Ni
15 Cr
3 Al
0.5 Ti

INCONEL ALLOY 702

1. GENERAL
This heat treatable nickel base alloy contains chromium aluminum and titanium as hardeners. Due to its high aluminum content it exhibits exceptional oxidation resistance up to 2400 F. It is available primarily in sheet form, although strip, wire and tubing are also produced.

1.01 Commercial Designation
Inconel 702

1.02 Alternate Designations
None

1.03 Specifications

Table 1.03

AMS	Form
5550 A	Alloy sheet and strip, corrosion and heat resistant.

1.04 Composition
Table 1.04

TABLE 1.04

Source	AMS (4)	
	Percent	
	Min	Max
Carbon		0.10
Manganese		1.00
Silicon		0.70
Sulfur		0.01
Chromium	14.0	17.0
Titanium	0.25	1.00
Aluminum	2.75	3.75
Cobalt (if determined)		1.0
Iron		2.00
Copper		0.50
Nickel + Cobalt	Balance	

1.05 Heat Treatment
1.051 Anneal. 1950 to 2000 F, air cool.
1.052 Age annealed condition. 1350 to 1400 F, 4 to 5 hr.
1.053 Dimensional change during aging 0.05 percent contraction.

1.06 Hardness
1.061 If cooled slowly from the annealed condition, the alloy will fully age.
1.062 The alloy can also be hardened by cold work.

1.07 Forms and Conditions Available
1.071 Alloy is available in form of sheet, strip, wire and tubing.
1.072 Other wrought products, such as bar, are available on special order.
1.073 These forms are usually supplied in the annealed condition.

1.08 Melting and Casting Practice
Induction furnace air melt.

1.09 Special Considerations
1.091 Contact with sulfur containing atmospheres at high temperatures should be avoided.

2. PHYSICAL AND CHEMICAL PROPERTIES

2.01 Thermal Properties
2.011 Melting range.
2.012 Phase changes. Alloy is subject to precipitation of age hardening constituents.
2.013 Thermal conductivity, Figure 2.013.
2.014 Thermal expansion, Figure 2.014
2.015 Specific heat.
2.016 Thermal diffusivity.

2.02 Other Physical Properties
2.021 Density. 0.295 lb per cu in. 8.18 gr per cu cm, (3, p. 1)
0.302 lb per cu in. 8.37 gr per cu cm, (1)(2).
0.304 lb per cu in. 8.41 gr per cu cm, (6)
2.022 Electrical resistivity, Figure 2.022.
2.023 Magnetic properties. Alloy is nonmagnetic at room and elevated temperatures. Permeability at room temperature and 200 oersted, 1.0004. Curie temperature in the aged condition is below -320 F.
2.024 Emissivity.

2.03 Chemical Properties
2.031 Corrosion resistance.
2.032 Oxidation resistance above 2000 F exceeds that of any other nickel base alloy.

2.04 Nuclear Properties

3. MECHANICAL PROPERTIES

3.01 Specified Mechanical Properties
3.011 AMS requirements, Table 3.011.

TABLE 3.011

Source	(4)			
Alloy	Ni-15Cr-3Al-0.5Ti			
Condition	Precipitation HT 1375-1425 F, 5 hrs, AC			
Form	Strip		Sheet	
	< 0.010	0.010 to 0.125	0.010 to 0.025	>0.025 to 0.250
Ftu - ksi min	125	125	125	125
Fty - ksi min			60	60
e-(2 inch) min percent		15	17	25
Hardness Rockwell "C" min		21	21	25

3.02 Mechanical Properties at Room Temperatures
See 3.03

3.03 Mechanical Properties at Various Temperatures
3.031 Tension
3.0311 Effect of test temperature on tensile properties of welded and aged sheet, Figure 3.0311.
3.0312 Effect of test temperature, strain rate and holding time on tensile properties of aged sheet, Figure 3.0312.
3.0313 Tensile stress strain curves at various test temperatures, Figure 3.0313.
3.032 Compression.
3.0321 Effect of test temperature on the compressive yield strength of sheet and strip, Figure 3.0321.
3.0322 Compressive stress-strain curves at various test temperatures, Figure 3.0322.
3.033 Impact.
3.034 Bending.
3.035 Torsion and shear
3.0351 Effect of test temperature on the shear strength of sheet, Figure 3.0351.
3.036 Bearing.
3.0361 Effect of test temperature on the bearing properties of sheet, Figure 3.0361.
3.037 Stress concentration.
3.0371 Notch properties.
3.0372 Fracture toughness.
3.038 Combined properties.

3.04 Creep and Creep Rupture Properties
3.041 Creep and creep rupture curves at 1400 and 1600 F, for aged sheet, Figure 3.041.
3.042 Creep rupture curves at 1000 to 1700 F for aged sheet, Figure 3.042.

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3.043 Master curves for 0.2 percent creep and creep rupture of annealed and of aged sheet, Figure 3.043.

3.044 Master curves for creep rupture of bar stock, Figure 3.044.

3.05 Fatigue Properties

3.051 Typical S-N curve for sheet at room temperature, Figure 3.051.

3.06 Elastic Properties

3.061 Modulus of elasticity at room and elevated temperatures, Figure 3.061.

4. FABRICATION

4.01 Forming and Casting

4.011 Forging. Starting temperature 2200 F, maximum finishing temperature 1800 F, minimum. Alloy should not be forged at 1200 to 1600 F, because of low ductility.

4.02 Machining

The alloy is preferably machined in the annealed or hot-worked condition, although aged material can also be machined. The recommended practice is to machine slightly oversize in the unaged condition, age-harden, and finish machine to size. High speed steel, cast nonferrous or carbide tools with positive rake angles should be used, since considerable heat is generated. Sulfur base oils are recommended for lubrication, but they should be completely removed before any exposure to elevated temperatures.

4.03 Welding

Alloy can be welded by the inert gas shielded tungsten arc method and, for thicknesses up to 1/8 inch, also by inert gas shielded autogenous welding. Inconel 702 can be used as welding wire. The gas tungsten arc process using filler metal of matching composition is the preferred method of joining.

4.04 Heating and Heat Treating

Should be done in a slightly reducing sulfur free atmosphere containing about 2 percent carbon monoxide.

4.05 Surface Treating

4.051 Pickling is performed in a nitric acid-hydrofluoric acid solution at 125 F. An alkaline pretreatment either in fused salt or in a caustic permanganate solution and followed by a 20 percent sulfuric acid bath reduces the time required for pickling.

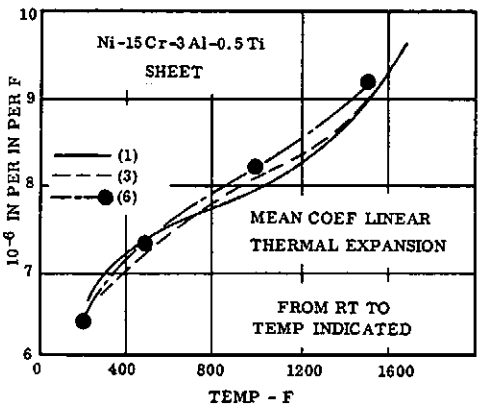

FIG. 2.014 THERMAL EXPANSION (1pg 2)(3)(6)

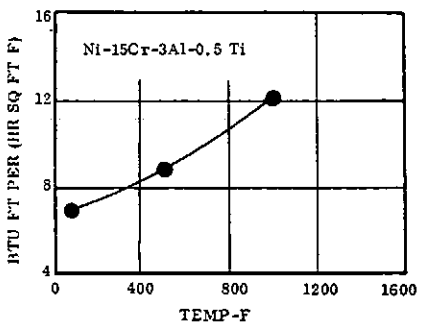

FIG. 2.013 THERMAL CONDUCTIVITY (6)

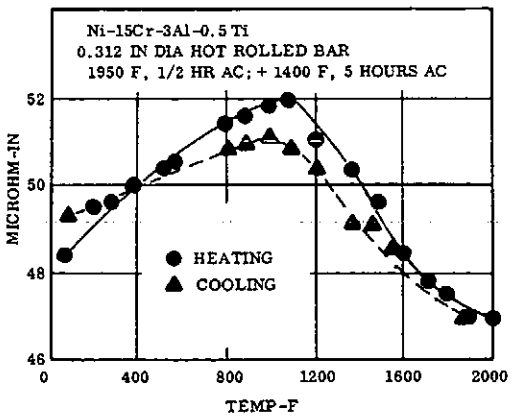

FIG. 2.022 ELECTRICAL RESISTIVITY (6)

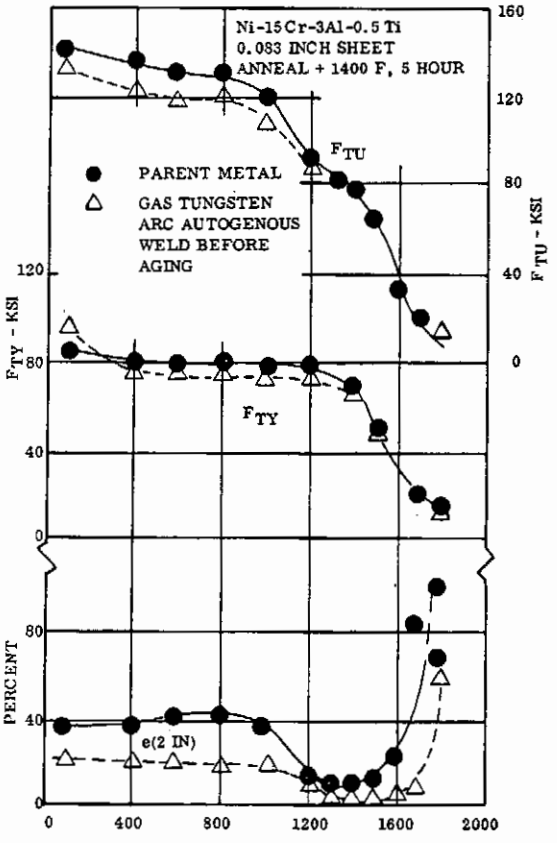

FIG. 3.0311 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF WELDED AND AGED SHEET
(6)

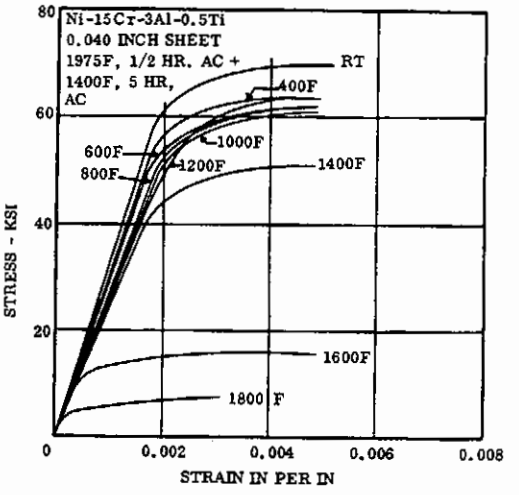

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FIG. 3.0313 TEMPERATURE STRESS STRAIN CURVES AT VARIOUS TEMPERATURES
(5)

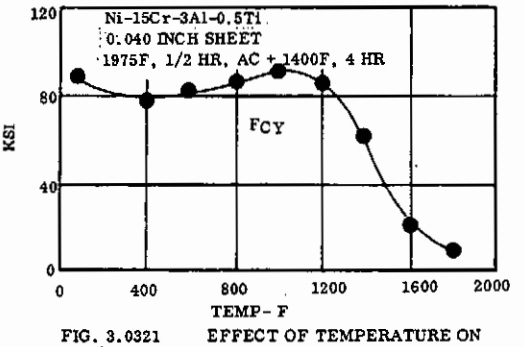

FIG. 3.0321 EFFECT OF TEMPERATURE ON COMPRESSIVE YIELD STRENGTH OF SHEET
(5)

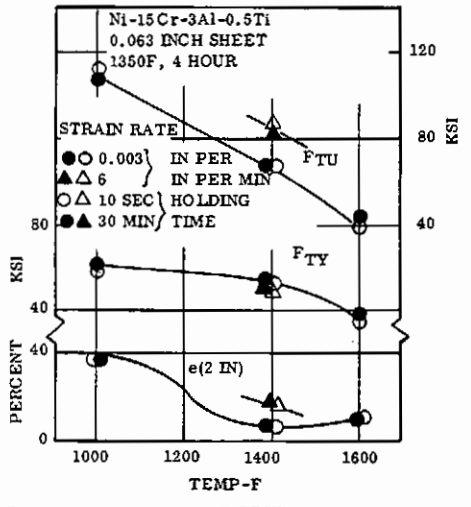

FIG. 3.0312 EFFECTS OF TEST TEMPERATURE, STRAIN RATE AND HOLDING TIME ON TENSILE PROPERTIES OF AGED SHEET
(1,p.3)

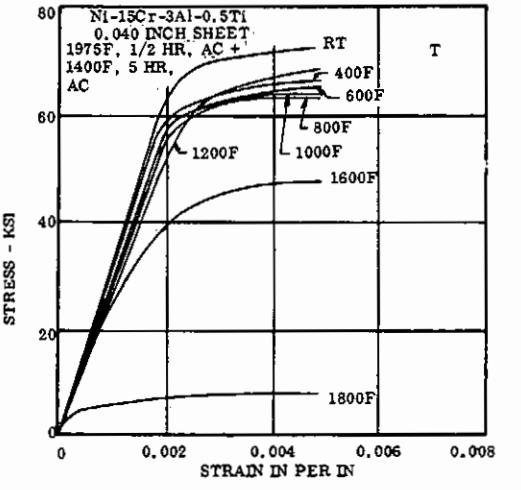

FIG. 3.0322 COMPRESSIVE STRESS-STRAIN CURVES AT TEMPERATURE
(5)

	Ni
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3	Al
0.5	Ti

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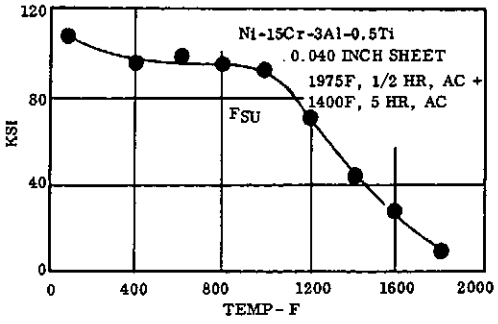

FIG. 3.0351 EFFECT OF TEMPERATURE ON SHEAR STRENGTH OF SHEET (5)

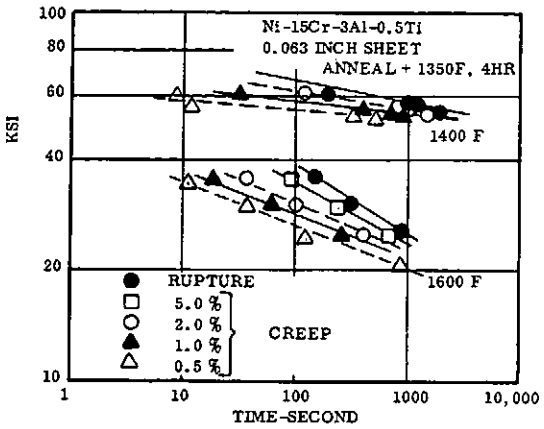

FIG. 3.041 CREEP AND CREEP RUPTURE CURVES AT 1400 AND 1600 F FOR AGED SHEET (1,p.3)

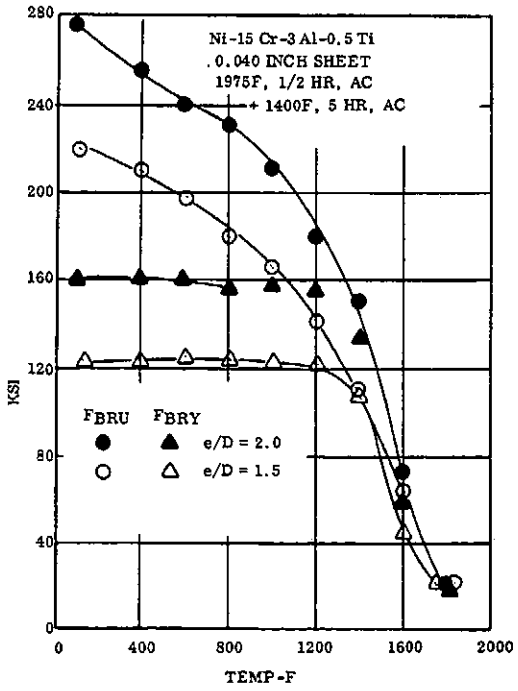

FIG. 3.0361 EFFECT OF TEMPERATURE ON BEARING PROPERTIES OF SHEET

(5)

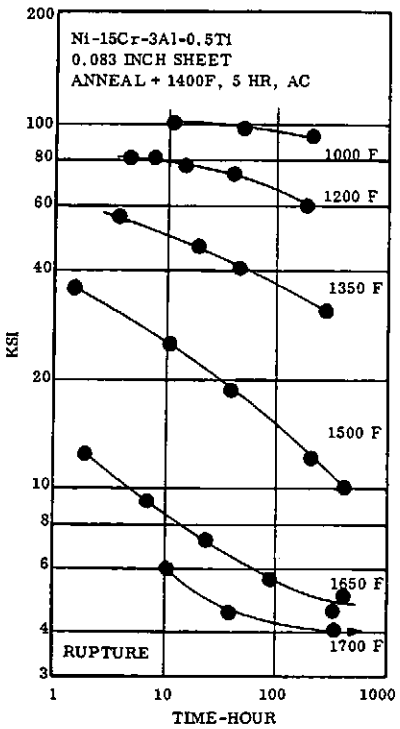

FIG. 3.042 CREEP RUPTURE CURVES AT 1000 TO 1700 F FOR AGED SHEET (2)

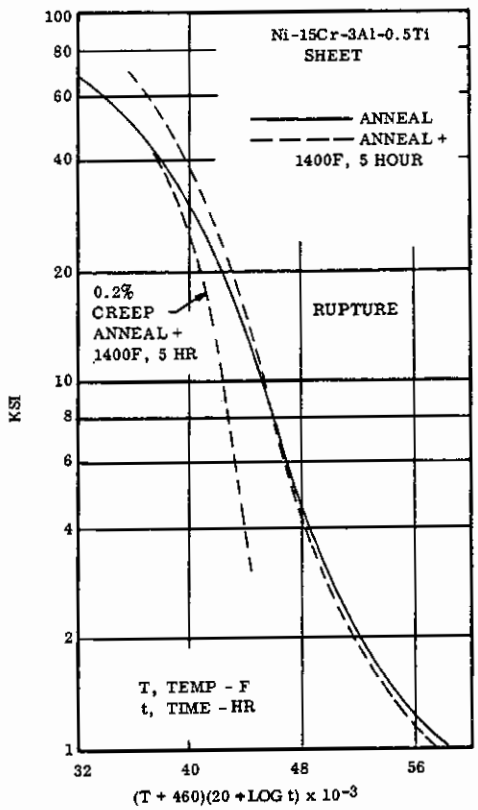

FIG. 3.043 MASTER CURVES FOR 0.2 PERCENT CREEP AND CREEP RUPTURE OF ANNEALED AND AGED SHEET
(3)

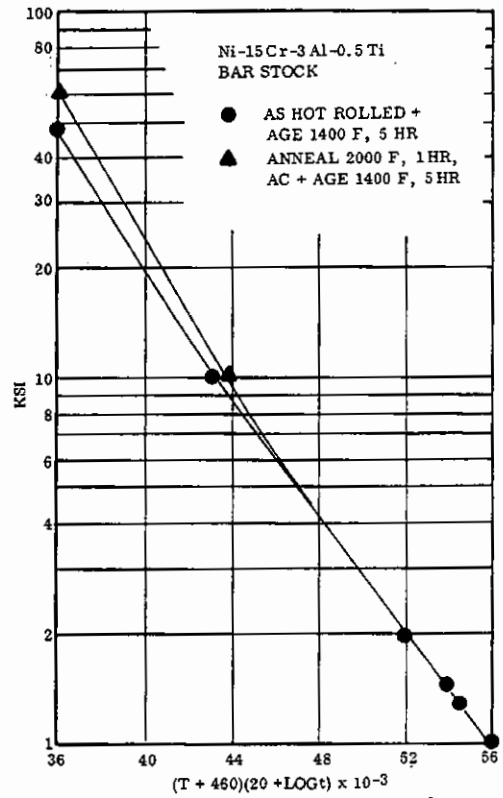

FIG. 3.044 MASTER CURVE FOR CREEP RUPTURE OF BAR STOCK
(6)

	Ni
15	Cr
3	Al
0.5	Ti

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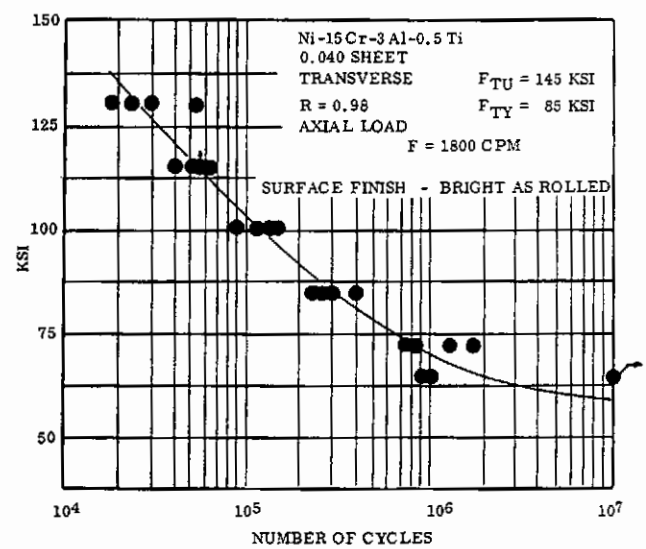

FIG. 3.051 TYPICAL S-N CURVE FOR SHEET AT ROOM TEMPERATURE
(5)

	Ni
15	Cr
3	Al
0.5	Ti

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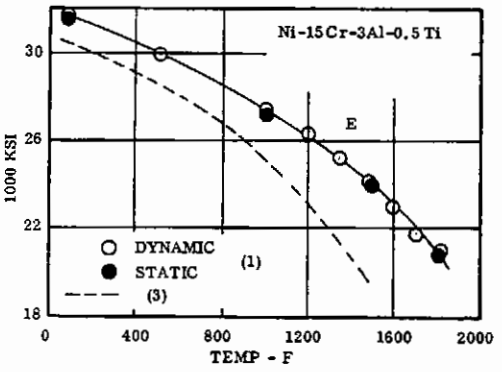

FIG. 3.061 MODULUS OF ELASTICITY AT ROOM AND ELEVATED TEMPERATURES
(1,p.2)(3)

REFERENCES

1. International Nickel Co., "Basic Data Inconel 702", 4M 3-58 (2)-3391, 3391, 138B, (March 15, 1958)
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5. "Research Investigation to Determine Mechanical Properties of Nickel and Cobalt Base Alloys For Inclusion in Military Handbook 5", Vol's I & II, TDR No. ML-TDR-64-116, (October 1964)
6. "702" Data from International Nickel Co., Huntington Alloys Division - Mechanical Properties Data Center, Document 61744.