	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

1 GENERAL

Inconel X-750 is a precipitation-hardenable nickel chromium alloy containing aluminum and titanium, which form the hardening component. Although much of the effect of precipitation-hardening is lost with increasing temperature over 1300 F, the heat-treated material has useful strength and oxidation resistance at temperatures up to 1800 F. It also has excellent properties at subzero temperatures; consequently, it is useful for cryogenic applications. The alloy has good formability and weldability and resistance to corrosion and stress corrosion in most environments. Aerospace applications include rotor blades, wheels, and bolts for gas turbines; rocket-engine thrust chambers; and hot-air ducting systems and thrust reversers for airframes. It is also used for large pressure vessels, forming tools, extrusion dies, and heat-treat fixtures. For springs and fasteners, Inconel X-750 is used from subzero temperatures to 1200 F.

1.01 Commercial Designation

Inconel Alloy X-750.

1.02 Alternate Designations

UNS NO7750, Inconel-X750, IN-X750, Inconel-X (obsolete).

1.03 Specifications

Table 1.03.

1.04 Composition

Table 1.04.

1.05 Heat Treatment

1.051 Annealing to remove the effects of cold work and heat treatment: 2000 F, 1 hr or less, AC.

1.052 Solution treatment for complete solution of all microconstituents and for maximum softening: 2100 F, 1 hr or less, AC.

1.053 Inconel X-750 is normally used in the precipitation-hardened condition. The exact thermal treatment required varies with the product form, service temperature range, and desired optimum properties.

1.0531 Typical thermal treatments to precipitation-harden various Inconel X-750 products, Table 1.0531.

1.054 If oxidation cannot be tolerated, protective atmospheres should be used during annealing and solution treating. A dilute exothermic atmosphere provides partial protection against oxidation, but a bright finish requires a vacuum or argon environment. Air is the most common atmosphere for aging since the smooth oxide layer that is formed is usually acceptable. However, if the oxide layer must be minimized, a lean exothermic gas can be used. To prevent carbon pickup, atmospheres with a carbonization potential and surface contamination with organic material should be avoided. Sulfur-bearing atmospheres and surface contaminants should be avoided since they tend to corrode the metal (46).

1.06 Hardness

1.061 Hardness at room temperature of wrought products in various heat-treated conditions, Table 1.061.

1.062 Hardness from 80 to 1750 F of bar in the precipitation-treated condition and in the fully solution-treated, stabilized, and precipitation-treated conditions, Figure 1.062.

1.063 Effect of cold work on hardness at room temperature, Figure 1.063.

1.07 Forms and Conditions Available

1.071 Inconel X-750 is available in a wide range of standard shapes and forms including sheet, strip, plate, rod, bar, forgings, tube, and wire. The forms can be obtained in the annealed or precipitation-hardened condition (1).

1.08 Melting and Casting Practice

1.081 The alloy is produced by air-induction melting, vacuum-induction melting, and vacuum-arc remelting of vacuum-induction-melted stock.

1.09 Special Considerations

1.091 A marked reduction in ductility occurs from 1000 to 1500 F, which is characteristic of many nickel-base superalloys. See Figures 3.0313 through 3.0317.

1.092 Grain growth increases rapidly with increasing temperatures above 1900 F.

1.0921 Effects of time and temperature on grain growth, Figure 1.0921.

1.093 A small amount of contraction occurs during precipitation treatment. For example, aging 20 hr at 1300 F causes linear contraction of 0.044 percent in hot-rolled material, 0.052 percent in material which is cold-rolled 20 percent, and 0.026 percent in annealed material (1).

2 PHYSICAL PROPERTIES AND ENVIRONMENTAL EFFECTS

2.01 Thermal Properties

2.011 Melting range, 2540 to 2600 F (1).

2.012 Phase changes.

2.0121 Time-temperature-transformation diagrams.

2.0122 Full solution treatment produces a face-centered cubic structure with all alloying elements in solid solution. Precipitation treatments produce a fine dispersion of nickel (aluminum, titanium) and chromium carbides in the face-centered cubic matrix (1) (29).

2.013 Thermal conductivity.

2.0131 Thermal conductivity from –459 to 1880 F, Figure 2.0131.

2.014 Thermal expansion.

2.0141 Thermal expansion from –400 to 1800 F, Figure 2.0141.

2.015 Specific heat.

2.0151 Specific heat from –459 to 1700 F, Figure 2.0151.

2.016 Thermal diffusivity.

2.0161 Thermal diffusivity from –415 to 1880 F, Figure 2.0161.

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

2.02 Other Physical Properties
2.021 Density.
2.0211 Density from -460 to 2420 F, Figure 2.0211.
2.022 Electrical properties.
2.0221 Electrical properties at room temperature of hot-rolled bar in various heat-treated conditions, Table 2.0221.
2.0222 Electrical resistivity from 70 to 1600 F for all wrought products in the fully solution-treated, stabilized, and precipitation-treated conditions, Figure 2.0222.
2.0223 Resistivity from 32 F to -453 F, Figure 2.0223.
2.023 Magnetic properties.
2.0231 Magnetic permeability (70 F, H = 200 oersted): As hot rolled, 1.0020 (1). Fully solution-treated, stabilized, and precipitation-treated, 1.0035 (1).
2.024 Emittance.
2.0241 Total normal emittance from -320 to 1900 F, Figure 2.0241.
2.0242 Spectral emittance, Figure 2.0242.
2.025 Damping capacity.
2.0251 Damping decrement in torsion for wire in various heat-treated conditions, Table 2.0251.

2.03 Chemical Environment
2.031 Inconel X-750 has good resistance to general corrosion and stress corrosion over a wide range of temperatures under both oxidizing and reducing conditions.
2.0311 Gain in weight of sheet exposed to pure oxygen at 1832 F, Figure 2.0311.
2.0312 In corrosion tests at 1700 F, samples coated with sodium chloride, exposed for 100 hr to moving air containing 1 percent sulfur dioxide, and corroded to a maximum penetration of about 0.007 inch (1).
2.0313 The alloy is highly resistant to attack by liquid sodium-potassium (NaK) at temperatures up to at least 1300 F (20).
2.0314 It is compatible with cesium vapor for at least 48 hr at temperatures up to 1200 F. At 1600 F liquid cesium causes decarbonization but no corrosive surface attack (23).
2.0315 It has good resistance to corrosion when exposed at 1500 F to the combustion products of high-sulfur diesel fuel (45).
2.0316 Inconel X-750 is resistant to chloride-ion stress-corrosion cracking even in the fully precipitation-hardened condition. Standard U-bend specimens of precipitation-hardened material (hardness R_C 33) showed no cracking when exposed to boiling 42 percent magnesium chloride for 30 days (1).
2.0317 In both moving and still seawater, Inconel X-750 has excellent resistance to both general corrosion and stress corrosion; however, it is susceptible to localized crevice corrosion severe enough to cause perforations of panels 1/8 inch thick in a 2-year period (54).
2.0318 It is highly resistant to stress corrosion in aqueous hydrogen sulfide solutions (49).
2.0319 It is susceptible to stress-corrosion cracking in hydrazine around a 300 F regime and also to general corrosion in hydrazine at 1750 F (25).

2.04 Nuclear Environment
2.041 Effects of neutron irradiation on longitudinal tensile properties from -320 to 1540 F of sheet in the solution-treated, stabilized, and precipitation-treated conditions, Table 2.041.
2.042 Effects of neutron irradiation on tensile properties of butt-welded sheet from -320 to 1540 F; gas-tungsten-arc welds with No. 69 filler metal across center of gage section of specimens, Table 2.042.
2.043 Inconel X-750 is highly susceptible to embrittlement by helium in concentrations equivalent to accruals in fast-reactor core components after several years of reactor service (15).
2.044 Plate material, annealed and precipitation-treated at 1300 F, 20 hr, had ultimate shear strength (F_{su}) of 152.8 ksi at -423 F before exposure and 162.0 ksi after exposure to nuclear radiation of 6 x 10^{16} nvt (E > 1.0 nev) (28).
2.045 The alloy is resistant to corrosion in moist air under high-dose-rate gamma-radiation fields of 5 to 6 megarads per hr (44).

3 MECHANICAL PROPERTIES

3.01 Specified Mechanical Properties
3.011 AMS specified mechanical properties of strip, sheet, plate, and tubing, Table 3.011.
3.012 AMS specified mechanical properties of bars, forgings, and rings, Table 3.012.
3.013 AMS specified mechanical properties of wire, Table 3.013.

3.02 Mechanical Properties at Room Temperature
3.021 Tension—Stress-strain diagrams—Tension properties.
3.0211 Stress-strain diagrams, see Figures 3.0311 and 3.0312.
3.0212 Room-temperature tensile properties of furnace-cool precipitation-treated bar in diameters from 1/2 inch to 2-15/16 inch, Figure 3.0212.
3.0213 Effects of cold-rolling on tensile properties of precipitation-treated sheet, Figure 3.0213.
3.0214 Room-temperature tensile properties of wire in various tempers and heat-treated conditions, Table 3.0214.
3.022 Compression—Stress-strain diagrams—Compression properties.
3.0221 Stress-strain diagrams, see Figure 3.0321.
3.0222 Compressive yield strength at room temperature of sheet in the precipitation-treated condition, Table 3.0222.
3.023 Impact.
3.0231 Room-temperature impact properties of plate in various sizes in the furnace-cool precipitation-treated condition, Table 3.0231.
3.024 Bending.
3.025 Torsion and shear.
3.0251 Ultimate shear strength at room temperature of sheet in the precipitation-treated condition, Table 3.0251.
3.026 Bearing, see Figure 3.0361.
3.027 Stress concentration.
3.0271 Notch properties.

3.02711	Comparison of room-temperature notch tensile strength with tensile properties of bar in the equalized and precipitation-treated conditions, Table 3.02711.
3.0272	Fracture toughness, see Table 4.0314.
3.028	Combined properties.
3.03	Mechanical Properties at Various Temperatures
3.031	Tension–Stress-strain diagrams–Tension properties.
3.0311	Stress-strain curves from room temperature to −423 F for sheet in the precipitation-treated condition, Figure 3.0311.
3.0312	Complete stress-strain curves from room temperature to −423 F for bar in the precipitation-treated condition, Figure 3.0312.
3.0313	Tensile properties of equalized and precipitation-treated bar from 80 to 1500 F, Figure 3.0313.
3.0314	Tensile properties of bar in solution-treated condition and in two furnace-cool precipitation-treated conditions from 80 to 1500 F, Figure 3.0314.
3.0315	Tensile properties from 80 to 1600 F of sheet in the annealed and precipitation-treated conditions, Figure 3.0315.
3.0316	Tensile properties from 80 to 1500 F of sheet in the furnace-cool precipitation-treated condition, Figure 3.0316.
3.0317	Tensile properties from 80 to 1800 F of bar fully solution-treated, stabilized, and precipitation-treated, Figure 3.0317.
3.0318	Tensile properties from 78 to −423 F of sheet in the solution-treated condition, Figure 3.0318.
3.0319	Tensile properties from 78 to −423 F of sheet in the precipitation-treated condition, Figure 3.0319.
3.03110	Tensile properties of precipitation-treated sheet and bar with various surface finishes from 75 to −423 F, Figure 3.03110.
3.03111	Tensile properties from 80 to −423 F of rod fully solution-treated, stabilized, and precipitation treated, Figure 3.03111.
3.03112	Effects of strain rate and holding time from 75 to 2250 F on tensile properties of precipitation-treated sheet after it had been heated to test temperature within 10 seconds, Figure 3.03112.
3.032	Compression–Stress-strain diagrams–Compression properties.
3.0321	Stress-strain curves in compression for precipitation-treated sheet from room temperature to 1200 F, Figure 3.0321.
3.0322	Compressive yield strength of precipitation-treated sheet from 75 to 1200 F, Figure 3.0322.
3.033	Impact.
3.0331	Impact strength from −320 to 1600 F of bar in precipitation-treated, fully solution-treated, and stabilized conditions, Figure 3.0331.
3.034	Bending.
3.035	Torsion and shear.
3.0351	Comparison of shear strength and tensile strength of precipitation-treated sheet and forgings from 75 to −423 F, Figure 3.0351.
3.0352	Shear strength from 75 to 1000 F of equalized and precipitation-treated bar, Figure 3.0352.
3.036	Bearing.
3.0361	Bearing properties from 80 to 1600 F of sheet in the precipitation-treated condition, Figure 3.0361.
3.037	Stress concentration.
3.0371	Notch properties.
3.03711	Comparison of ultimate tensile strength and notch tensile strength from 78 to −423 F of sheet in solution-treated and precipitation-treated conditions, Figure 3.03711.
3.03712	Notched tensile strength compared with ultimate tensile strength from 80 to −423 F of rod fully solution-treated, stabilized, and precipitation-treated, Figure 3.03712
3.0372	Fracture toughness, see Table 4.0314.
3.038	Combined properties.
3.04	Creep and Creep-Rupture Properties
3.041	Creep-rupture curves from 1000 to 1800 F for bar in fully solution-treated, stabilized, and precipitation-treated conditions, Figure 3.041.
3.042	Minimum creep rate of fully solution-treated, stabilized, and precipitation-treated bar at various stresses and from 1200 to 1600 F, Figure 3.042.
3.043	Creep and rupture curves at 1800 F for bar in the fully solution-treated, stabilized, and precipitation-treated conditions, Figure 3.043.
3.044	Total strain, plastic strain, and rupture curves at 1200 F for bar in the fully solution-treated, stabilized, and precipitation-treated conditions, Figure 3.044.
3.045	Total strain, plastic strain, and rupture curves at 1350 F for bar in the fully solution-treated, stabilized, and precipitation-treated conditions, Figure 3.045.
3.046	Total strain, plastic strain, and rupture curves at 1500 F for bar in the fully solution-treated, stabilized, and precipitation-treated conditions, Figure 3.046.
3.047	Creep-rupture curves from 1100 to 1500 F for smooth and notched bar in the fully solution-treated, stabilized, and precipitation-treated conditions, Figure 3.047.
3.048	Creep-rupture curves from 600 to 1500 F for notched bar in the fully solution-treated, stabilized, and precipitation-treated conditions, Figure 3.048.
3.049	Effects of test temperature and creep-rupture time on the notch strength ratio of bar in the fully solution-treated, stabilized, and precipitation-treated conditions, Figure 3.049.
3.0410	Creep and rupture curves at 1000 F for bar in the equalized and precipitation-treated conditions, Figure 3.0410.
3.0411	Creep-rupture curves for smooth and notched bar in the equalized and precipitation-treated conditions, Figure 3.0411
3.0412	Minimum creep rate of equalized and precipitation-treated bar at various stresses and from 1000 to 1500 F, Figure 3.0412.
3.0413	Creep-rupture life from 1200 to 1500 F of sheet in two precipitation-treated conditions, Table 3.0413.
3.0414	Stress-rupture curves at 1200 and 1350 F for sheet in the annealed and precipitation-treated conditions, Figure 3.0414.

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

3.0415 Total strain curves at 1350 and 1500 F for sheet in the precipitation-treated conditions, Figure 3.0415.

3.0416 Stress relaxation from 1000 to 1200 F of bar in the equalized and precipitation-treated conditions, Figure 3.0416.

3.0417 Stress relaxation from 1000 to 1350 F of bar in the fully solution-treated, stabilized, and precipitation-treated conditions, Figure 3.0417.

3.0418 Effects of temperatures from 800 to 1100 F and various starting stresses on stress relaxation of springs coiled from No. 1 temper wire in the precipitation-treated condition, Figure 3.0418.

3.0419 Effects of temperatures from 1100 to 1300 F and various starting stresses on stress relaxation of springs coiled from spring temper wire in the fully solution-treated, stabilized, and precipitation-treated conditions, Figure 3.0419.

3.05 Fatigue Properties

3.051 Fatigue life at room temperature and at various ratios (R) of minimum-to-maximum stress for smooth and notched bars in the equalized and precipitation-treated conditions, Figure 3.051.

3.052 Fatigue life at 1000 F and at various ratios (R) of minimum-to-maximum stress for smooth and notched bars in the equalized and precipitation-treated conditions, Figure 3.052.

3.053 Fatigue life at 1200 F and at various ratios (R) of minimum to-maximum stress for smooth and notched bars in the equalized and precipitation-treated conditions, Figure 3.053.

3.054 Axial fatigue life of precipitation-treated bar at 70, -320, and -423 F, Figure 3.054.

3.055 Constant-fatigue-life diagram at room temperature for smooth and notched bar in the equalized and precipitation-treated conditions, Figure 3.055.

3.056 Rotating-beam fatigue life of equalized and precipitation-treated bar at various stresses and from 80 to 1500 F, Figure 3.057.

3.057 Rotating-beam fatigue life of fully solution-treated, stabilized, and precipitation-treated bar at various stresses and from 80 to 1500 F, Figure 3.057.

3.058 Rotating-beam fatigue life of precipitation-treated bar at 70 and -320 F, Figure 3.058.

3.059 Fatigue strength at various cycles to failure for precipitation-treated bar from 75 to -423 F, Figure 3.059.

3.0510 Rotating-beam fatigue strength, at 10^8 cycles to failure of bar in several heat-treated conditions from 80 to 1500 F, Figure 3.0510.

3.0511 Fatigue life at room temperature of sheet in two precipitation-treated conditions, Figure 3.0511.

3.0512 Fatigue life in reversed bending of precipitation-treated sheet with two different surface finishes at 70 and -423 F, Figure 3.0512.

3.0513 Fatigue strength at various cycles to failure for precipitation-treated sheet with different surface finishes from 75 to -423 F, Figure 3.0513.

3.0514 Fatigue life in reversed bending of Spring temper strip in as cold-rolled and two precipitation-treated conditions, Figure 3.0514.

3.0515 Fatigue crack-growth rate at various temperatures for plate fully solution-treated, stabilized, and precipitation-treated, Figure 3.0515.

3.0516 Fatigue crack-growth rates at room temperature for plate produced by various melting techniques and subsequently subjected to different heat-treat cycles, Figure 3.0516.

3.06 Elastic Properties

3.061 Poisson's ratio.

3.0611 Poisson's ratio from -460 to 1400 F, Figure 3.0611.

3.062 Modulus of elasticity.

3.0621 Typical static and dynamic modulus of elasticity for all heat-treated conditions from 80 to 1800 F, Figure 3.0621.

3.063 Modulus of rigidity.

3.0631 Modulus of rigidity from -320 to 1200 F, Figure 3.0631.

3.064 Tangent modulus.

3.0641 Tangent modulus curves from room temperature to 1200 F for sheet in the precipitation-treated condition, Figure 3.0641.

3.065 Secant modulus.

3.0651 Secant modulus curves from room temperature to 1200 F for sheet in the precipitation-treated condition, Figure 3.0651.

4 FABRICATION

4.01 Forming

4.011 Inconel X-750 can be cold formed by a variety of processes. Because of its rapid strain hardening rate, frequent process anneals are necessary when large cold reductions are desired (1).

4.012 Relatively powerful equipment is necessary for hot forming Inconel X-750 because of its resistance to deformation. The recommended hot-working temperature range is 1800 to 2200 F. All heavy hot working should be done above 1900 F. Light finishing forgings, with some light reduction, can be done in the 1800 to 1900 F range. Below 1800 F the metal is difficult to work and has a tendency to split when attempts are made to hot work it (1).

4.02 Machining and Grinding

4.021 Although the machinability of Inconel X-750, like other nickel-base superalloys, is inferior to that of most steels, it can readily be machined at low feeds and speeds. Because of its high strength and hardness in the precipitation-treated condition, rough machining is usually done before precipitation hardening; finish machining follows precipitation hardening. Since precipitation hardening relieves machining stresses, allowance must be made for possible warpage. Allowance may also be made for a slight permanent contraction that occurs during precipitation treatment (1).

4.022 All types of grinding, including thread grinding, can be done in the precipitation-hardened or annealed condition.

4.03 Joining

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

4.031 Welding processes suitable for Inconel X-750 are gas-tungsten-arc (GTA), plasma arc, electron beam, resistance, and pressure-oxyacetylene. Inconel No. 69 filler metal is normally used with the gas-tungsten-arc process. Based on the results of tensile and stress-rupture tests, joint efficiencies of nearly 100 percent at room temperatures and 80 percent at 1300 to 1500 F can be readily obtained. The alloy should preferably be in the annealed or solution-treated condition prior to welding. It is possible to weld it in the precipitation treated condition, but there is a danger of parent-metal cracking; in addition, the high strength imparted by precipitation treatment is not retained in the weld area. For optimum properties, complete solution and precipitation treatments should be carried out after welding (1).

4.0311 Tensile properties from 80 to 1000 F of plate butt welded with GTA process and Inconel No. 69 filler metal; butt weld perpendicular to the loading direction in the tensile tests, Figure 4.0311.

4.0312 Tensile properties from –423 to 1500 F of plate butt welded with GTA process and Inconel No. 69 filler metal; butt weld perpendicular to the loading direction in tensile tests, Figure 4.0312.

4.0313 Tensile properties at low temperatures of parent metal and of welded joints in various conditions of heat treatment; parent metal produced by vacuum-induction melt followed by vacuum-arc remelt, Table 4.0313.

4.0314 Fracture toughness at low temperatures of parent metal and of welded and brazed joints in various heat-treatment conditions, Table 4.0314.

4.032 Inconel X-750 can be brazed by conventional procedures with many of the commercial brazing alloys. Precipitation treatment, if desired, must be carried out after brazing; therefore, a brazing alloy should be selected that welds above precipitation-treatment temperatures (1).

4.04 Surface Treating

4.041 Removal of hot-work and heat-treat scales is best done by immersion in one of the commercially available caustic-base salt baths followed by pickling in hot sulfuric and hot nitric hydrofluoric acid.

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15	Cr
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0.7	Al

Inconel X-750

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54 Plummer, F. A., "Sea-Water Corrosion Characteristics of Nickel-Base Alloys", Naval Ship Research and Development Center Report 2859 (May 1969).

Alloy	IN X-750	
Form	AMS	Military
Sheet, Strip, and Plate	5542 H, 5598	MIL-N-7786
Pipe and Tube	5582A	–
Wire	5698C, 5699C	MIL-S-21977
Bars, Forgings, and Rings	5667H, 5668E, 5670, 5671D, 5747	MIL-N-24114, MIL-N-8550, MIL-S-23192

TABLE 1.03. SPECIFICATIONS (1)

Alloy	IN X-750	
	Percent	
Composition	Min	Max
Ni (Plus Co)	70.00	–
Cr	14.00	17.00
Fe	5.00	9.00
Ti	2.25	2.75
Al	0.40	1.00
Cb (Plus Ta)	0.70	1.20
Mn	–	1.00
Si	–	0.50
S	–	0.010
Cu	–	0.50
C	–	0.08
Co	–	1.00

Note: AMS 5671D (38) and 5598 (34) limit manganese and silicon contents to 0.35 percent maximum each, and those two specifications plus 5670 (37) and 5747 (41) have a maximum phosphorus limit of 0.015 percent; otherwise the compositions given in those four specifications are the same as that given above.

TABLE 1.04. COMPOSITION (1) (32) (33) (35) (36) (39) (40)

Ni	
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

Alloy	IN X-750	
Forms	Desired Properties	Thermal Treatment
Rods, Bars, and Forgings	Strength and Optimum Ductility up to 1100 F	Equalize: 1625 F, 24 hr, AC + Precipitation: 1300 F, 20 hr, AC
Rods, Bars, and Forgings	Optimum Tensile Strength up to 1100 F	Solution: 1800 F, AC + Furnace-Cool Precipitation: 1350 F, 8 hr, FC to 1150 F, Hold 8 hr, AC
Rods, Bars, and Forgings	Maximum Creep Strength Above 1100 F	Full Solution: 2100 F, 2 to 4 hr, AC + Stabilize: 1550 F, 24 hr, AC + Precipitation: 1300 F, 20 hr, AC
Sheet, Strip, and Plate	High Strength at High Temperatures	Annealed + Precipitation: 1300 F, 20 hr, AC
Sheet, Strip, and Plate	High Strength and Higher Tensile Properties to 1300 F	Annealed + Furnace-Cool Precipitation: 1350 F, 8 hr, FC to 1150 F, Hold 8 hr, AC(a)
Tubing	High Strength at High Temperatures	Annealed + Precipitation: 1300 F, 20 hr, AC
No. 1 Temper Wire	Service up to 1000 F	ST + CD 15 to 20 Percent + 1350 F, 16 hr, AC
Spring Temper Wire	Service up to 700 F	ST + CD 30 to 65 Percent + 1200 F, 4 hr, AC
Spring Temper Wire	Service at 900-1200 F	CD 30 to 65 Percent + 2100 F, 2 hr, AC + 1550 F, 24 hr, AC + 1300 F, 20 hr, AC

(a) Equivalent properties in a shorter time can be developed by the following precipitation treatment: 1400 F, 1 hr, FC to 1150 F, hold 3 hr, AC.

TABLE 1.0531. TYPICAL THERMAL TREATMENTS TO PRECIPITATION-HARDEN VARIOUS INCONEL X-750 PRODUCTS (1) (6) (29) (46)

Alloy	IN X-750	
Form	Hot-Finished Products	
	Hardness	
Condition	Brinell	Rockwell
As-Rolled or As-Forged	228-298	C 20-32
Hot Worked + 1300 F, 24 hr, AC	313-400	C 34-44
2100 F, 2 hr, AC	140-277	B 77-C 29
2100 F, 2 hr + 1550 F, 24 hr, AC	200-277	C 13-29
2100 F, 2 hr + 1550 F, 24 hr, AC + 1300 F, 20 hr, AC	262-340	C 26-37
1625 F, 24 hr, AC	200-298	C 13-32
1625 F, 24 hr, AC + 1300 F, 20 hr, AC	302-363	C 32-40
1800 F, 1 hr, AC	231-286	C 21-30
1800 F, 1 hr, AC + 1350 F, 8 hr, FC to 1150 F, Hold 8 hr, AC	302-385	C 32-42
1800 F, 1 hr, AC + 1400 F, 1 hr, FC to 1150 F, Hold 3 hr, AC	335-353	C 36-38

TABLE 1.061. HARDNESS AT ROOM TEMPERATURE OF WROUGHT PRODUCTS IN VARIOUS HEAT-TREATED CONDITIONS (1) (4)

Alloy	IN X-750		
Form	Hot-Rolled Bar		
Condition	Resistivity, Microhm inch	Conductivity, Megohms/in.^{3}	Conductivity, percent IACS
As Hot Rolled	49.7	0.0201	1.37
2000 F, 1 hr, AC	49.9	0.0200	1.36
2100 F, 2 hr, AC + 1500 F, 24 hr, AC + 1300 F, 20 hr, AC	47.4	0.0211	1.43
1800 F, 1 hr, AC + 1350 F, 8 hr, FC to 1150 F, Hold 8 hr, AC	48.4	0.0207	1.40

TABLE 2.0221. ELECTRICAL PROPERTIES AT ROOM TEMPERATURE OF HOT-ROLLED BAR IN VARIOUS HEAT-TREATED CONDITIONS (1)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

Alloy	IN X-750	
Form	CD Wire	
Condition	Wire Diam, inch	Damping Decrement in Torsion, percent/cycle
No. 1 Temper	0.037	0.123
No. 1 Temper + 1350 F, 16 hr, AC	0.037	0.060
No. 1 Temper + 2100 F, 2 hr, AC + 1550 F, 24 hr, AC + 1300 F, 20 hr, AC	0.037	0.100
1900 F + CD 15% + 1350 F, 16 hr, AC	0.149	0.091
2000 F + CD 15% + 1350 F, 16 hr, AC	0.149	0.072
1900 F + CD 15% + 2100 F, 2 hr, AC + 1550 F, 24 hr, AC + 1300 F, 20 hr, AC	0.149	0.067
2000 F + CD 15% + 2100 F, 2 hr, AC + 1550 F, 24 hr, AC + 1300 F, 20 hr, AC	0.149	0.048
2100 F + CD 15% + 2100 F, 2 hr, AC + 1550 F, 24 hr, AC + 1300 F, 20 hr, AC	0.149	0.047
Annealed + 65% CR	0.149	0.089

TABLE 2.0251. DAMPING DECREMENT IN TORSION FOR WIRE IN VARIOUS HEAT-TREATED CONDITIONS (1)

Alloy	IN X-750				
Form	0.063-inch Sheet				
Condition	1900 F, 1/2 hr, AC + 1550 F, 24 hr, AC + 1300 F, 20 hr, AC				
Irradiation	Post-Irrad Treatment	Test Temp, F	F_{ty}, ksi	F_{tu}, ksi	e (1.0 inch), percent
None	–	-320	105.0	197.4	38.8
(a)	None	-320	142.0	200.1	31.2
(a)	540 F, 1 hr	-320	115.0	197.9	37.6
None	–	80	93.7	157.6	23.9
(a)	None	80	119.0	159.8	25.4
None	–	80	88.7	156.1	27.8
(b)	None	80	136.0	150.5	21.4
(b)	1540 F, 1 hr	80	72.2	136.4	35.2
None	–	1040	78.6	137.8	19.5
(b)	None	1040	74.9	118.4	6.2
None	–	1540	31.6	33.9	12.5
(b)	None	1540	30.4	30.4	1.8

(a) Fluence = 7.8×10^{17} n/cm^2 (E > 1 MeV) + 8.5×10^{6} n/cm^2 (E < 0.48 eV).
(b) Fluence = 8.2×10^{19} n/cm^2 (E < 0.48 eV) + 6.6×10^{18} n/cm^2 (E > 1 MeV).

TABLE 2.041. EFFECTS OF NEUTRON IRRADIATION ON LONGITUDINAL TENSILE PROPERTIES FROM -320 TO 1540 F OF SHEET IN THE SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED CONDITIONS (21)

Alloy	IN X-750				
Form	Butt-Welded 0.063-inch Sheet				
Condition	1900 F, 1/2 hr, AC + 1550 F, 24 hr, AC + 1300 F, 20 hr, AC (Entire Heat Treatment After Welding, Before Irradiation)				
Irradiation	Post-Irrad Treatment	Test Temp, F	F_{ty}, ksi	F_{tu}, ksi	e (1.0 inch), percent
None	–	-320	105.0	195.0	31.5
(a)	None	-320	143.0	190.4	18.0
None	–	80	196.7	150.3	13.6
(a)	None	80	120.0	155.2	15.4
None	–	80	93.6	151.7	17.3
(b)	None	80	129.0	147.4	13.9
(b)	1540 F, 1 hr	80	74.4	135.2	27.0
None	–	1040	79.4	133.8	14.1
(b)	None	1040	79.9	118.1	6.9
None	–	1540	33.0	34.8	4.8
(b)	None	1540	24.8	29.1	2.0

(a) Fluence = 17.8×10^{17} n/cm^2 (E > 1 MeV).
(b) Fluence = 8.2×10^{19} n/cm^2 (E < 0.48 eV).

TABLE 2.042. EFFECTS OF NEUTRON IRRADIATION ON TENSILE PROPERTIES OF BUTT-WELDED SHEET FROM -320 TO 1540 F: GAS-TUNGSTEN-ARC WELDS WITH NO. 69 FILLER METAL ACROSS CENTER OF GAGE SECTION OF SPECIMENS (21)

Ni	
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

Alloy	IN X-750						
Form	Thickness, inch	Condition	Source	F_{tu}, ksi	F_{ty}, ksi	e, (2 inch), (Min)	Hardness, R_C, (Min)
Strip	<0.010	Annealed	(32)	140 (Max)	–	–	–
	0.010-0.024			130 (Max)	–	–	–
	>0.024			–	–	–	–
Sheet	0.010-0.024	Annealed	(32)	140 (Max)	–	30	–
	0.025-0.125			130 (Max)	60 (Max)	40	–
	0.126-0.250			130 (Max)	65 (Max)	40	30
Strip	<0.010	Annealed +	(32)	150 (Min)	–	–	30
	0.010-0.024	1300 F,		155 (Min)	–	15	–
	>0.024	20 hr, AC		155 (Min)	–	15	30
Sheet	0.010-0.250	Annealed + 1300 F, 20 hr, AC	(32)	165 (Min)	105 (Min)	20	32
Plate	0.187-4.000	Annealed + 1300 F, 20 hr, AC	(32)	155 (Min)	100 (Min)	20	30
Strip	<0.010	Annealed +	(34)	140 (Max)	–	–	–
	0.010-0.024	1800 F, AC		135 (Max)	–	18	–
	>0.024			–	–	–	–
Sheet	0.010-0.024	Annealed +	(34)	135 (Max)	75 (Max)	30	–
	0.025-0.250	1800 F, AC		135 (Max)	75 (Max)	35	–
Strip	<0.010	1800 F, AC +	(34)	155 (Min)	–	–	30
	>0.009	1350 F, 8 hr, FC to 1150 F, Hold 8 hr, AC		160 (Min)	–	12	30
Sheet	0.010-0.250	1800 F, AC + 1350 F, 8 hr, FC to 1150 F, Hold 8 hr, AC	(34)	170 (Min)	115 (Min)	18	32
Plate	0.187-4.000	1800 F, AC + 1350 F, 8 hr, FC to 1150 F, Hold 8 hr, AC	(34)	160 (Min)	105 (Min)	18	30
Tubing	>0.125 OD + >0.015 Wall	Annealed	(33)	140 (Max)	80 (Max)	30	–
Tubing[(a)]	>0.125 OD + >0.015 Wall	Annealed + 1300 F, 20 hr, AC	(33)	155 (Min)	100 (Min)	15	–

(a) At 1350 F and a load of 45,000 psi, a stress-rupture time of at least 23 hours is required (33).

TABLE 3.011. AMS SPECIFIED MECHANICAL PROPERTIES OF STRIP, SHEET, PLATE, AND TUBING

Alloy	IN X-750						
Form	Diameter or Thickness, inch	Condition	Source	F_{tu}, ksi (Min)	F_{ty}, ksi (Min)	e (4D), (Min)	Hardness, Brinell
Bars, Forgings, and Rings	<4.0	HF + 1625 F, 24 hr,	(35)	165	105	20	302-363
	4.0 and Over	AC + 1300 F, 20 hr, AC		160	100	15	302-363
Bars, Forgings, and Rings	<2.50	1800 F, 1 hr, AC +	(37)(41)	170	115	18	298-382
	2.50-4.00	1350 F, 8 hr, FC to 1150 F, Hold 8 hr, AC		170	115	15	298-382
Bars and Forgings[(a)]	–	2100 F, 2 hr, AC + 1550 F, 24 hr, + 1300 F, 20 hr, AC	(36)	140	80	8	262-341
Rings[(a)]	–	2100 F, 2 hr, AC + 1550 F, 24 hr, + 1300 F, 20 hr, AC	(36)	125	80	8	262-341
Bars, Forgings, and Rings	<2.50	1800 F, 1 hr, AC +	(38)	170 (L)	115 (L)	18 (L)	302-401
	2.50-4.00	1350 F, 8 hr, FC to		165 (T)	110 (T)	15 (T)	302-401
		1150 F, Hold 8 hr,		170 (L)	115 (L)	15 (L)	302-401
		AC		160 (T)	105 (T)	12 (T)	302-401

(a) At 1350 F and with a 52,500 psi load, a stress rupture time of at least 23 hours is required (36).

TABLE 3.012. AMS SPECIFIED MECHANICAL PROPERTIES OF BARS, FORGINGS, AND RINGS

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

Alloy	IN X-750				
Form	Diameter or Thickness, inch	Condition	Source	F_{tu}, ksi	
				Min	Max
Wire, Round and Flat	<0.025	2100 F, 1/4 hr, AC	(39)	–	150
	0.025-0.500			130	165
Wire, Round and Flat	<0.025	2100 F, 1/4 hr, AC + 1350 F, 16 hr, AC	(39)	155	–
	0.025-0.500			165	–
Round Wire	<0.250	2100 F, 1/4 hr, AC + CD	(40)	190	–
	0.250-0.625			160	–
Flat Wire	<0.250			175	–
	0.250-0.625			160	–
Wire, Round and Flat	0.012-0.250	2100 F, 1/4 hr, AC + CD + 1200 F, 4 hr, AC	(40)	220	–
	0.251-0.418			200	–
	0.419-0.625			180	–
Wire, Round and Flat	0.012-0.250	2100 F, 2 hr, AC + 1550 F, 24 hr, AC + 1300 F, 20 hr, AC	(40)	150	–
	0.251-0.625			145	–

TABLE 3.013. AMS SPECIFIED MECHANICAL PROPERTIES OF WIRE

Alloy	IN X-750							
Form	Wire							
	Prop Limit 0.0 Offset, ksi		F_{ty}, ksi		F_{tu}, ksi		e (2 inch), percent	
Diameter, inch	0.020	0.229	0.020	0.229	0.020	0.229	0.020	0.229
Condition								
No. 1 Temper (15-20% CD) +								
As-Drawn	40	56	68	119	139	145	30	24
1950 F, 15 min, WQ	34	24	43	42	120	110	34	53
2100 F, 2 hr, WQ + 1550 F, 24 hr + 1300 F, 20 hr, AC	65	64	93	101	158	166	13	14
1350 F, 16 hr, AC	93	91	141	159	202	204	16	16
1200 F, 4 hr, AC	77	81	109	136	178	176	25	19
Spring Temper (30-65% CD) +								
As-Drawn	137	–	233	–	269	–	1.6	–
1950 F, 15 min, WQ	37	–	51	–	130	–	33	–
2100 F, 2 hr, WQ + 1550 F, 24 hr + 1300 F, 20 hr, AC	81	–	104	–	154	–	8.0	–
1300 F, 16 hr, AC	168	–	268	–	274	–	1.0	–
1200 F, 4 hr, AC	173	–	293	–	298	–	1.0	–

Note: No. 1 temper represents wire cold reduced about 15 to 20 percent after the final process anneal. Spring temper represents wire cold reduced 30 to 65 percent after the final process anneal.

TABLE 3.0214. ROOM-TEMPERATURE TENSILE PROPERTIES OF WIRE IN VARIOUS TEMPERS AND HEAT-TREATED CONDITIONS (1)

Alloy	IN X-750	
Condition	Annealed + 1300 F, 20 hr, AC	
Property	F_{cy}, ksi	
Form	0.062-inch Sheet	0.125-inch Sheet
L	121.0	127.0
T	122.5	130.0

TABLE 3.0222. COMPRESSIVE YIELD STRENGTH AT ROOM TEMPERATURE OF SHEET IN THE PRECIPITATION-TREATED CONDITION (1)

Alloy	IN X-750	
Form	Hot-Rolled Plate	
Condition	1800 F, 1 hr, AC + 1350 F, 8 hr, FC to 1150 F, Hold 8 hr, AC	
	Charpy Impact Energy, ft lb	
Plate Size, inch	V Notch	Keyhole Notch
1/2 x 48 x 96	47.5	31.0
3/4 x 48 x 120	50.5	35.0
1 x 36 x 96	40.5	26.0
1-1/4 x 37 x 82	34.0	24.0
2 x 48 x 120	48.5	28.5

TABLE 3.0231. ROOM-TEMPERATURE IMPACT PROPERTIES OF PLATE IN VARIOUS SIZES IN THE FURNACE-COOL PRECIPITATION-TREATED CONDITION (1)

Alloy	IN X-750	
Form	0.062-inch Sheet	
Condition	Annealed + 1300 F, 20 hr, AC	
	F_{su}, ksi	
Property	Single Shear	Double Shear
L	124.2	111.8
T	122.8	112.5

TABLE 3.0251. ULTIMATE SHEAR STRENGTH AT ROOM TEMPERATURE OF SHEET IN THE PRECIPITATION-TREATED CONDITION (1)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

Alloy	IN X-750
Form	Hot-Rolled 0.75-inch Bar
Condition	1625 F, 24 hr, AC + 1300 F, 20 hr, AC
F_{ty}, ksi	148.3
F_{tu}, ksi	192.2
e (2 inch), percent	22.4
RA, percent	44.3
NTS, ksi (K_t = 3.0)	311.2
NTS, ksi (K_t = 5.0)	312.2
NTS (K_t = 3.0)/F_{tu}	1.62
NTS (K_t = 5.0)/F_{tu}	1.62

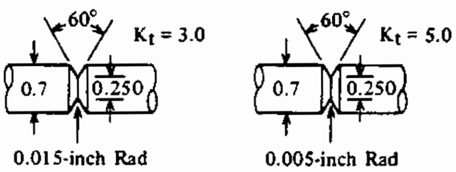

TABLE 3.02711. COMPARISON OF ROOM-TEMPERATURE NOTCH TENSILE STRENGTH WITH TENSILE PROPERTIES OF BAR IN THE EQUALIZED AND PRECIPITATION-TREATED CONDITIONS (6)

Alloy	IN X-750			
Condition			CR + Annealed + 1300 F, 20 hr, AC	CR + Annealed + 1350 F, 8 hr, FC to 1150 F, Hold 8 hr, AC
Form	Temp, F	Stress, ksi	Rupture Time, hr	
0.031-inch Sheet	1200	70	19.25	20.70
	1350	40	46.15	50.90
	1500	20	42.15	52.70
0.093-inch Sheet	1200	70	85.60	93.3
	1350	40	123.60	125.05
	1500	20	70.65	79.85

TABLE 3.0473. CREEP-RUPTURE LIFE FROM 1200 TO 1500 F OF SHEET IN TWO PRECIPITATION-TREATED CONDITIONS (1)

Alloy	IN X-750				
Form	Hot Forged				
Condition	Test Temp, F	F_{ty}, ksi	F_{tu}, ksi	e (5D), percent	RA, percent
ST[a] (Parent)	75	96.2	143.2	17.6	18.2
	-320	111.6	157.5	15.6	13.8
	-453	106.8	147.7	14.1	12.9
STDA[b] (Parent)	75	119.5	159.2	12.9	12.4
	-320	129.4	165.4	9.2	8.6
	-453	125.7	152.5	6.1	6.2
ST/VEBW[c]	75	80.0	112.0	8.0	30.8
	-320	98.2	137.5	11.8	25.0
	-453	106.0	140.1	11.6	19.6
STDA/VEBW	75	86.2	117.0	3.2	30.3
	-320	109.0	133.5	2.6	11.4
	-453	111.8	135.8	3.0	10.3
ST/VEBW/STDA	75	122.1	157.9	10.0	10.3
	-320	131.0	156.9	6.4	8.7
	-453	132.5	154.1	7.1	8.7
ST/GTAW[d]	75	91.0	121.6	13.3	27.0
	-320	104.0	143.2	13.6	22.0
	-453	108.0	145.5	12.7	17.1
STDA/GTAW	75	94.1	121.9	8.2	27.0
	-320	116.1	140.5	5.5	17.0
	-453	125.0	144.0	4.8	14.5
ST/GTAW/STDA	75	124.2	159.0	9.0	11.9
	-320	135.0	160.8	5.6	9.2
	-453	139.0	163.0	5.5	8.7

(a) ST = solution-treated: 1800 F, 1 hr, AC.
(b) STDA = solution-treated double aged: 1800 F, 1 hr, AC + 1350 F, 8 hr, FC to 1150 F, 8 hr, hold 8 hr, AC.
(c) VEBW = vacuum electron beam weld (no filler metal).
(d) GTAW = gas-tungsten-arc weld (INCO 69 filler metal).

TABLE 4.0313. TENSILE PROPERTIES AT LOW TEMPERATURES OF PARENT METAL AND OF WELDED JOINTS IN VARIOUS CONDITIONS OF HEAT TREATMENT; PARENT METAL PRODUCED BY VACUUM-INDUCTION MELT FOLLOWED BY VACUUM-ARC REMELT (19)

Alloy	IN X-750				
Form	Hot Forged				
Material Condition	Manufacturing Process[a]	Temp Heat Treatment	Temp, F	F_{ty}, ksi	K_{Ic}, ksi$\sqrt{in.}$
Parent Metal	VIM-VAR	1800 F, 1 hr, AC	75	96.2	103.6
Ditto	Ditto	Ditto	-452	106.8	92.2
"	"	1800 F, 1 hr, AC + 1350 F, 8 hr, FC + 1150 F, Hold 8 hr, AC	-452	125.7	69.2
"	AAM-VAR	Ditto	-452	141.3	216.0
"	VIM	"	-452	173.2	131.5
"	HIP	"	-452	150.5	89.7
EBW[b]	VIM-VAR	1800 F, 1 hr, AC, Weld 1800 F, 1 hr, AC + 1350 F, 8 hr, FC to 1150 F, Hold 8 hr, AC	-452	132.5	160.1
GTAW[c]	Ditto	Ditto	-452	139.0	121.5
Ditto	"	1800 F, 1 hr, AC, Weld	-452	108.8	174.3
"	"	1800 F, 1 hr, AC + 1350 F, 8 hr, FC to 1150 F, Hold 8 hr, AC, Weld	-452	125.0	154.8
Cu Brazed	VIM-VAR	1800 F, 1 hr, AC, Braze	-75	94.5	34.7
Ditto	Ditto	Ditto	-320	108.4	35.3
"	"	"	-452	115.1	40.5

(a) VIM = vacuum-induction melt
VAR = vacuum-arc remelt
AAM = air-arc melt
HIP = hot isostatic pressed.
(b) EBW = electron-beam welded (no filler metal).
(c) GTAW = gas-tungsten-arc welded (INCO 69 filler metal).

TABLE 4.0314. FRACTURE TOUGHNESS AT LOW TEMPERATURES OF PARENT METAL AND OF WELDED AND BRAZED JOINTS IN VARIOUS HEAT-TREATMENT CONDITIONS (14)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

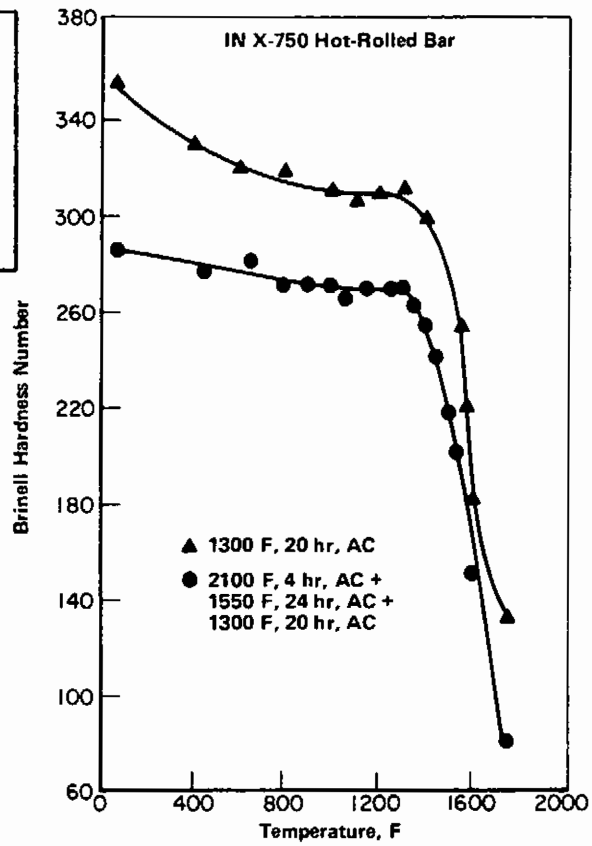

FIGURE 1.062. HARDNESS FROM 80 TO 1750 F OF BAR IN THE PRECIPITATION-TREATED CONDITION AND IN THE FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED CONDITIONS (1) (5)

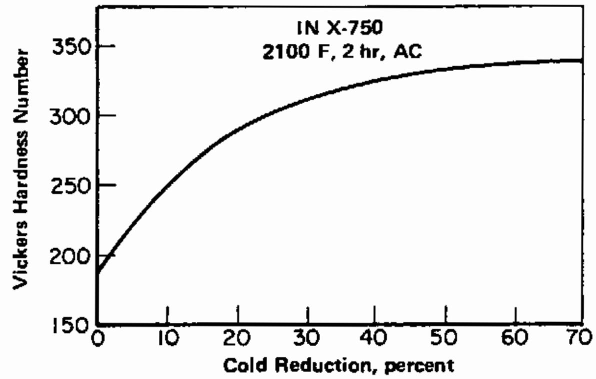

FIGURE 1.063. EFFECT OF COLD WORK ON HARDNESS AT ROOM TEMPERATURE (1)

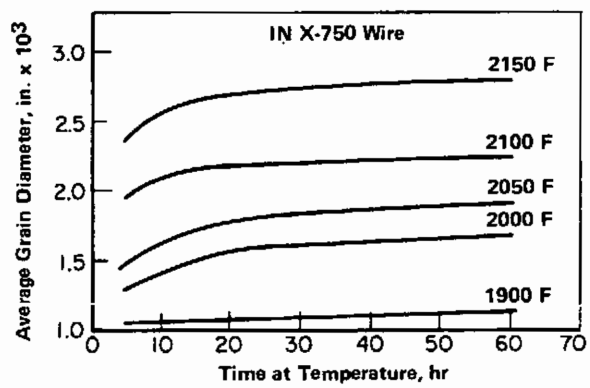

FIGURE 1.0921 EFFECTS OF TIME AND TEMPERATURE ON GRAIN GROWTH (1)

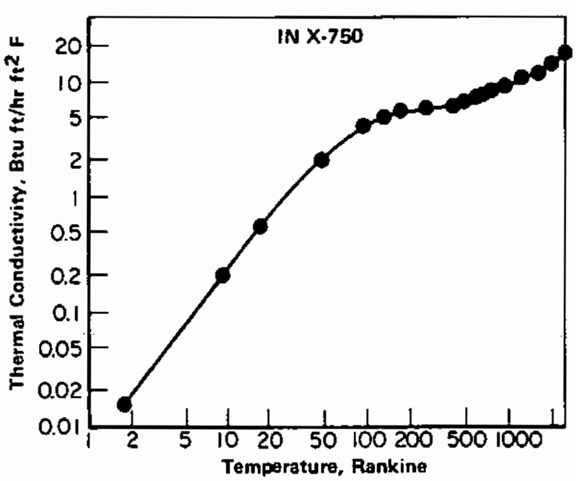

FIGURE 2.0131. THERMAL CONDUCTIVITY FROM -459 TO 1880 F (8)

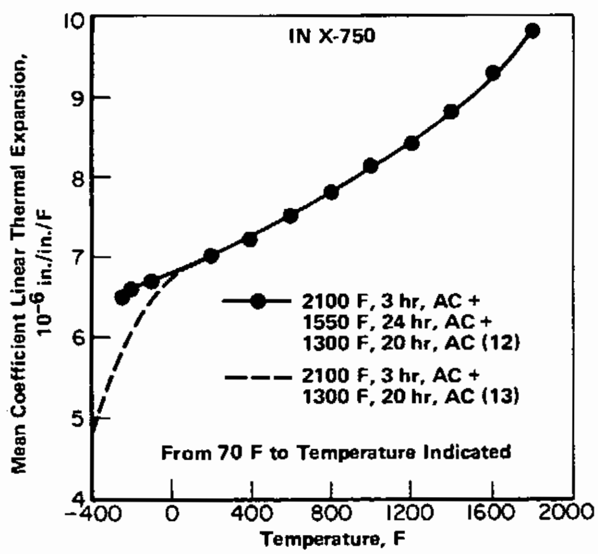

FIGURE 2.0141. THERMAL EXPANSION FROM -400 TO 1800 F (12) (13)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

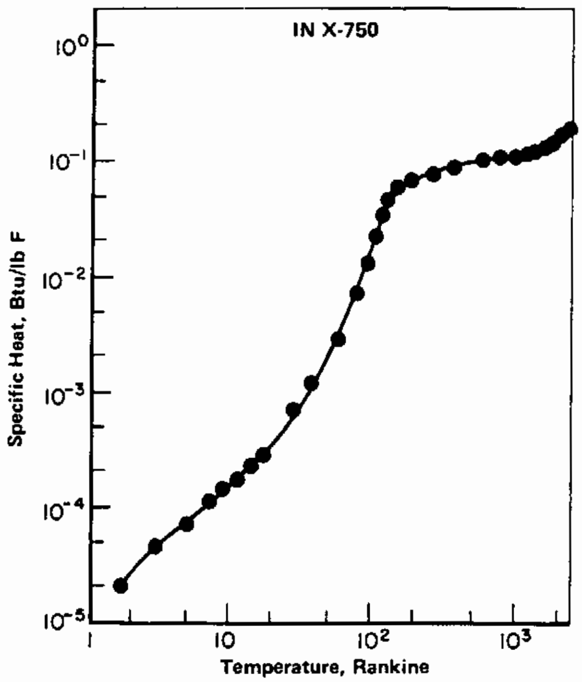

FIGURE 2.0151. SPECIFIC HEAT FROM -459 TO 1700 F (8)

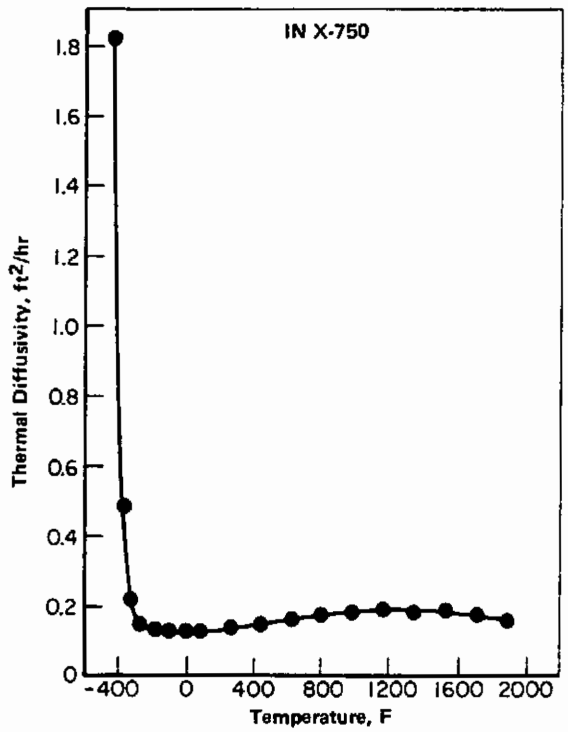

FIGURE 2.0161. THERMAL DIFFUSIVITY FROM -415 TO 1880 F (9)

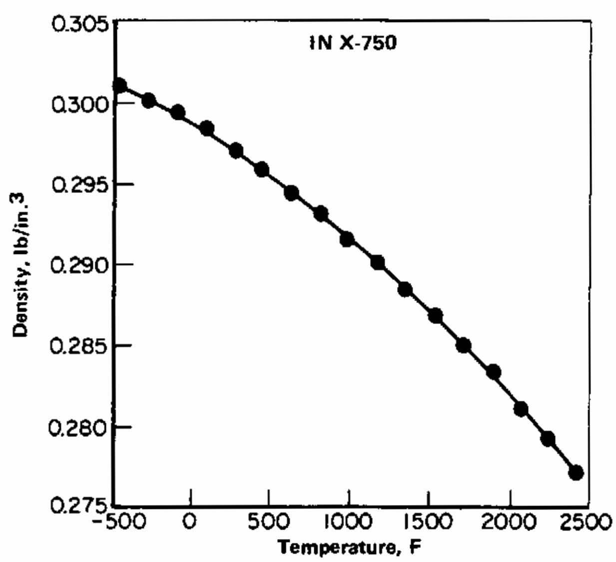

FIGURE 2.0211. DENSITY FROM -460 TO 2420 F (8)

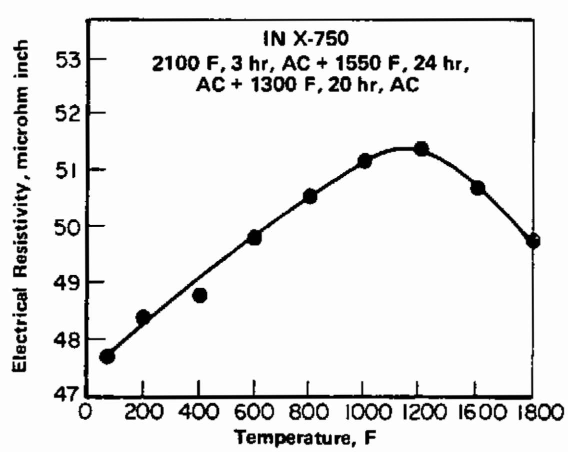

FIGURE 2.0222. ELECTRICAL RESISTIVITY FROM 70 TO 1600 F FOR ALL WROUGHT PRODUCTS IN THE FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED CONDITIONS (1)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

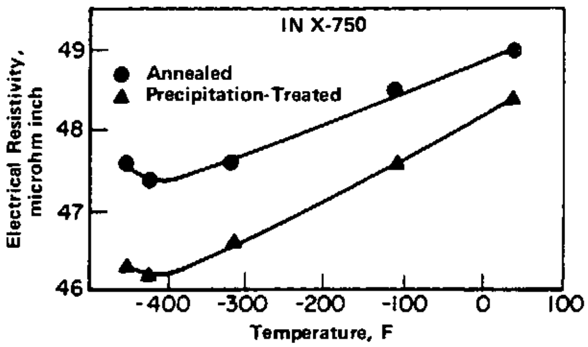

FIGURE 2.0223. RESISTIVITY FROM 32 F TO -453 F (22)

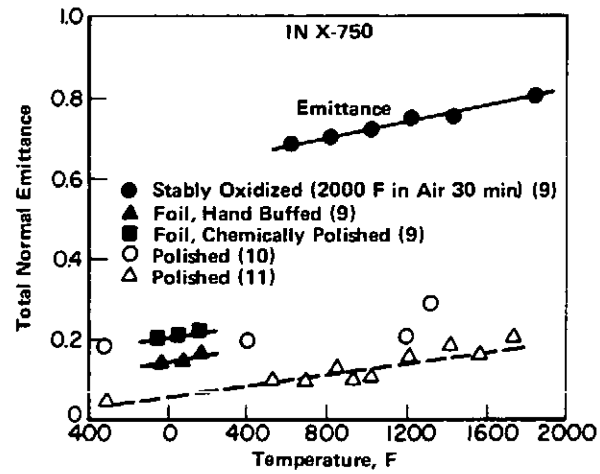

FIGURE 2.0241. TOTAL NORMAL EMITTANCE FROM -320 TO 1900 F (9) (10) (11)

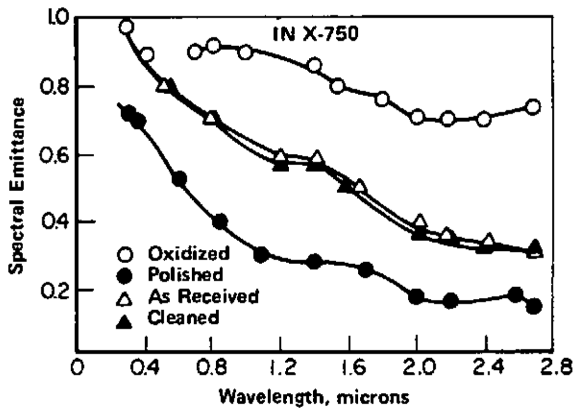

FIGURE 2.0242. SPECTRAL EMITTANCE (11) (47)

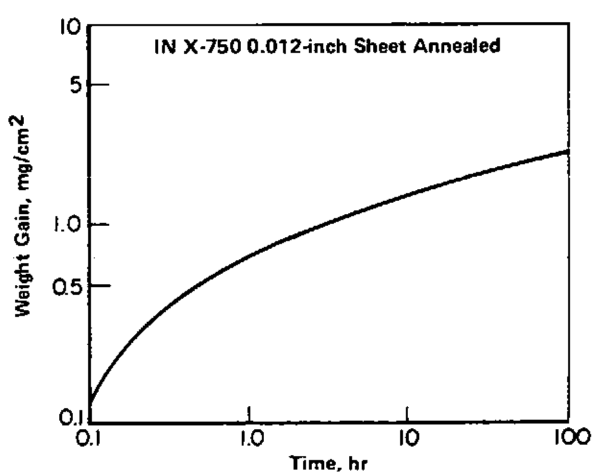

FIGURE 2.0311. GAIN IN WEIGHT OF SHEET EXPOSED TO PURE OXYGEN AT 1832 F (27)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel
X-750

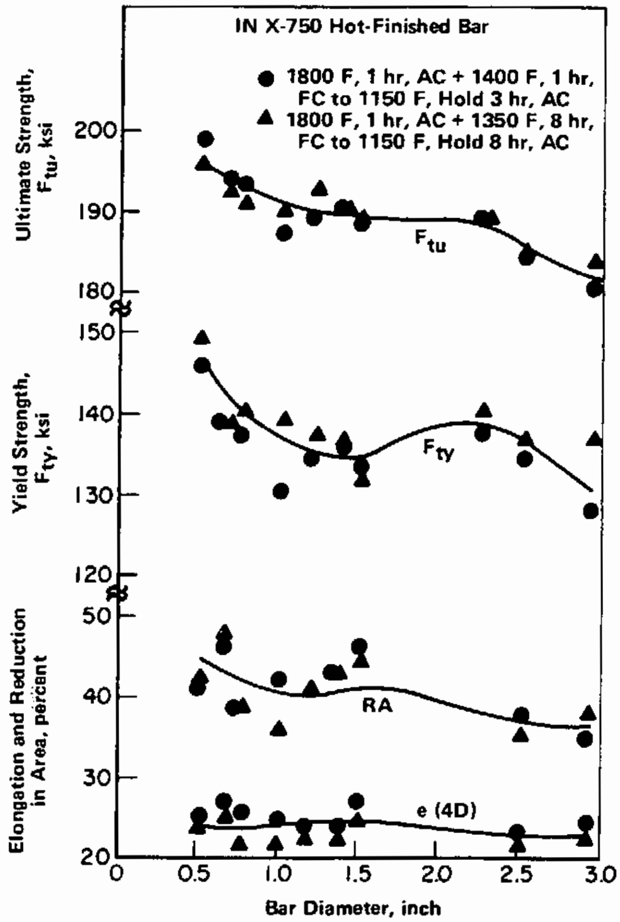

FIGURE 3.0212. ROOM-TEMPERATURE TENSILE PROPERTIES OF FURNACE-COOL PRECIPITATION-TREATED BAR IN DIAMETERS FROM 1/2 INCH TO 2-15/16 INCH (1)

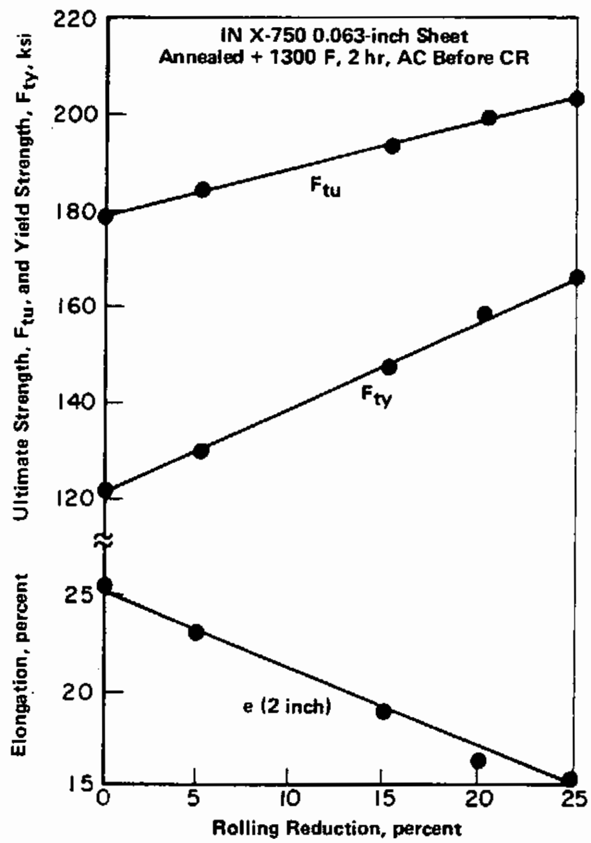

FIGURE 3.0213. EFFECTS OF COLD ROLLING ON TENSILE PROPERTIES OF PRECIPITATION-TREATED SHEET (29)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

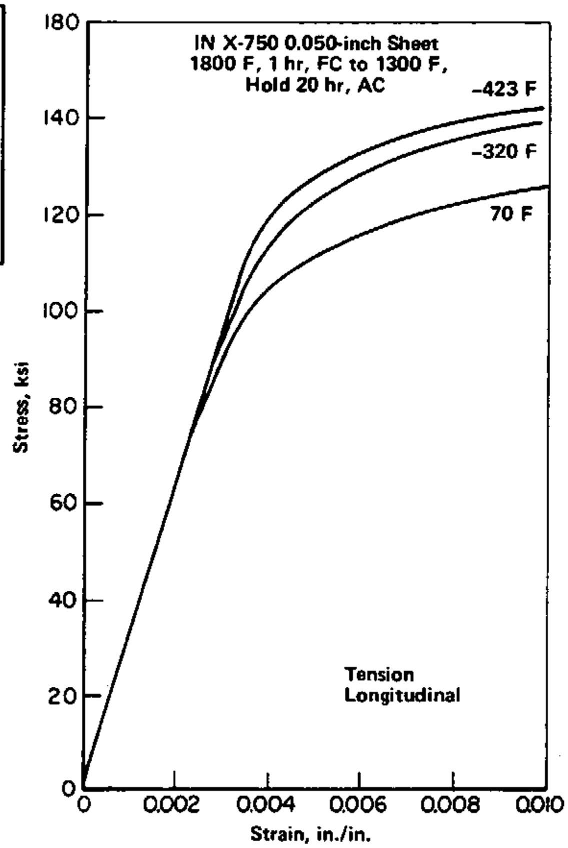

FIGURE 3.0311. STRESS-STRAIN CURVES FROM ROOM TEMPERATURE TO -423 F FOR SHEET IN THE PRECIPITATION-TREATED CONDITION (24)

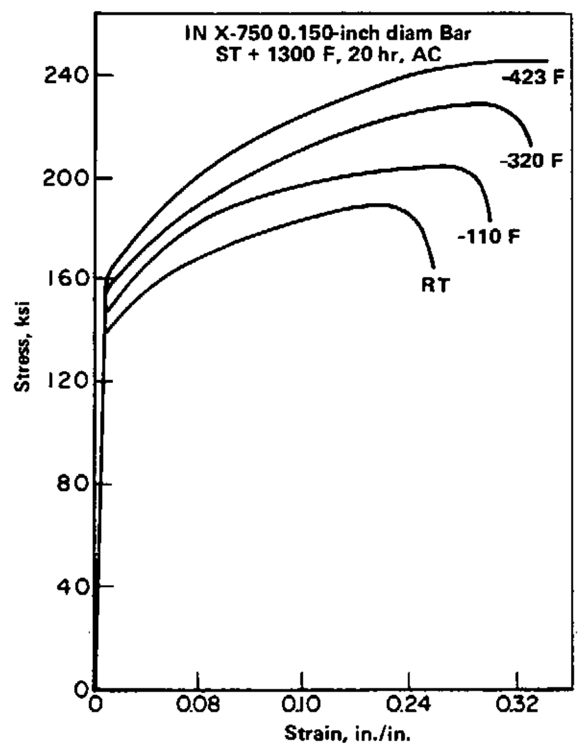

FIGURE 3.0312. COMPLETE STRESS-STRAIN CURVES FROM ROOM TEMPERATURE TO -423 F FOR BAR IN THE PRECIPITATION-TREATED CONDITION (48)

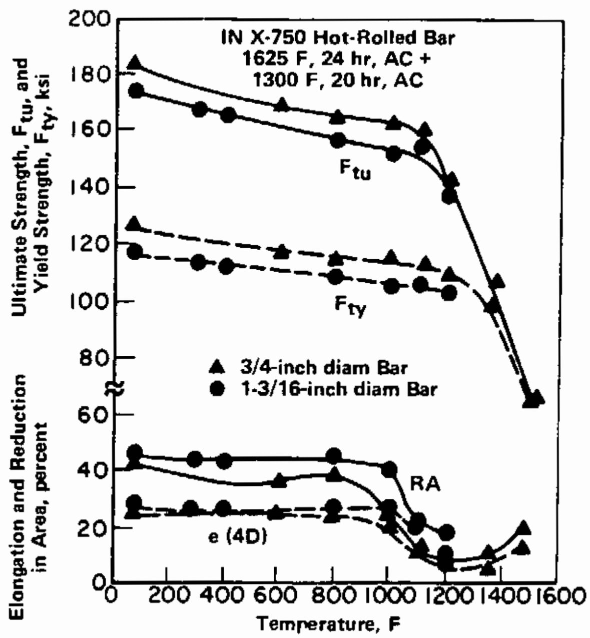

FIGURE 3.0313. TENSILE PROPERTIES OF EQUALIZED AND PRECIPITATION-TREATED BAR FROM 80 TO 1500 F (1)

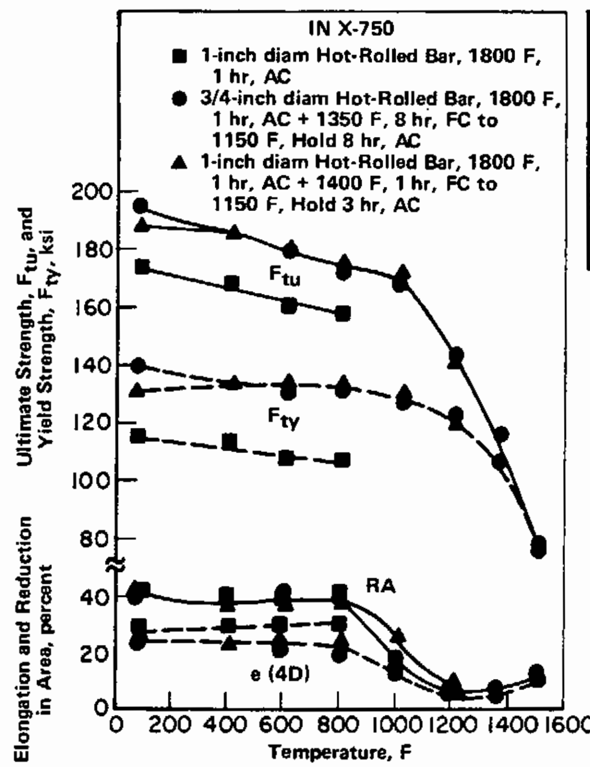

FIGURE 3.0314. TENSILE PROPERTIES OF BAR IN THE SOLUTION-TREATED CONDITION AND IN TWO FURNACE-COOL PRECIPITATION-TREATED CONDITIONS FROM 80 TO 1500 F (1)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

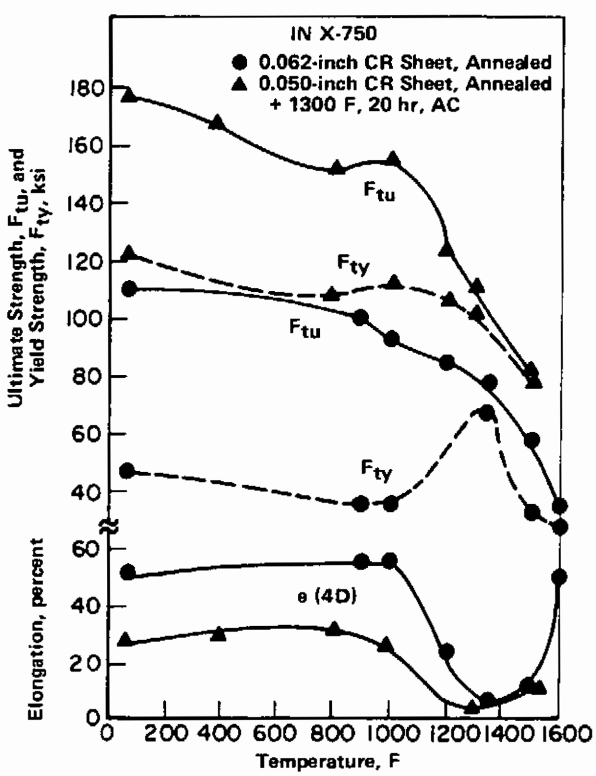

FIGURE 3.0315. TENSILE PROPERTIES FROM 80 TO 1600 F OF SHEET IN THE ANNEALED AND PRECIPITATION-TREATED CONDITIONS (1)

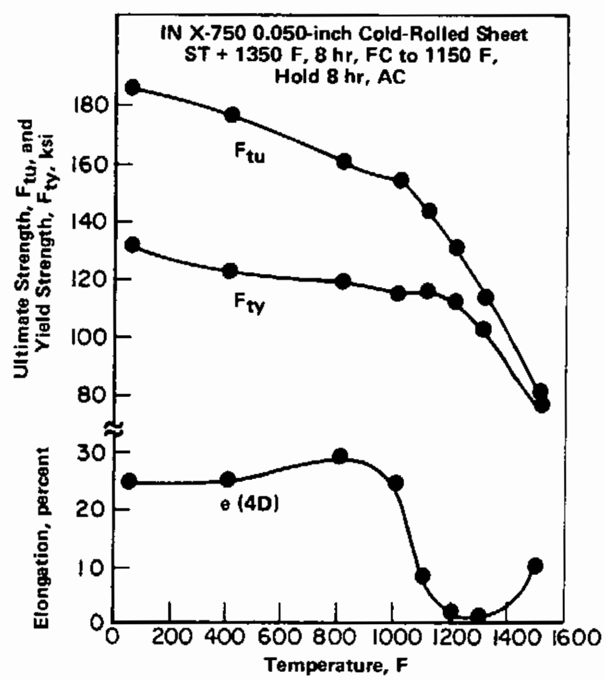

FIGURE 3.0316. TENSILE PROPERTIES FROM 80 TO 1500 F OF SHEET IN THE FURNACE-COOL PRECIPITATION-TREATED CONDITIONS (1)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel
X-750

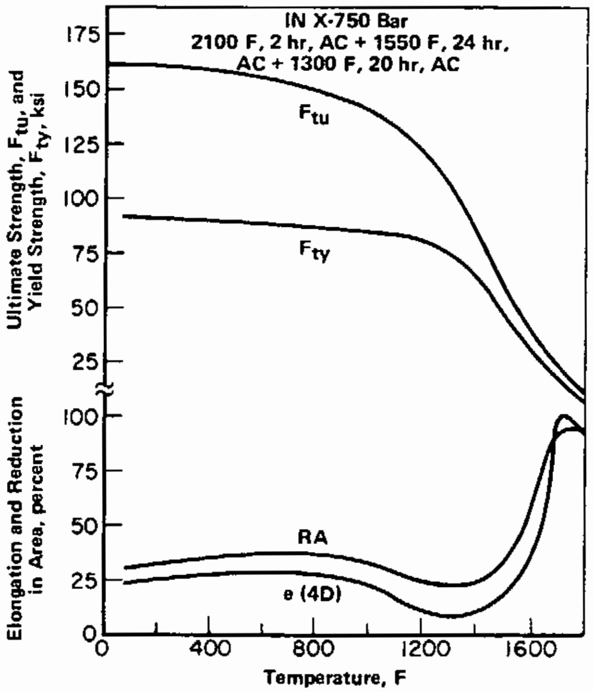

FIGURE 3.0317. TENSILE PROPERTIES FROM 80 TO 1800 F OF BAR FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED (1)

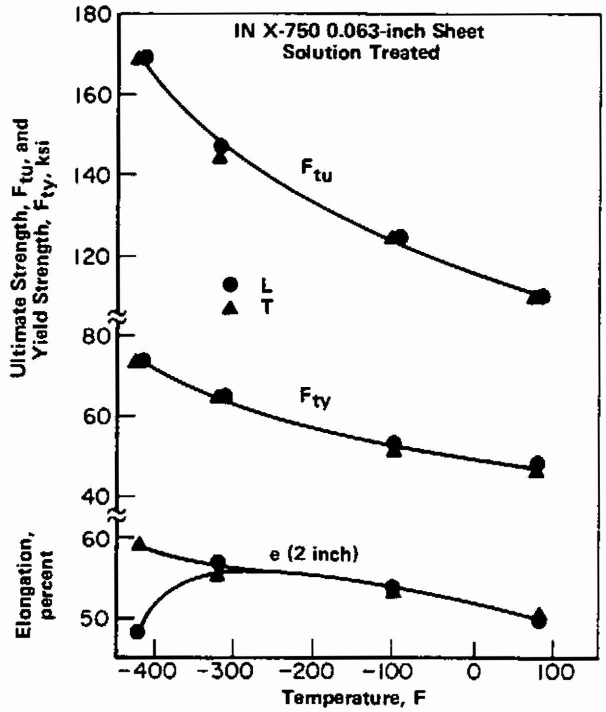

FIGURE 3.0318. TENSILE PROPERTIES FROM 78 TO -423 F OF SHEET IN THE SOLUTION-TREATED CONDITION (7)

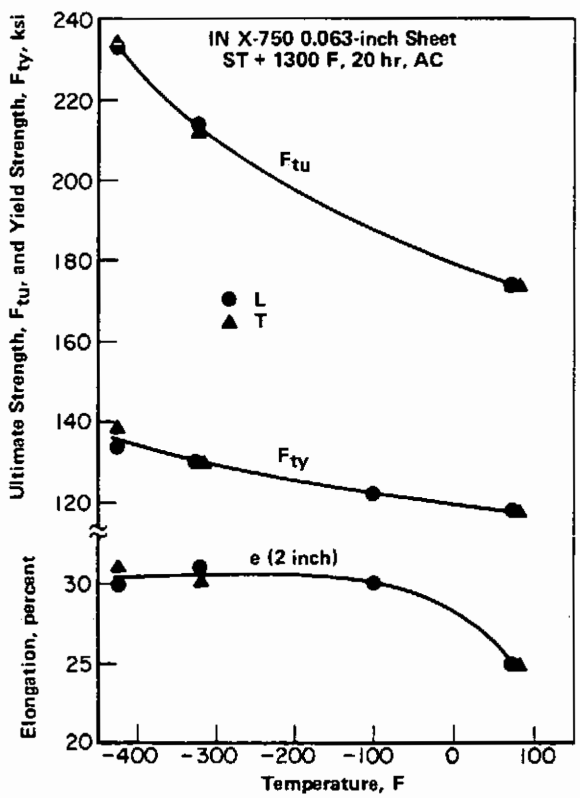

FIGURE 3.0319. TENSILE PROPERTIES FROM 78 TO -423 F OF SHEET IN THE PRECIPITATION-TREATED CONDITION (1) (7)

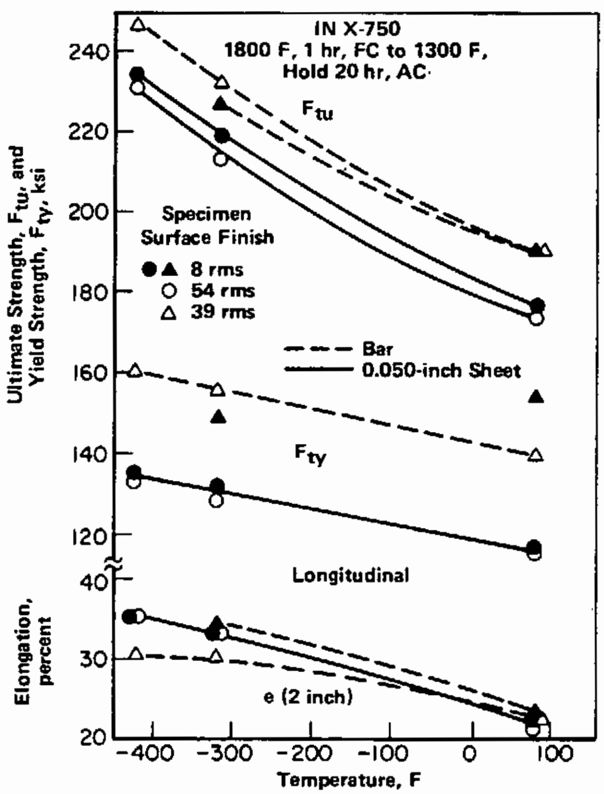

FIGURE 3.03110. TENSILE PROPERTIES OF PRECIPITATION-TREATED SHEET AND BAR WITH VARIOUS SURFACE FINISHES FROM 75 TO -423 F (24)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

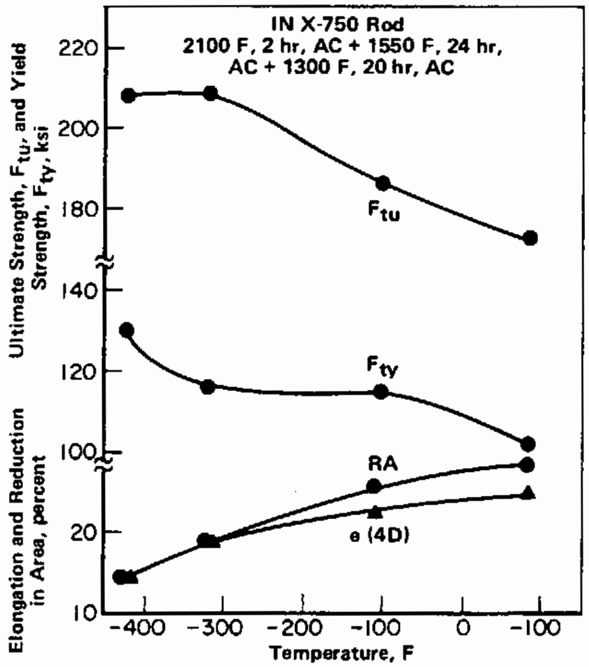

FIGURE 3.03111. TENSILE PROPERTIES FROM 80 TO –423 F OF ROD FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED (1)

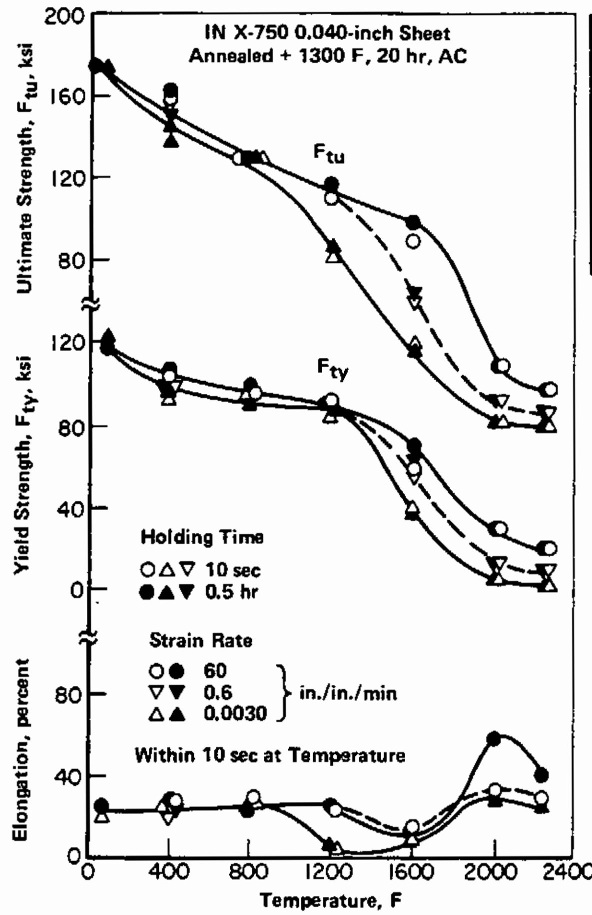

FIGURE 3.03112. EFFECTS OF STRAIN RATE AND HOLDING TIME FROM 75 TO 2250 F ON TENSILE PROPERTIES OF PRECIPITATION-TREATED SHEET AFTER IT HAD BEEN HEATED TO TEST TEMPERATURE WITHIN 10 SECONDS (49)

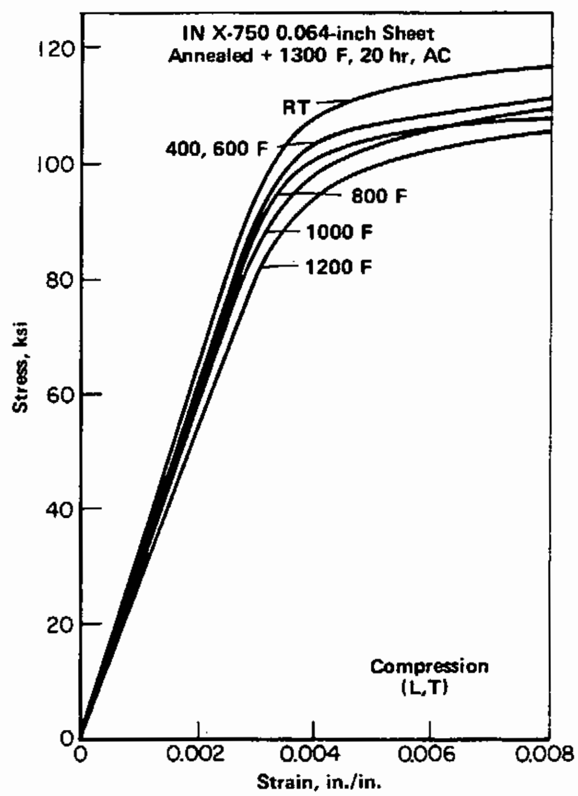

FIGURE 3.0321. STRESS-STRAIN CURVES IN COMPRESSION FOR PRECIPITATION-TREATED SHEET FROM ROOM TEMPERATURE TO 1200 F (50)

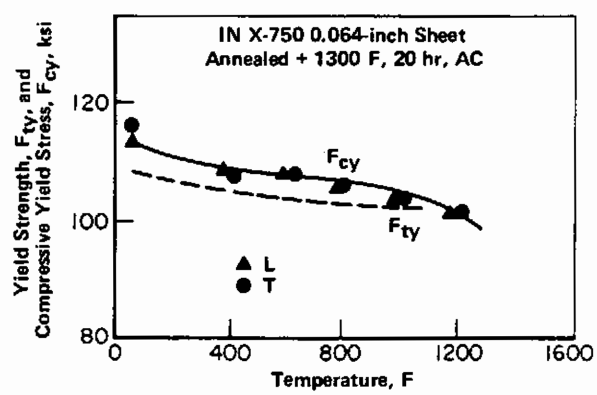

FIGURE 3.0322. COMPRESSIVE YIELD STRENGTH OF PRECIPITATION-TREATED SHEET FROM 75 TO 1200 F (50)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel
X-750

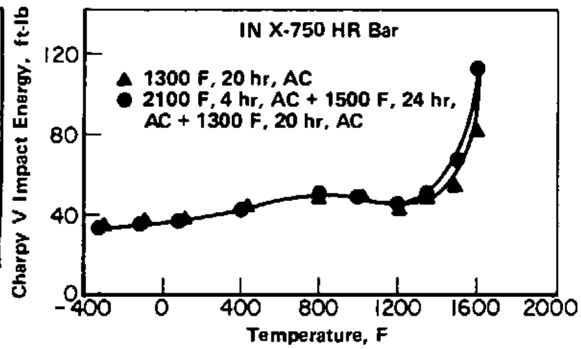

FIGURE 3.0331. IMPACT STRENGTH FROM -320 TO 1600 F OF BAR IN PRECIPITATION-TREATED, FULLY SOLUTION-TREATED, AND STABILIZED CONDITIONS (1) (5)

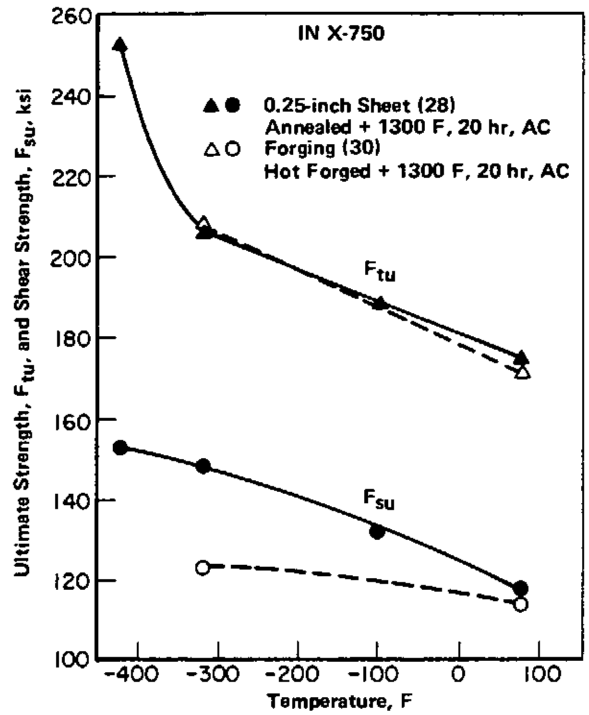

FIGURE 3.0351. COMPARISON OF SHEAR STRENGTH AND TENSILE STRENGTH OF PRECIPITATION-TREATED SHEET AND FORGINGS FROM 75 TO -423 F (28) (30)

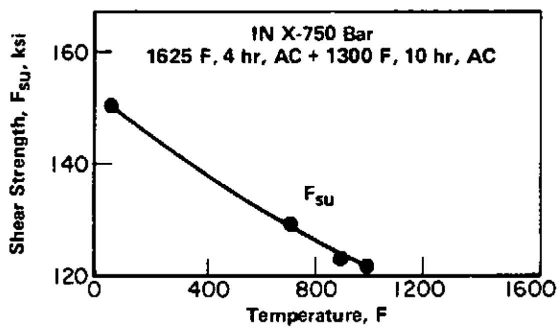

FIGURE 3.0352. SHEAR STRENGTH FROM 75 TO 1000 F OF EQUALIZED AND PRECIPITATION-TREATED BAR (51)

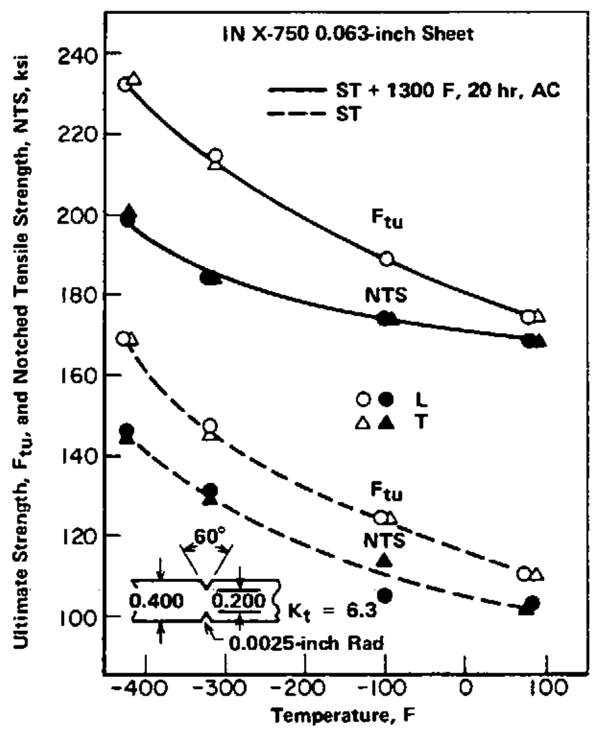

FIGURE 3.03711. COMPARISON OF ULTIMATE TENSILE STRENGTH AND NOTCH TENSILE STRENGTH FROM 78 TO -423 F OF SHEET IN SOLUTION-TREATED AND PRECIPITATION-TREATED CONDITIONS (7)

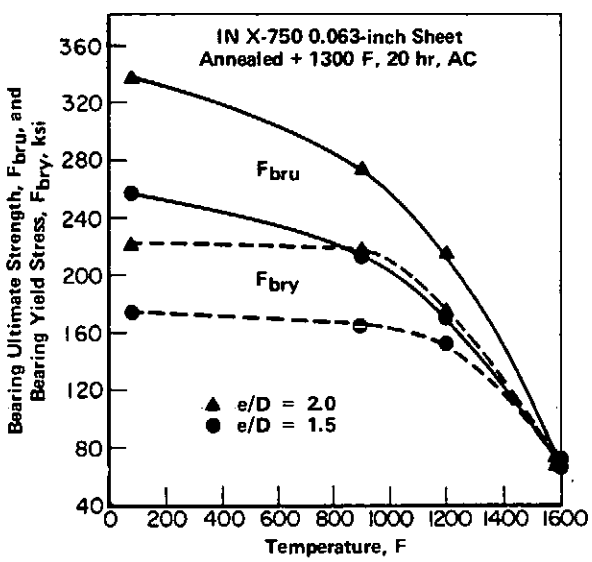

FIGURE 3.0361. BEARING PROPERTIES FROM 80 TO 1600 F OF SHEET IN THE PRECIPITATION-TREATED CONDITION (1)

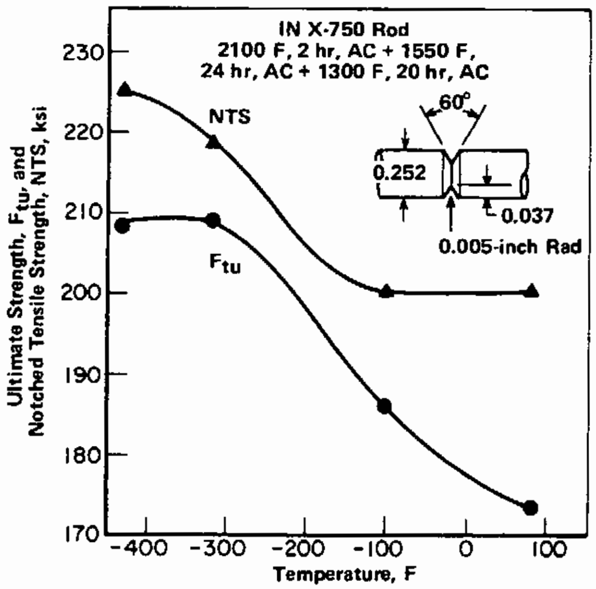

FIGURE 3.03712. NOTCHED TENSILE STRENGTH COMPARED WITH ULTIMATE TENSILE STRENGTH FROM 80 TO -423 F OF ROD FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED (1)

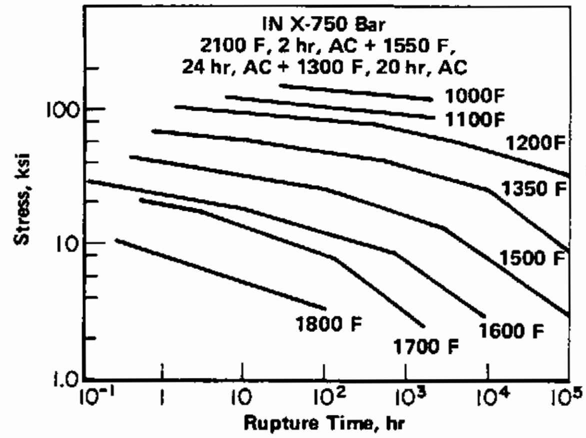

FIGURE 3.041. CREEP-RUPTURE CURVES FROM 1000 TO 1800 F FOR BAR IN FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED CONDITIONS (1)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

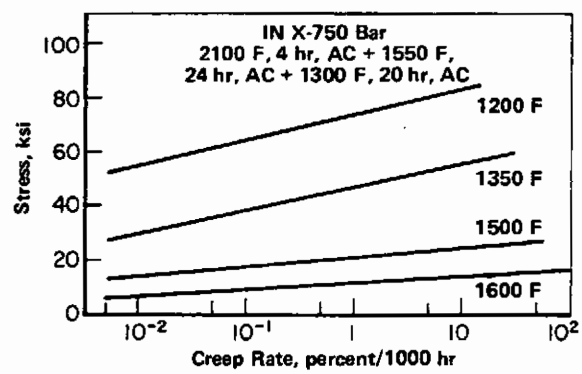

FIGURE 3.042. MINIMUM CREEP RATE OF FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED BAR AT VARIOUS STRESSES AND FROM 1200 TO 1600 F (1)

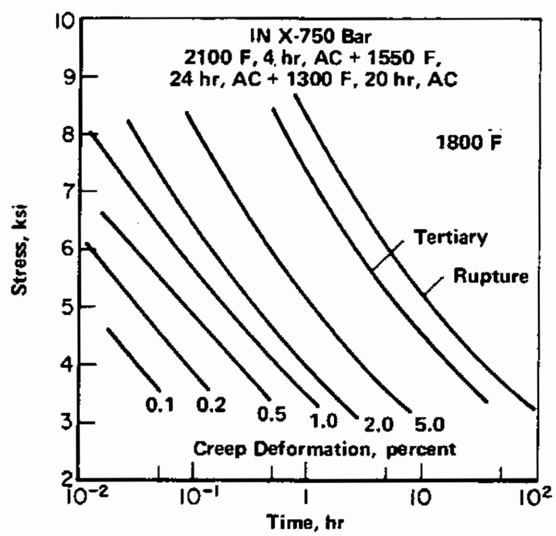

FIGURE 3.043. CREEP AND RUPTURE CURVES AT 1800 F FOR BAR IN THE FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED CONDITIONS (1)

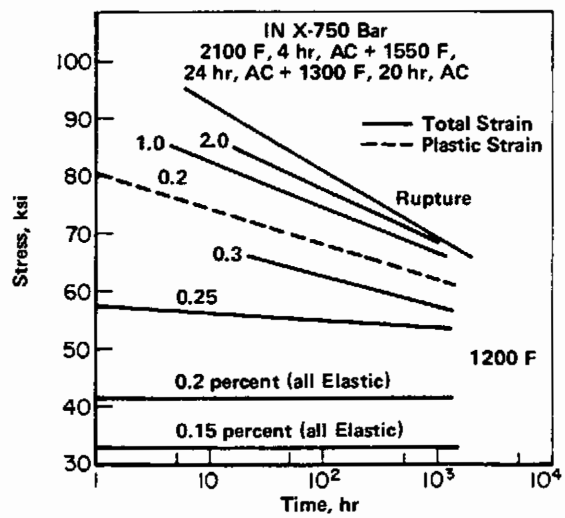

FIGURE 3.044. TOTAL STRAIN, PLASTIC STRAIN, AND RUPTURE CURVES AT 1200 F FOR BAR IN THE FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED CONDITIONS (1)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

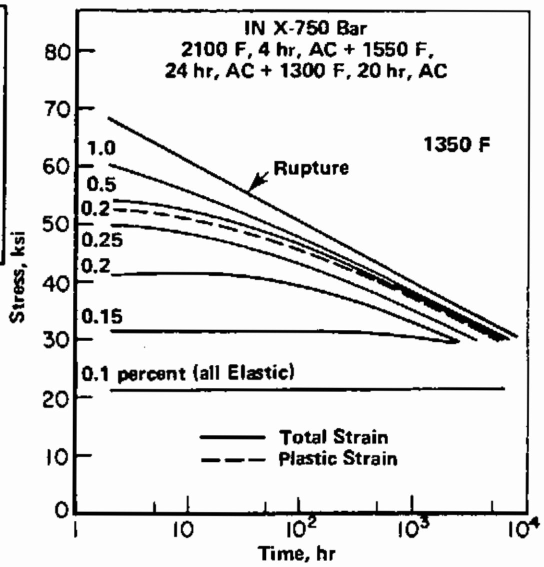

FIGURE 3.045. TOTAL STRAIN, PLASTIC STRAIN, AND RUPTURE CURVES AT 1350 F FOR BAR IN THE FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED CONDITIONS (1)

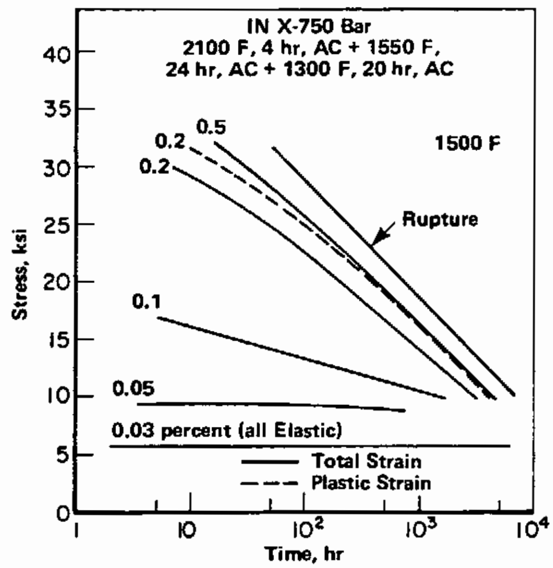

FIGURE 3.046. TOTAL STRAIN, PLASTIC STRAIN, AND RUPTURE CURVES AT 1500 F FOR BAR IN THE FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED CONDITIONS (1)

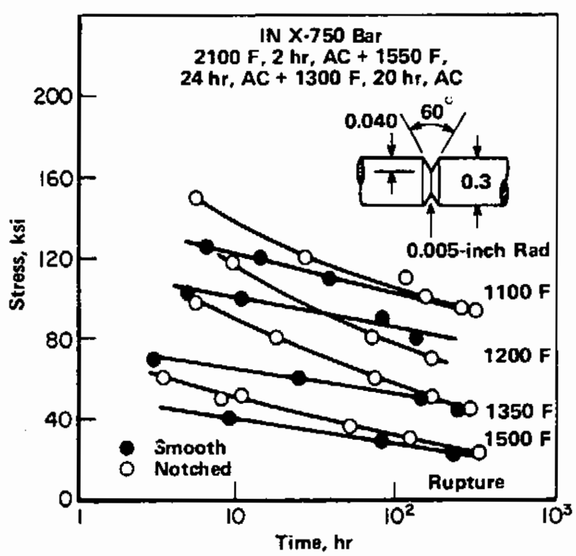

FIGURE 3.047. CREEP-RUPTURE CURVES FROM 1100 TO 1500 F FOR SMOOTH AND NOTCHED BAR IN THE FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED CONDITIONS (5)

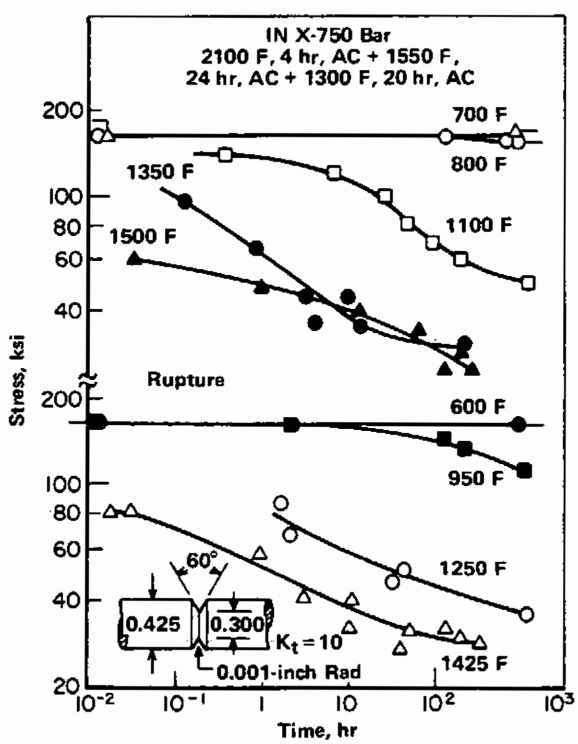

FIGURE 3.048. CREEP-RUPTURE CURVES FROM 600 TO 1500 F FOR NOTCHED BAR IN THE FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED CONDITIONS (52)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

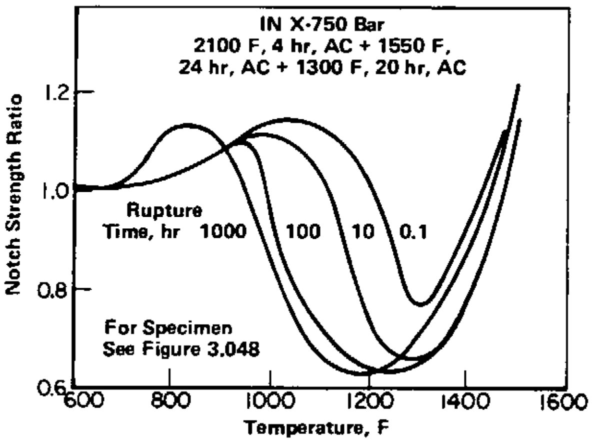

FIGURE 3.049. EFFECTS OF TEST TEMPERATURE AND AND CREEP-RUPTURE TIME ON THE NOTCH STRENGTH RATIO OF BAR IN THE FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED CONDITIONS (52)

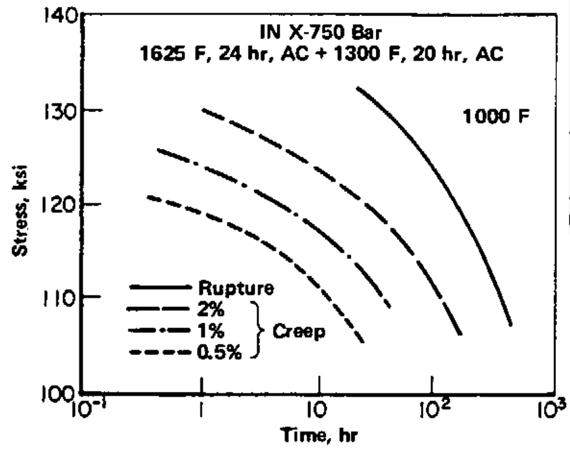

FIGURE 3.0410. CREEP AND RUPTURE CURVES AT 1000 F FOR BAR IN THE EQUALIZED AND PRECIPITATION-TREATED CONDITIONS (5)

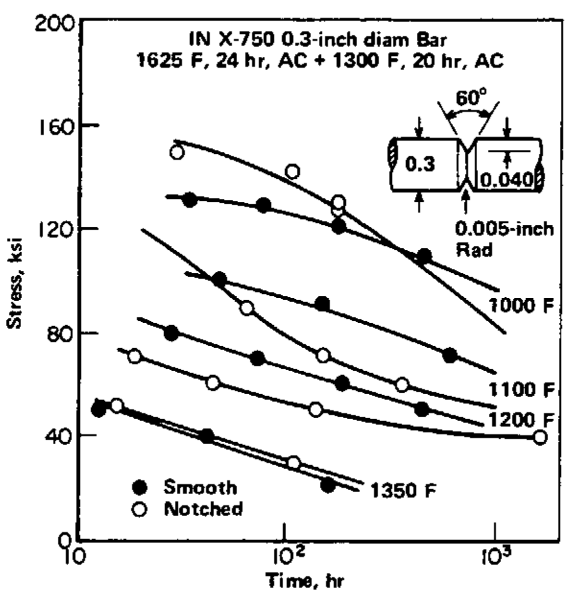

FIGURE 3.0411. CREEP-RUPTURE CURVES FOR SMOOTH AND NOTCHED BAR IN THE EQUALIZED AND PRECIPITATION-TREATED CONDITIONS (5)

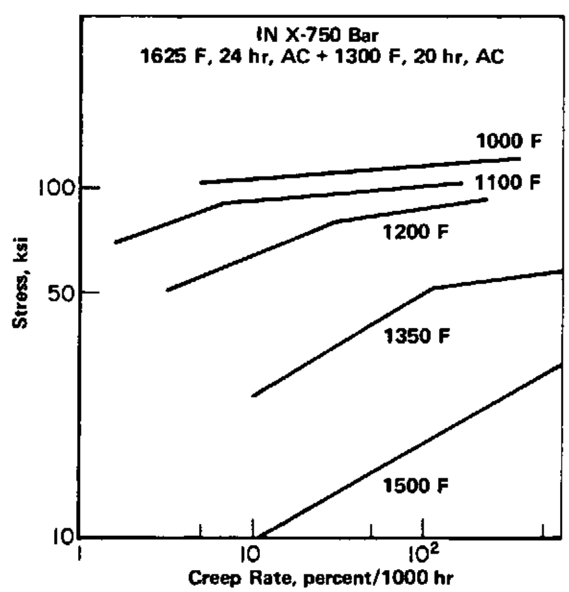

FIGURE 3.0412. MINIMUM CREEP RATE OF EQUALIZED AND PRECIPITATION-TREATED BAR AT VARIOUS STRESSES AND FROM 1000 TO 1500 F (1)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

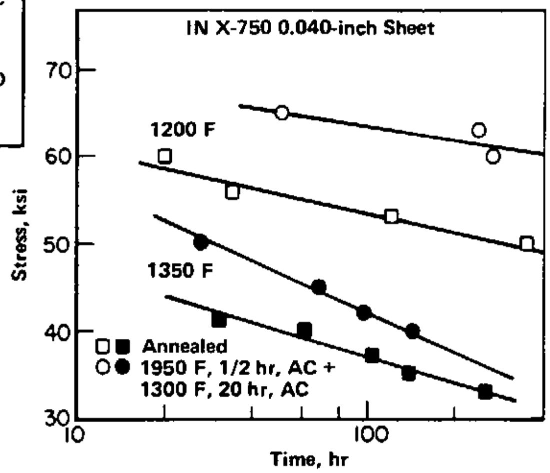

FIGURE 3.0414. STRESS-RUPTURE CURVES AT 1200 AND 1350 F FOR SHEET IN THE ANNEALED AND PRECIPITATION-TREATED CONDITIONS (53)

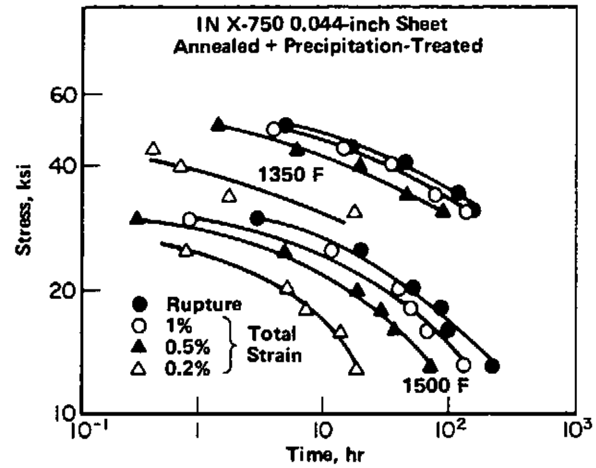

FIGURE 3.0415. TOTAL STRAIN CURVES AT 1350 AND 1500 F FOR SHEET IN THE PRECIPITATION-TREATED CONDITION (54)

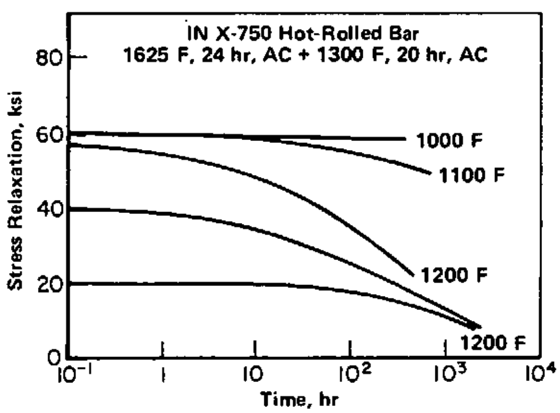

FIGURE 3.0416. STRESS RELAXATION FROM 1000 TO 1200 F OF BAR IN THE EQUALIZED AND PRECIPITATION-TREATED CONDITIONS (1)

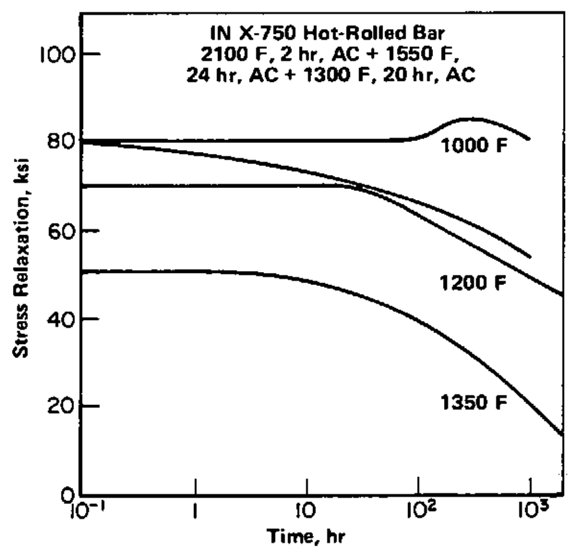

FIGURE 3.0417. STRESS RELAXATION FROM 1000 TO 1350 F OF BAR IN THE FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED CONDITIONS (1)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

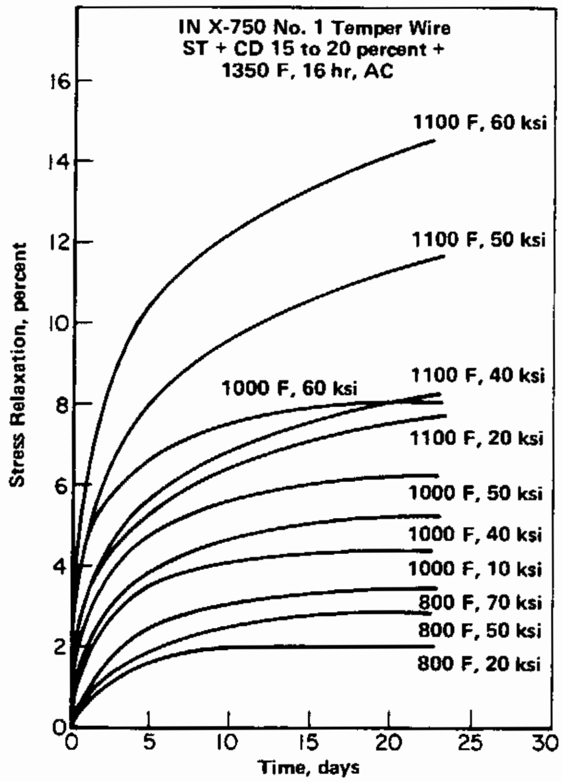

FIGURE 3.0418. EFFECTS OF TEMPERATURES FROM 800 TO 1100 F AND VARIOUS STARTING STRESSES ON STRESS RELAXATION OF SPRINGS COILED FROM NO. 1 TEMPER WIRE IN THE PRECIPITATION-TREATED CONDITION (1)

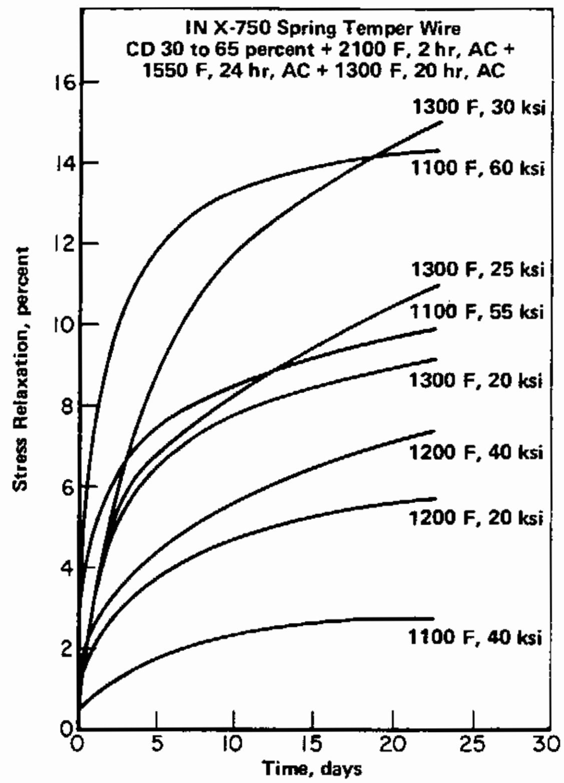

FIGURE 3.0419. EFFECTS OF TEMPERATURES FROM 1100 TO 1300 F AND VARIOUS STARTING STRESSES ON STRESS RELAXATION OF SPRINGS COILED FROM SPRING TEMPER WIRE IN THE FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED CONDITIONS (1)

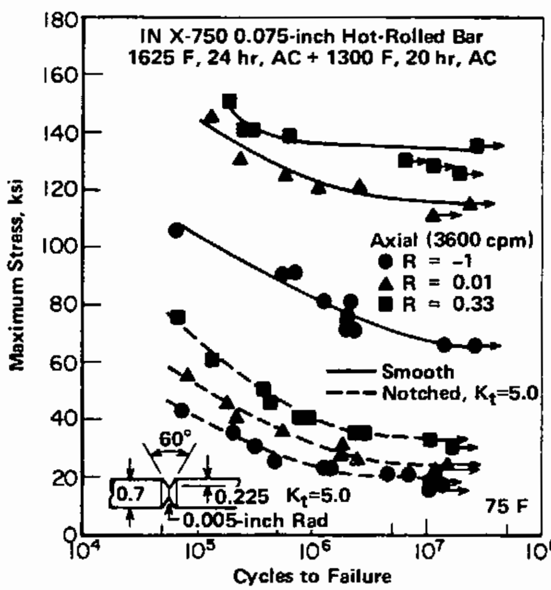

FIGURE 3.051. FATIGUE LIFE AT ROOM TEMPERATURE AND AT VARIOUS RATIOS (R) OF MINIMUM-TO-MAXIMUM STRESS FOR SMOOTH AND NOTCHED BARS IN THE EQUALIZED AND PRECIPITATION-TREATED CONDITIONS (6)

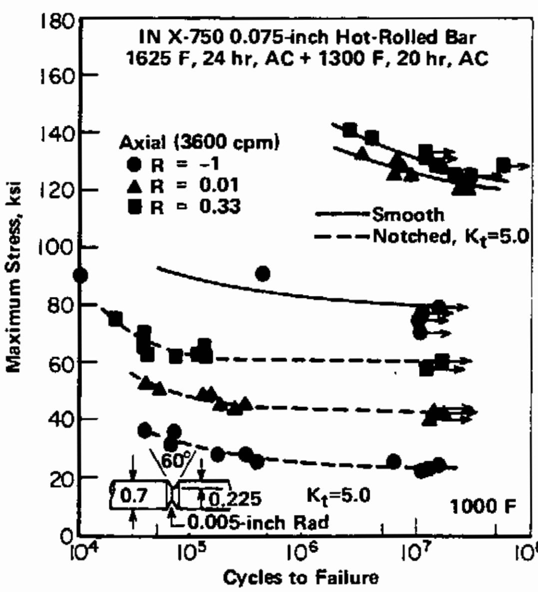

FIGURE 3.052. FATIGUE LIFE AT 1000 F AND AT VARIOUS RATIOS (R) OF MINIMUM-TO-MAXIMUM STRESS FOR SMOOTH AND NOTCHED BARS IN THE EQUALIZED AND PRECIPITATION-TREATED CONDITIONS (6)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

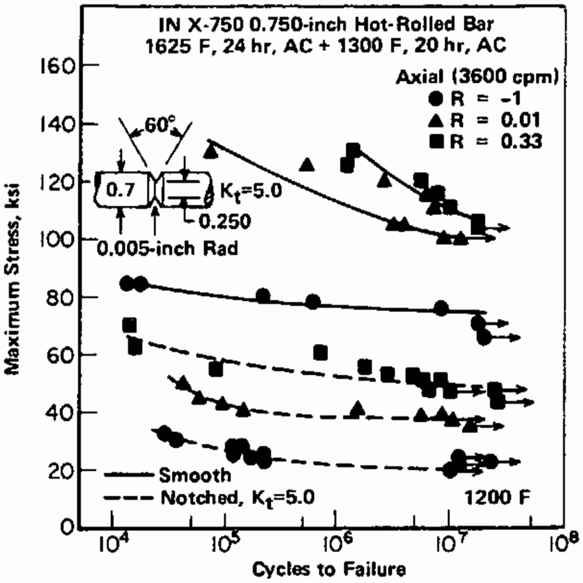

FIGURE 3.053. FATIGUE LIFE AT 1200 F AND AT VARIOUS RATIOS (R) OF MINIMUM-TO-MAXIMUM STRESS FOR SMOOTH AND NOTCHED BARS IN THE EQUALIZED AND PRECIPITATION-TREATED CONDITIONS (6)

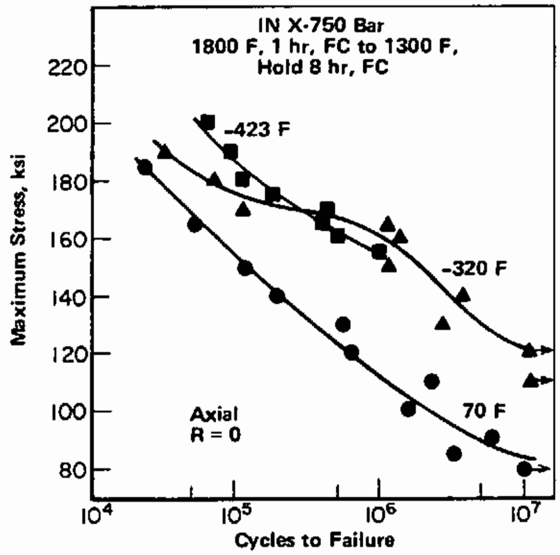

FIGURE 3.054. AXIAL FATIGUE LIFE OF PRECIPITATION-TREATED BAR AT 70, -320, AND -423 F (24)

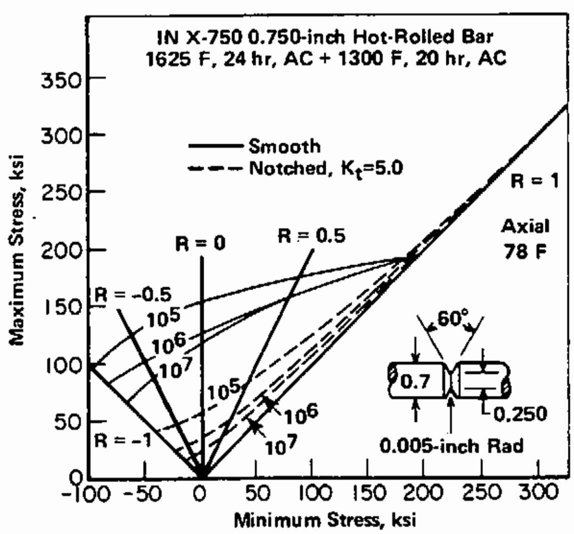

FIGURE 3.055. CONSTANT-FATIGUE-LIFE DIAGRAM AT ROOM TEMPERATURE FOR SMOOTH AND NOTCHED BAR IN THE EQUALIZED AND PRECIPITATION-TREATED CONDITIONS (6)

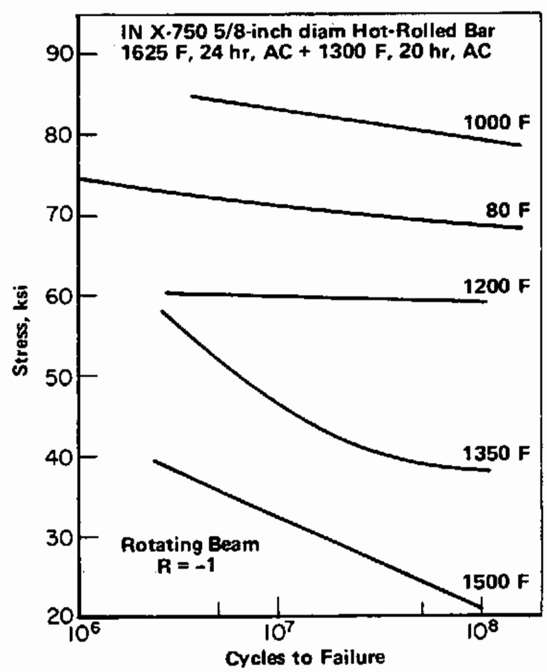

FIGURE 3.056. ROTATING-BEAM FATIGUE LIFE OF EQUALIZED AND PRECIPITATION-TREATED BAR AT VARIOUS STRESSES AND FROM 80 TO 1500 F (1)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

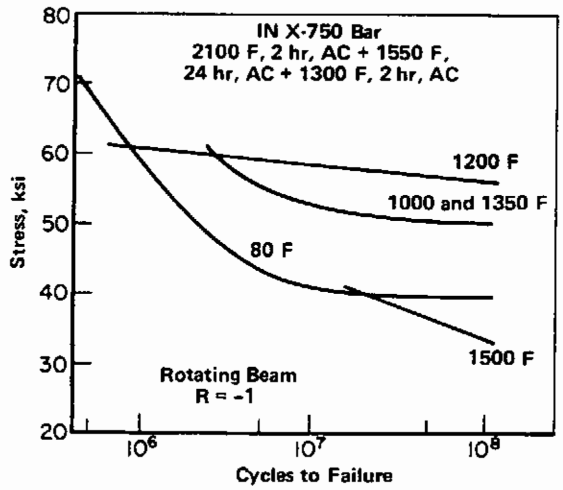

FIGURE 3.057. ROTATING-BEAM FATIGUE LIFE OF FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED BAR AT VARIOUS STRESSES AND FROM 80 TO 1500 F (1)

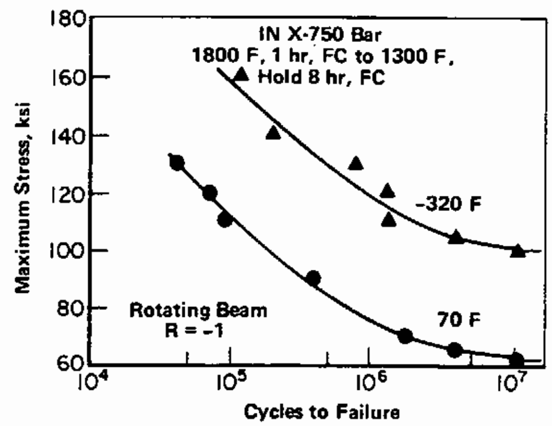

FIGURE 3.058. ROTATING-BEAM FATIGUE LIFE OF PRECIPITATION-TREATED BAR AT 70 AND -320 F (24)

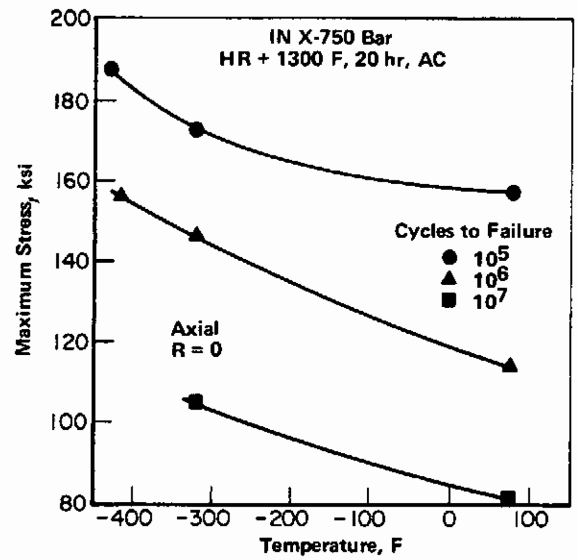

FIGURE 3.059. FATIGUE STRENGTHS AT VARIOUS CYCLES TO FAILURE FOR PRECIPITATION-TREATED BAR FROM 75 TO -423 F (26)

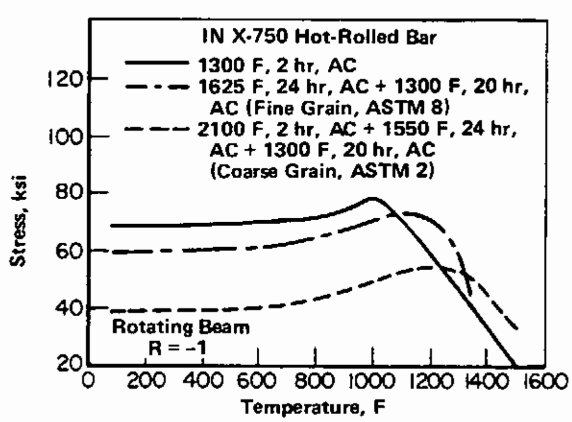

FIGURE 3.0510. ROTATING-BEAM FATIGUE STRENGTH AT 10^8 CYCLES TO FAILURE OF BAR IN SEVERAL HEAT-TREATED CONDITIONS FROM 80 TO 1500 F (1) (5)

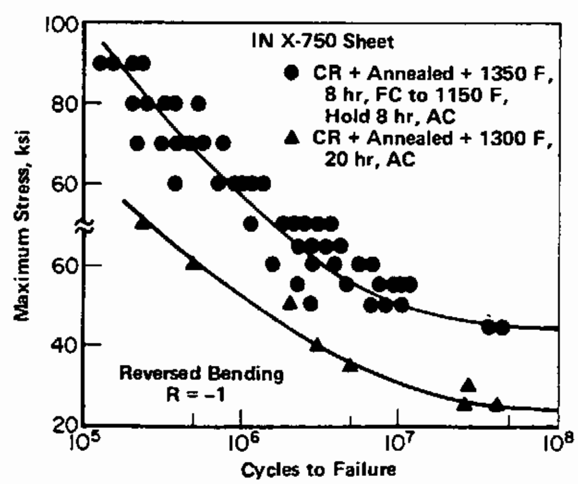

FIGURE 3.0511. FATIGUE LIFE AT ROOM TEMPERATURE OF SHEET IN TWO PRECIPITATION-TREATED CONDITIONS (1)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

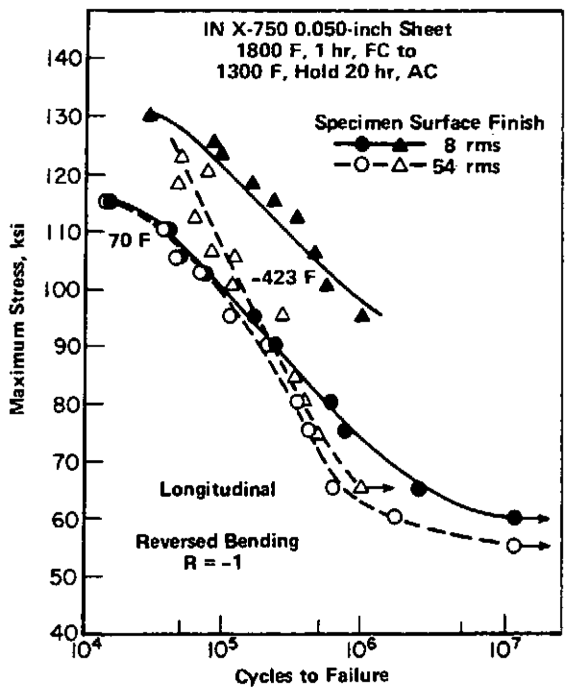

FIGURE 3.0512. FATIGUE LIFE IN REVERSED BENDING OF PRECIPITATION-TREATED SHEET WITH TWO DIFFERENT SURFACE FINISHES AT 70 AND -423 F (24)

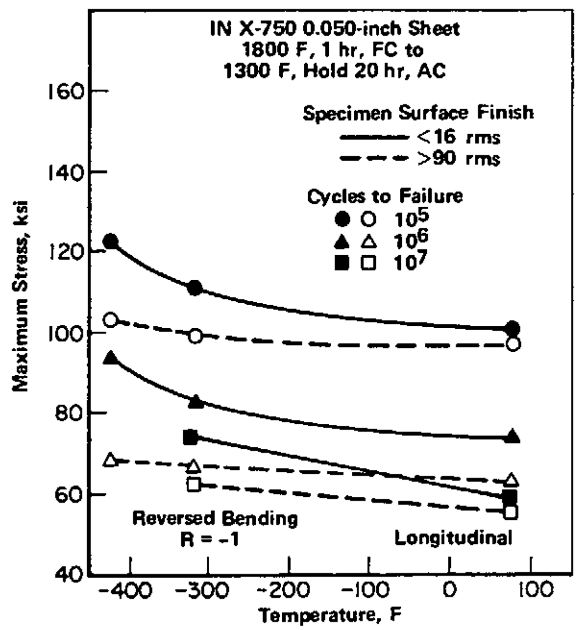

FIGURE 3.0513. FATIGUE STRENGTHS AT VARIOUS CYCLES TO FAILURE FOR PRECIPITATION-TREATED SHEET WITH DIFFERENT SURFACE FINISHES FROM 75 TO -423 F (26)

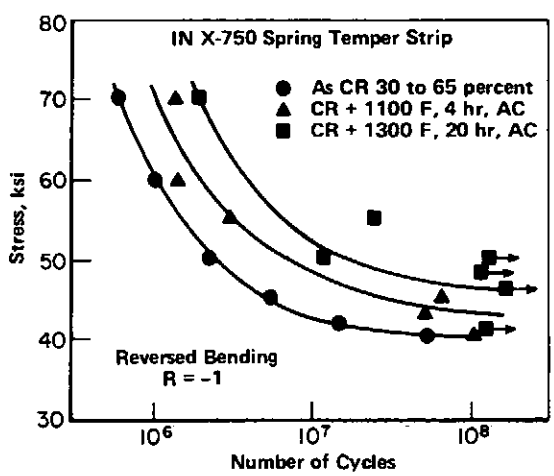

FIGURE 3.0514. FATIGUE LIFE IN REVERSED BENDING OF SPRING TEMPER STRIP IN AS COLD-ROLLED AND TWO PRECIPITATION-TREATED CONDITIONS (5)

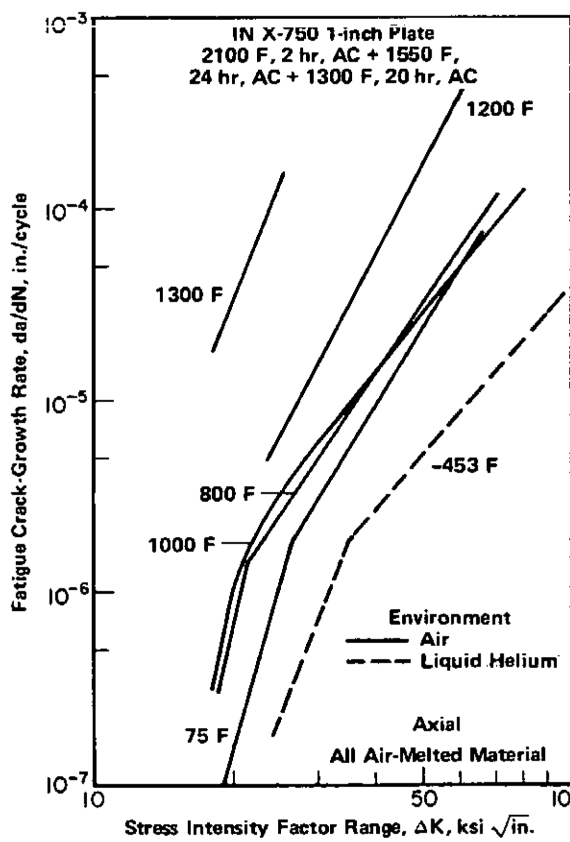

FIGURE 3.0515. FATIGUE CRACK-GROWTH RATE AT VARIOUS TEMPERATURES FOR PLATE FULLY SOLUTION-TREATED, STABILIZED, AND PRECIPITATION-TREATED (17) (18) (31)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

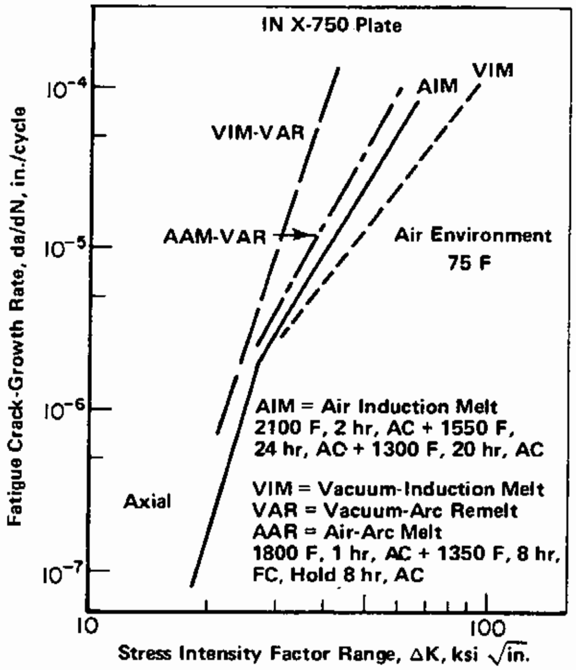

FIGURE 3.0516. FATIGUE CRACK-GROWTH RATES AT ROOM TEMPERATURE FOR PLATE PRODUCED BY VARIOUS MELTING TECHNIQUES AND SUBSEQUENTLY SUBJECTED TO DIFFERENT HEAT-TREAT CYCLES (17)

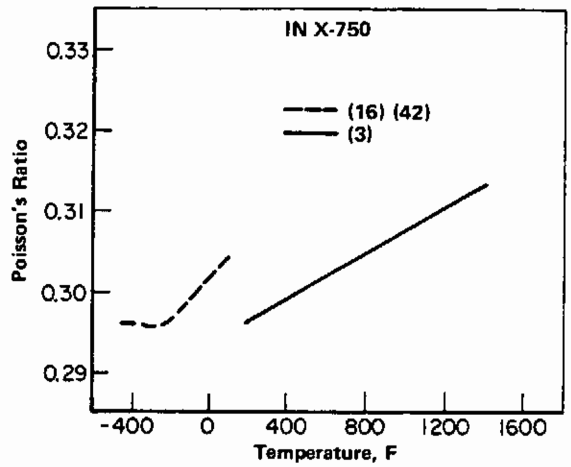

FIGURE 3.0611. POISSON'S RATIO FROM -460 TO 1400 F (16) (42) (3)

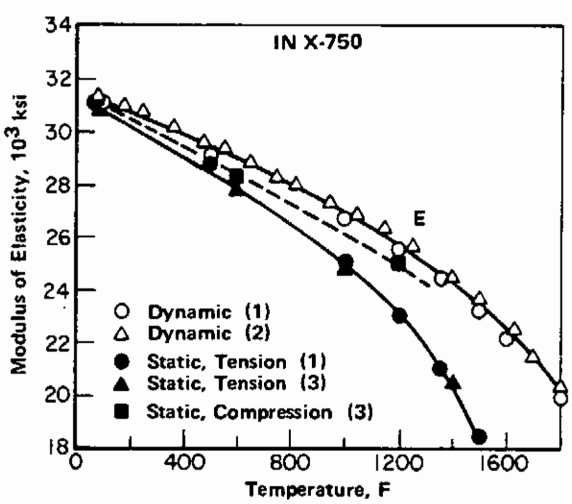

FIGURE 3.0621. TYPICAL STATIC AND DYNAMIC MODULUS OF ELASTICITY FOR ALL HEAT-TREATED CONDITIONS FROM 80 TO 1800 F (1) (2) (3)

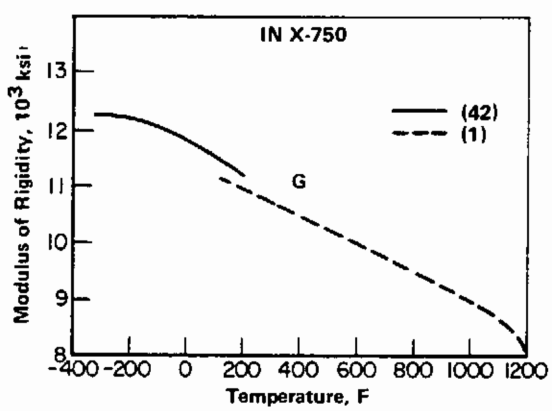

FIGURE 3.0631. MODULUS OF RIGIDITY FROM -320 TO 1200 F (1) (42)

	Ni
15	Cr
7	Fe
2.5	Ti
1	Cb
0.7	Al

Inconel X-750

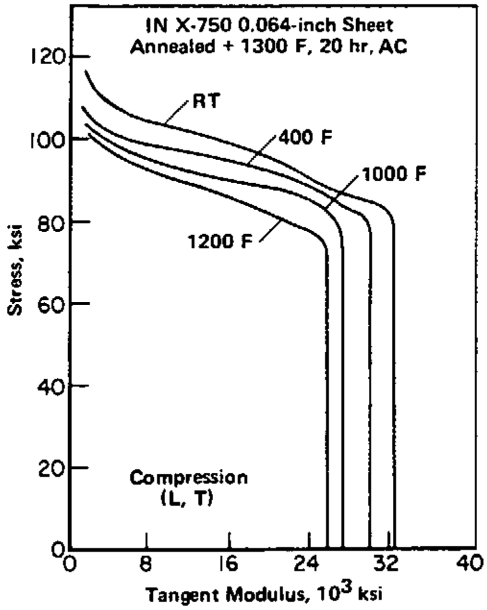

FIGURE 3.0641. TANGENT MODULUS CURVES FROM ROOM TEMPERATURE TO 1200 F FOR SHEET IN THE PRECIPITATION-TREATED CONDITION (50)

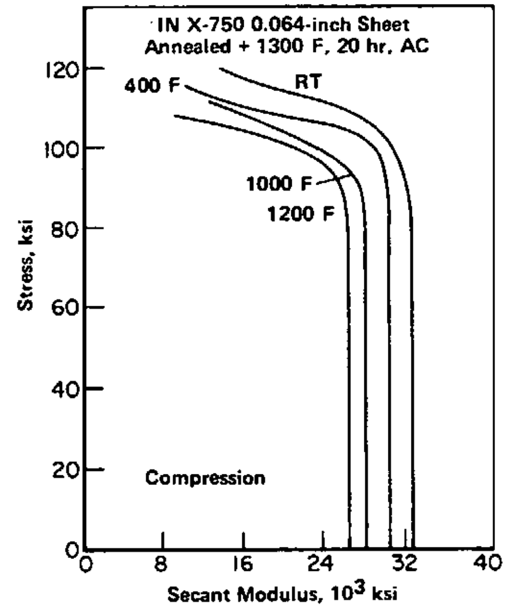

FIGURE 3.0651. SECANT MODULUS CURVES FROM ROOM TEMPERATURE TO 1200 F FOR SHEET IN THE PRECIPITATION-TREATED CONDITION (50)

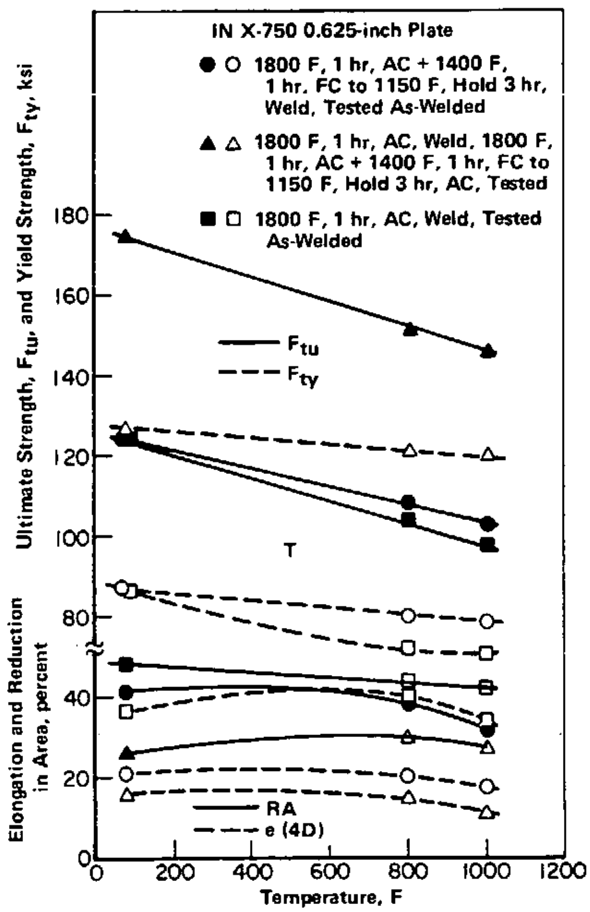

FIGURE 4.0311. TENSILE PROPERTIES FROM 80 TO 1000 F OF PLATE BUTT WELDED WITH GTA PROCESS AND INCONEL NO. 69 FILLER METAL; BUTT WELD PERPENDICULAR TO THE LOADING DIRECTION IN TENSILE TESTS (1)

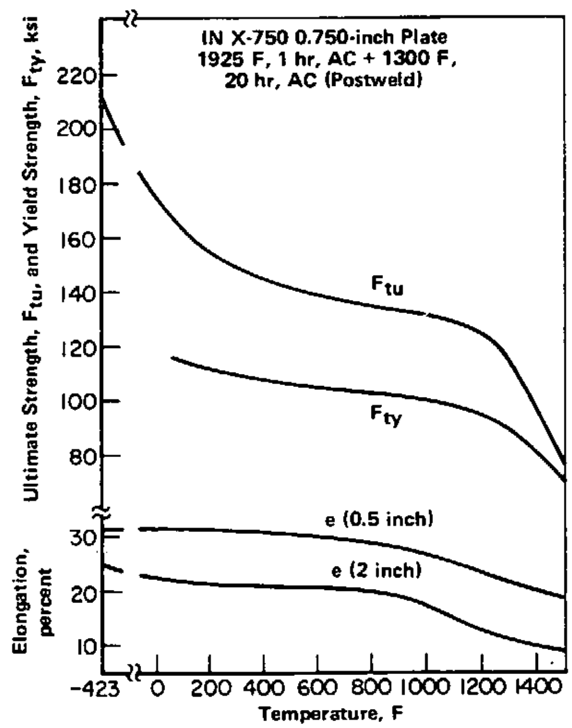

FIGURE 4.0312. TENSILE PROPERTIES FROM -423 TO 1500 F OF PLATE BUTT WELDED WITH GTA PROCESS AND INCONEL NO. 69 FILLER METAL; BUTT WELD PERPENDICULAR TO THE LOADING DIRECTION IN TENSILE TESTS (1)