOSURE FOR 18 HOURS AT VARIOUS TEMPERATURES ON TENSILE STRENGTH OF FINE WIRE. (9, p. 23)

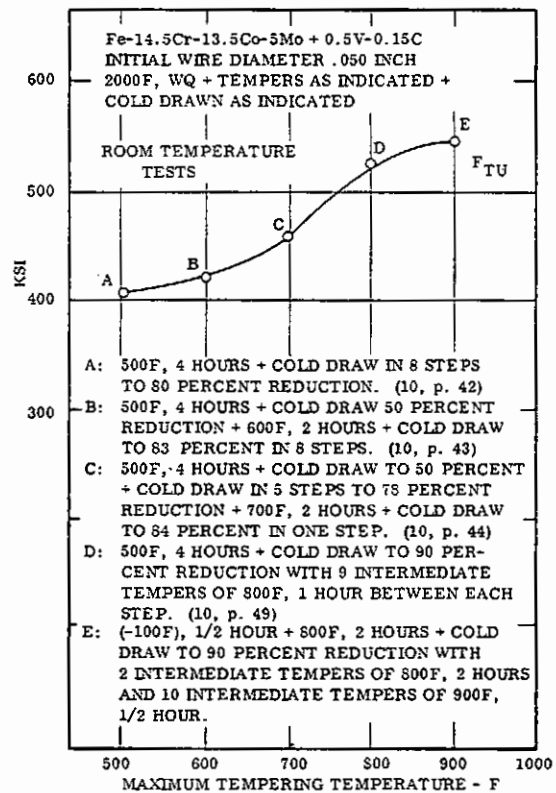


FIG. 3.02145 TENSILE STRENGTHS ACHIEVABLE BY COMBINATIONS OF COLD REDUCTION AND TEMPERING IN SUCCESSIVE STAGES. (10, pp. 42, 43, 49, 50, 56)

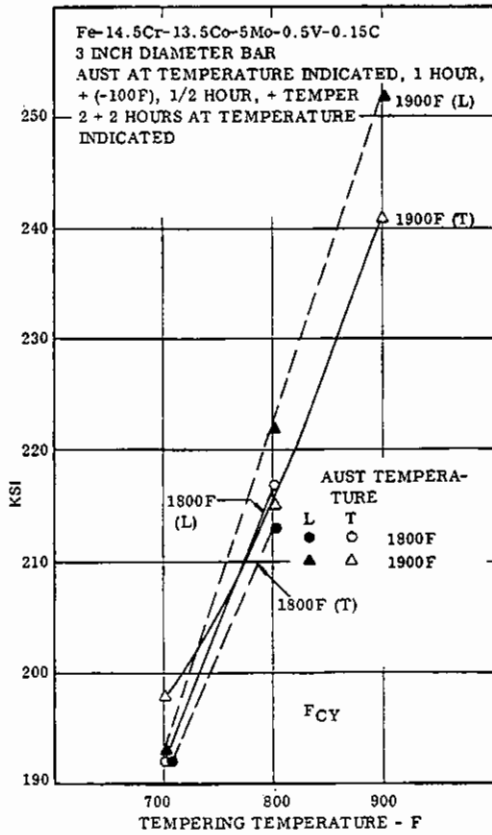


FIG. 3.0222 EFFECT OF AUSTENITIZING AND TEMPERING TEMPERATURES ON COMPRESSIVE YIELD STRENGTH. (12, p. 822)

	Fe
0.15	C
14.5	Cr
13.5	Co
5	Mo
0.5	V
0.05	N ₂

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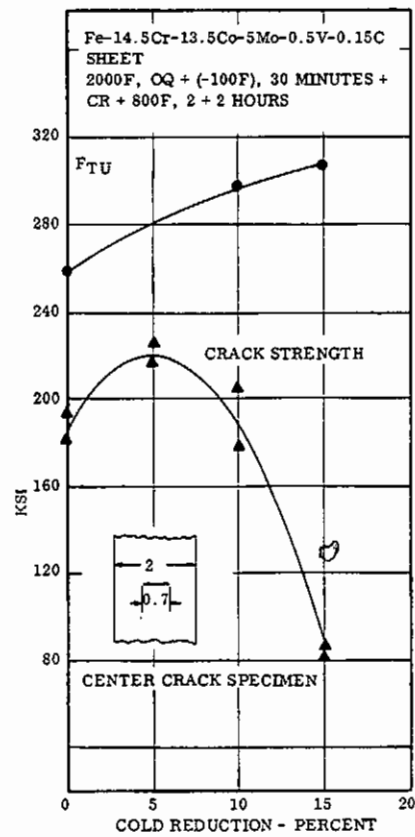


FIG. 3.02711 EFFECT OF COLD REDUCTION ON CRACK STRENGTH. (1, p. 49)

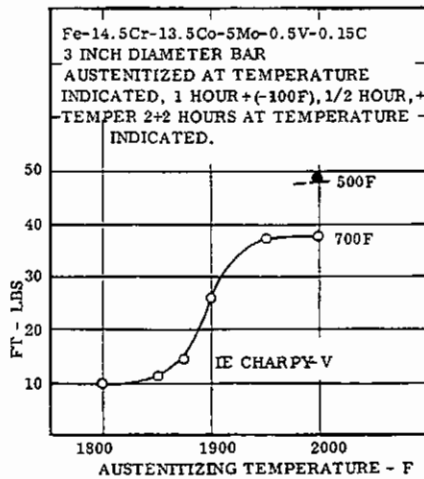


FIG. 3.0231 EFFECT OF AUSTENITIZING TEMPERATURE ON CHARPY IMPACT ENERGY OF BAR TEMPERED AT 500 AND 700F. (12, p. 819)

Fe
0.15 C
14.5 Cr
13.5 Co
5 Mo
0.5 V
0.05 N ₂

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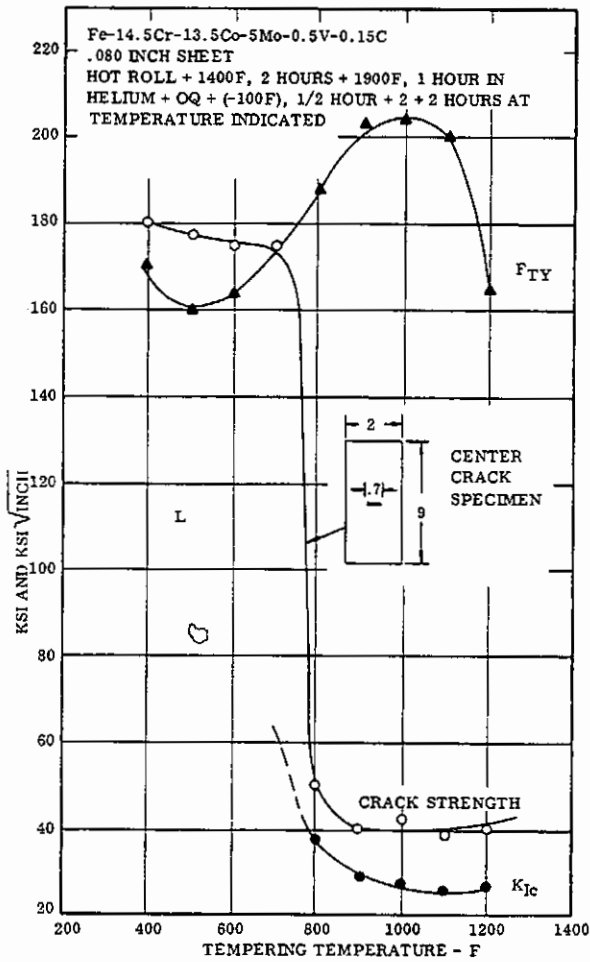


FIG. 3.02712 EFFECT OF TEMPERING TEMPERATURE ON YIELD STRENGTH, CRACK STRENGTH, AND PLANE STRAIN FRACTURE TOUGHNESS OF SHEET. (7, p. 78)

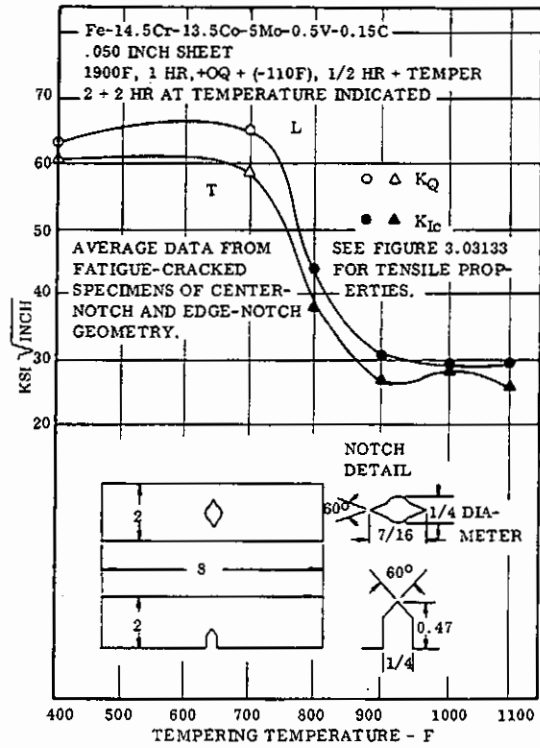


FIG. 3.02722 EFFECT OF TEMPERING TEMPERATURE ON PLANE STRAIN FRACTURE TOUGHNESS OF SHEET. (8, p. 38)

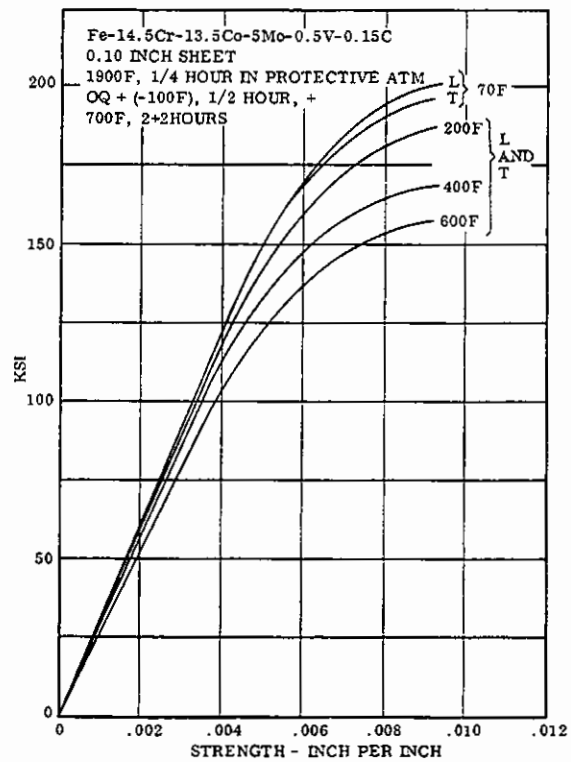


FIG. 3.03111 STRESS-STRAIN CURVES IN TENSION FOR SHEET TEMPERED AT 700F. (6, p. 145)

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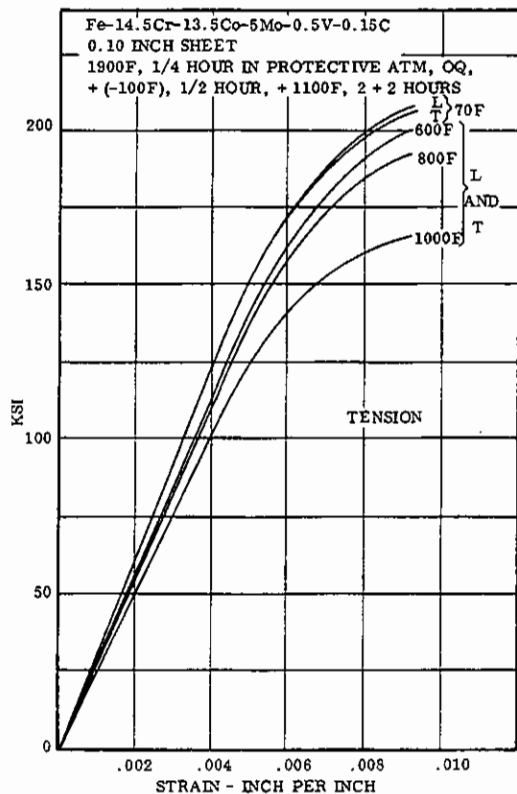


FIG. 3.03112 STRESS-STRAIN CURVES IN TENSION FOR SHEET TEMPERED AT 1100F. (61, p. 160)

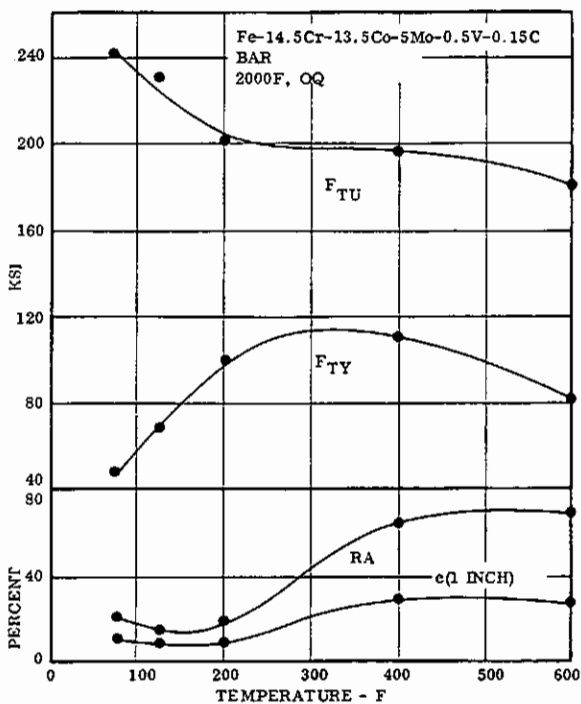


FIG. 3.03121 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF BAR AFTER AUSTENITIZING AT 2000F. (2, p. 48)

Fe
0.15 C
14.5 Cr
13.5 Co
5 Mo
0.5 V
0.05 N ₂
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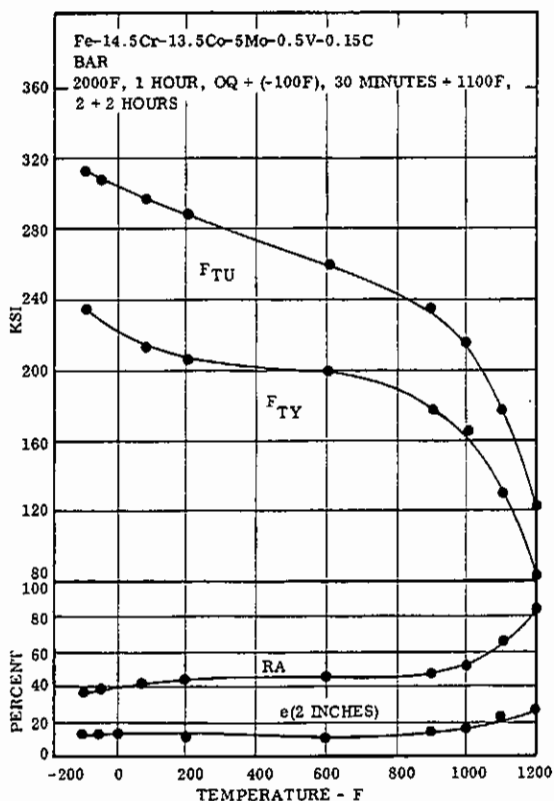


FIG. 3.03123 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF BAR FOR ALLOY AUSTENITIZED AT 2000F, AND TEMPERED AT 1100F. (1, p. 51)

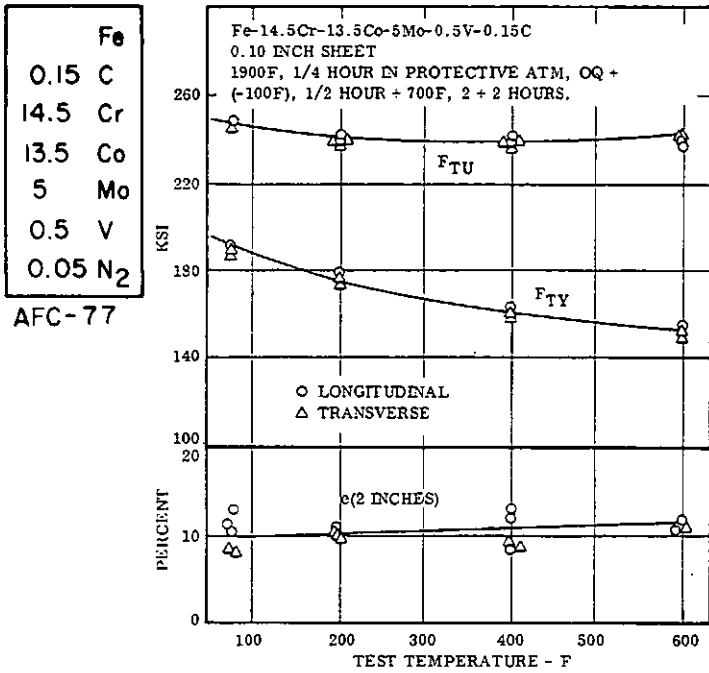


FIG. 3.03131 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF 0.10 INCH SHEET TEMPERED AT 700F. (6, p. 146)

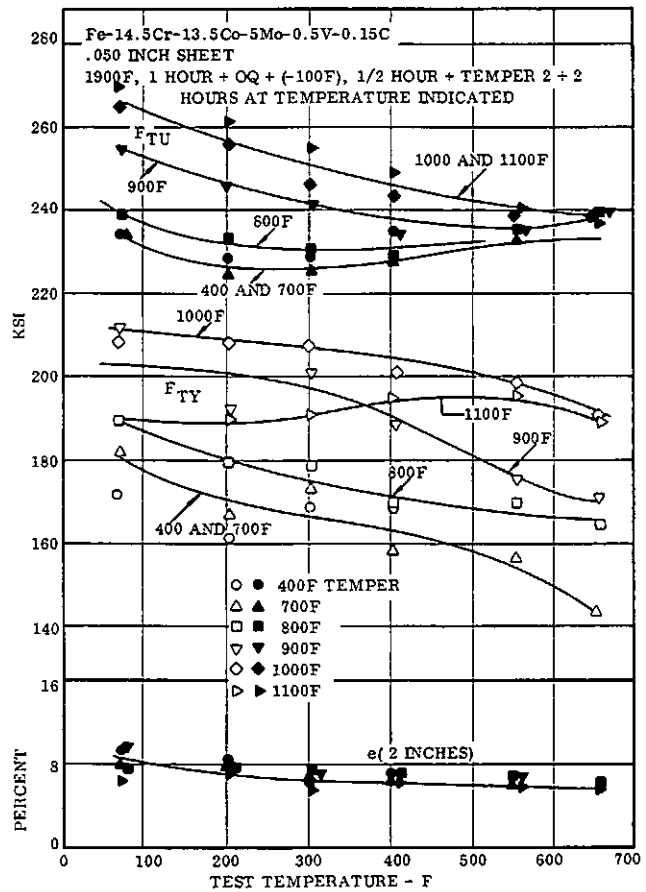


FIG. 3.03133 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF .050 INCH SHEET TEMPERED AT VARIOUS TEMPERATURES. (8, p. 22)

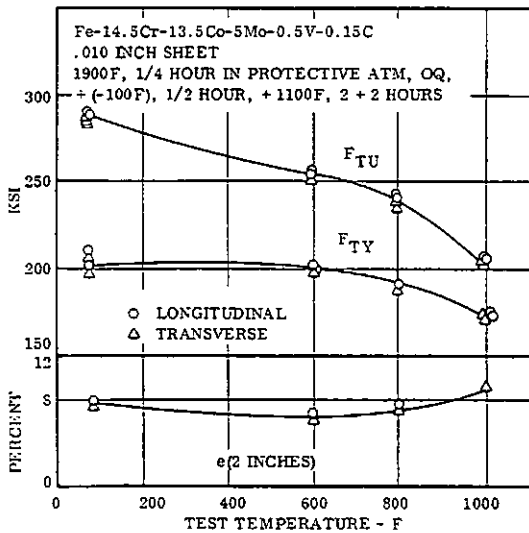
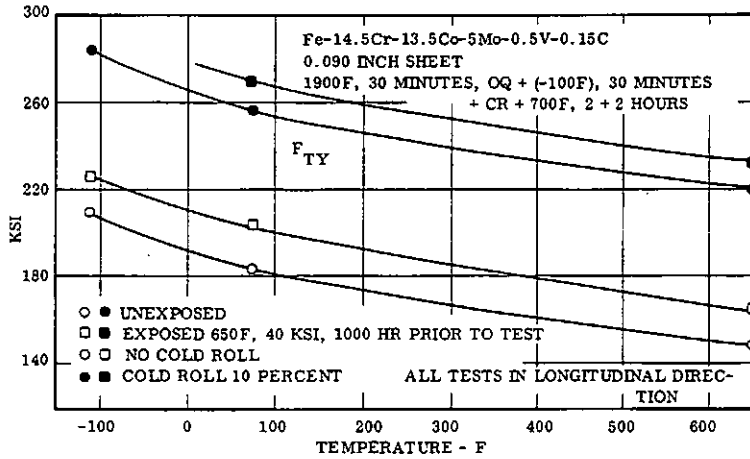


FIG. 3.03132 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF .010 INCH SHEET TEMPERED AT 1100F. (6, p. 161)

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Fe
0.15 C
14.5 Cr
13.5 Co
5 Mo
0.5 V
0.05 N ₂

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FIG. 3.03134 EFFECT OF TEST TEMPERATURE, PRIOR EXPOSURE TO STRESS AND TEMPERATURE ON YIELD STRENGTH OF SHEET IN AS-HEAT-TREATED CONDITION AND AFTER 10 PERCENT COLD ROLL. (1, p. 76)

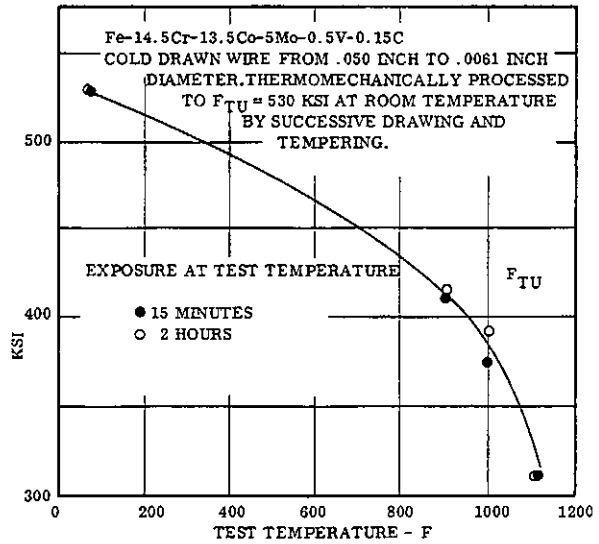


FIG. 3.03142 EFFECT OF ELEVATED TEMPERATURES ON TENSILE STRENGTH OF .006 INCH DIAMETER WIRE THERMOMECHANICALLY PROCESSED TO A ROOM TEMPERATURE TENSILE STRENGTH OF 530 KSI. (10, p. 58)

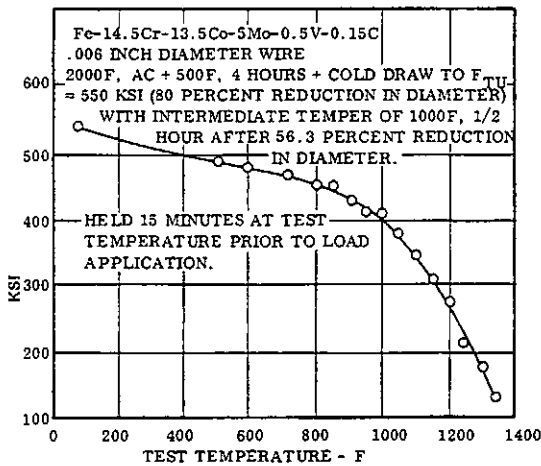


FIG. 3.03141 EFFECT OF TEST TEMPERATURE ON TENSILE STRENGTH OF .006 INCH DIAMETER WIRE. (9, p. 24)

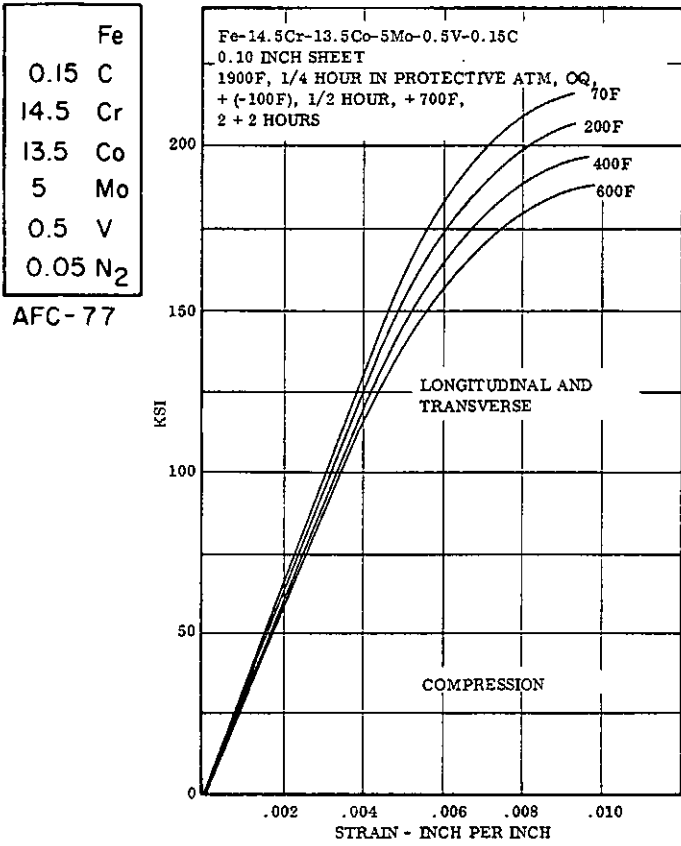


FIG. 3.0321 STRESS-STRAIN CURVES IN COMPRESSION FOR SHEET TEMPERED AT 700F. (6, p. 147)

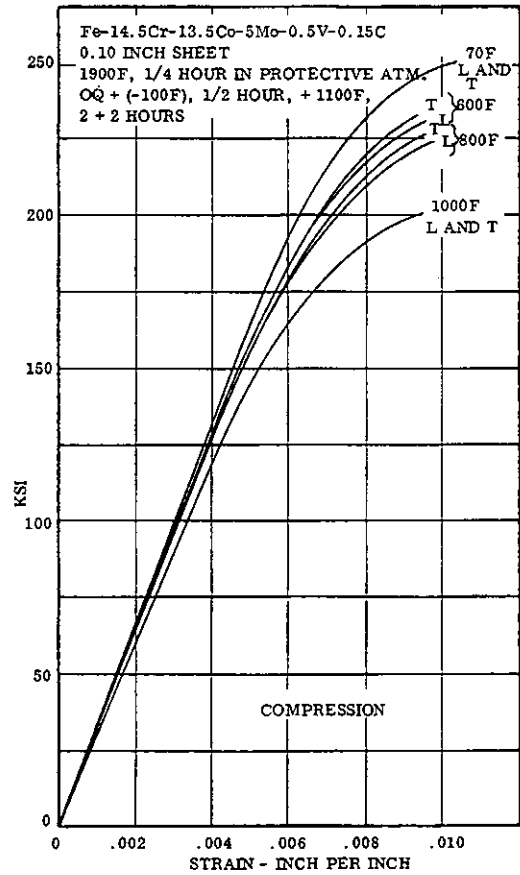
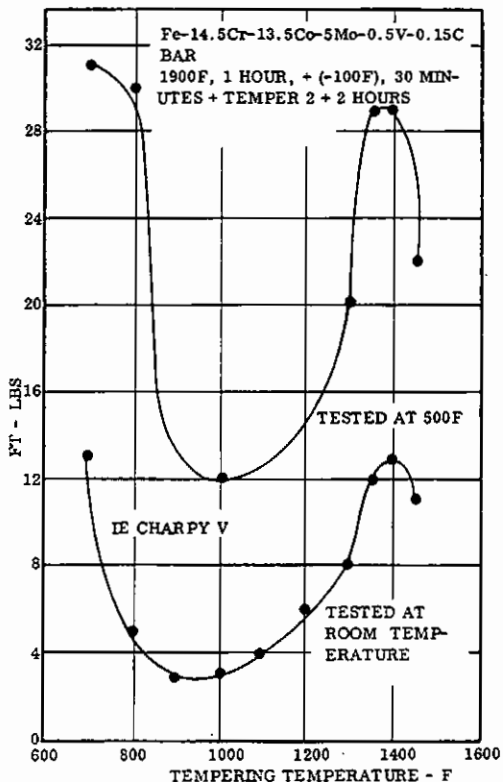


FIG. 3.0322 STRESS-STRAIN CURVES IN COMPRESSION FOR SHEET TEMPERED AT 1100F. (6, p. 162)

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Fe
0.15 C
14.5 Cr
13.5 Co
5 Mo
0.5 V
0.05 N ₂

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FIG. 3.0331 EFFECT OF TEMPERING TEMPERATURE ON CHARPY V IMPACT PROPERTIES AT ROOM TEMPERATURE AND 500F TEST TEMPERATURES. (1, p. 80)

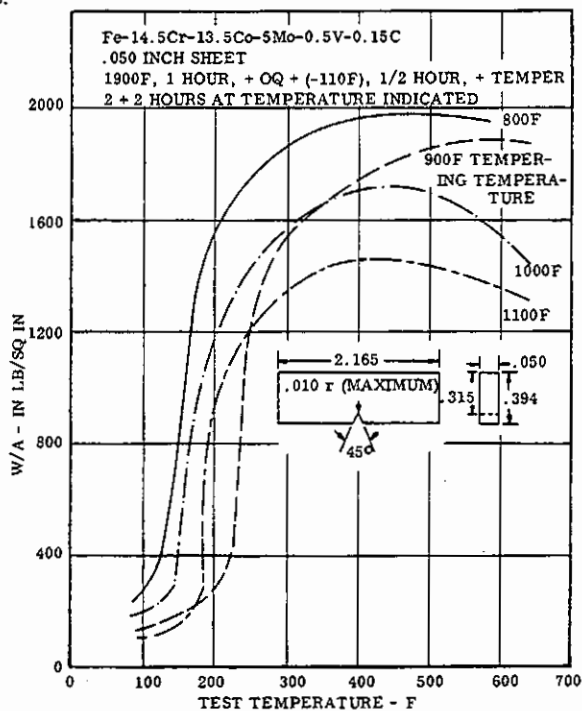


FIG. 3.0332 EFFECT OF TEMPERING TEMPERATURE ON IMPACT ENERGY OF SUBSIZE CHARPY SPECIMEN AT ROOM AND ELEVATED TEMPERATURES. (8, pp. 30, 32, 34, 36)

Fe
0.15 C
14.5 Cr
13.5 Co
5 Mo
0.5 V
0.05 N ₂

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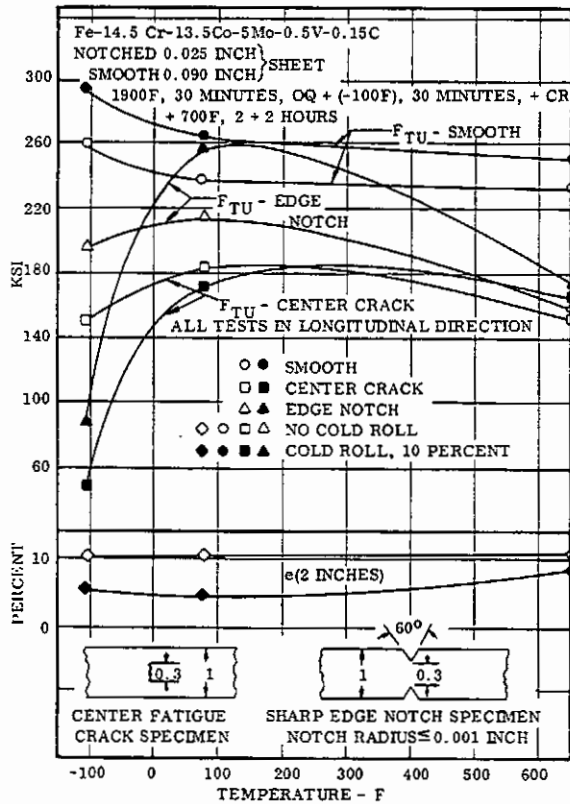


FIG. 3.03711 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF SMOOTH AND NOTCHED SHEET IN AS-HEAT-TREATED CONDITION AND AFTER 10 PERCENT COLD ROLL. (1, p. 76)

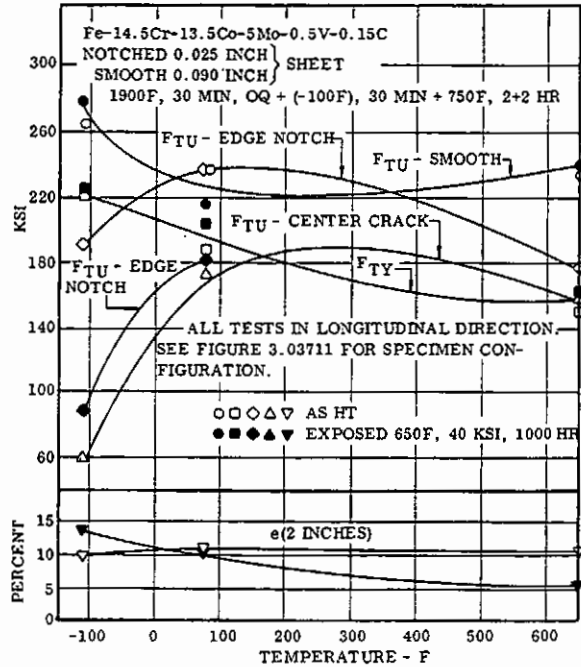


FIG. 3.03712 EFFECT OF TEST TEMPERATURE AND PRIOR EXPOSURE TO STRESS AND TEMPERATURE ON TENSILE PROPERTIES OF SMOOTH AND NOTCHED SHEET TEMPERED AT 750F. (1, p. 76)

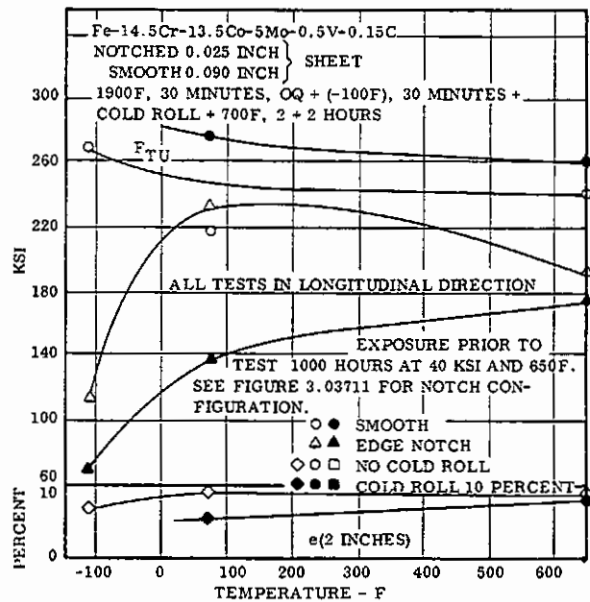


FIG. 3.03713 EFFECT OF TEST TEMPERATURE AND PRIOR EXPOSURE TO STRESS AND TEMPERATURE ON TENSILE STRENGTH AND ELONGATIONS OF SMOOTH AND NOTCHED SHEET IN AS-HEAT-TREATED CONDITION AND AFTER 10 PERCENT COLD ROLL. (1, p. 76)

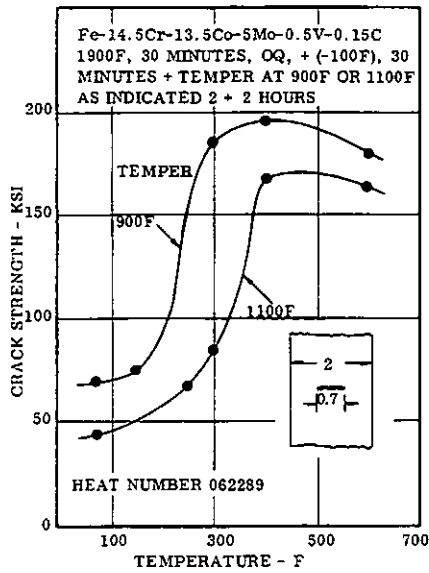


FIG. 3.03714 EFFECT OF TEST TEMPERATURE ON CRACK STRENGTH OF SHEET TEMPERED AT 900 AND 1100F. (5)

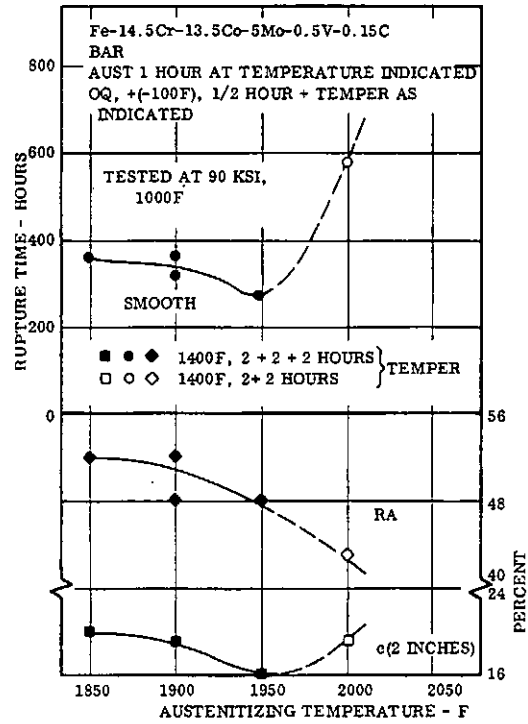


FIG. 3.0412 EFFECT OF AUSTENITIZING TEMPERATURE ON CREEP RUPTURE LIFE AND DUCTILITY AT 90 KSI AND 1000F FOR SMOOTH BAR. (11, p. 36)

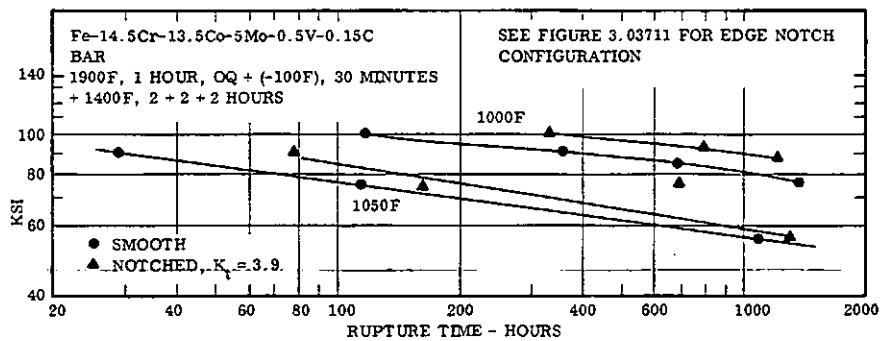


FIG. 3.0411 CREEP RUPTURE CURVES AT 1000 AND 1050F FOR SMOOTH AND NOTCHED BAR TEMPERED AT 1400F. (1, p. 52)

Fe
0.15 C
14.5 Cr
13.5 Co
5 Mo
0.5 V
0.05 N ₂

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