Material Data Sheet: INCOLOY® alloy 909F

INCOLOY® alloy 909F is an iron -nickel -cobalt alloy whose outstanding characteristics are a constant low coefficient of thermal expansion, a constant modulus of elasticity, and high strength. The alloy is strengthened by a precipitation - hardening heat treatment made possible by additions of niobium and titanium. The chemical composition of INCOLOY alloy 909F is given in Table 1.

The combination of low expansion and high strength makes INCOLOY alloy 909F especially useful for gas turbines. The low expansion enables closer control of clearances and tolerances for greater power output and fuel efficiency. The high strength increases strength-to-weight ratios for lower weight in automotive applications.

Table 1 - Limiting Chemical Composition, %

Iron	39.6% min.
Nickel	35.0-39.5
Cobalt.	12.0-16.0
Niobium.	4.3-5.2
Titanium	1.3-1.8
Silicon	0.25-0.50
Aluminum	0.15 max.
Carbon	0.06 max.

Physical and Mechanical Properties

The composition of INCOLOY alloy 909F is designed to provide a low and constant coefficient of thermal expansion. The alloy's expansion rate is about half the rate of other alloys having comparable strength.

The coefficient of expansion of INCOLOY alloy 909F is approximately 4.3 x 10-6 in/in/°F (7.7 µm/m/°C) from room temperature to the inflection point (Curie temperature).

At the inflection point, which is in the region of 800°F (425°C), the alloy changes from ferromagnetic to paramagnetic and displays higher expansion coefficients with increasing temperature.

The combination of low expansion and constant elastic modulus, in conjunction with relatively high thermal conductivity, makes INCOLOY alloy 909F highly resistant to thermal fatigue and thermal shock.

Table 2 - Typical mechanical properties on hot finished and heat treated* product:

Room Temperature Properties	0.2% Proof Strength		Ultimate Tensile Strength		Elongation	Reduction of Area
	ksi	MPa	ksi	MPa	%	%
	132.5	914	171.6	1183	12.5	15.5

Elevated Tensile 1200F (649C)	0.2% Proof Strength		Ultimate Tensile Strength		Elongation	Reduction of Area
	ksi	MPa	ksi	MPa	%	%
	107.8	743	129.5	893	20.7	47.0

*Results from capability samples using Solution Heat Treatment 968 to 1010C/ air cool and aging by heating to 745C, holding for 4 hours and cooling at a maximum rate of 56C per hour to 620C, holding at temperature for 4 hours, and cooling at a rate equivalent to an air cool.

Fabrication

INCOLOY alloy 909F has good fabricability and can be formed, machined, and welded by conventional procedures for nickel alloys. In most operations, its behaviour is similar to that of INCOLOY alloy 909.

Machining

INCOLOY alloy 909F is machined by conventional practices for high-strength nickel alloys. The tooling and procedures given for Group D-2 alloys in the Special Metals publication "Machining" on the website, www.specialmetals.com, should be used. Rough machining should be done with the material in the annealed condition.

Available Products and Specifications

INCOLOY alloy 909F standard product forms – bar and billet

Contact

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