LION® alloy 188 (UNS R30188) is a cobalt-base alloy with excellent high-temperature strength and good oxidation resistance to 2000°F (1093°C). The high chromium level coupled with small additions of lanthanum produce an extremely tenacious and protective scale. The alloy also has good sulfidation resistance and excellent metallurgical stability as displayed by its good ductility after prolonged exposure to elevated temperatures. Good fabricability and weldability combine to make the alloy useful in gas turbine applications such as combustors, flame holders, liners and transition ducts.

Mechanical Properties

Table 3 - Typical Room Temperature Mechanical Properties of annealed LION alloy 188 Sheet

Yield Strength		Tensile Strength		Elongation
ksi	MPa	ksi	MPa	%
65	446	140	963	55

Table 4 - Rupture Strength of LION alloy 188 Sheet (1000-hr)

Temperature	Rupture Strength	
	ksi	MPa
1300°F / 704°C	35	240
1400°F / 760°C	24	165
1500°F / 816°C	16	110
1600°F / 871°C	10	69
1700°F / 927°C	5.9	41
1800°F / 982°C	3.6	25
1900°F / 1038°C	2.2	15
2000°F / 1093°C	1.3	9

Table 1 - Limiting Chemical Composition, wt %

Carbon	0.05-0.15
Manganese	1.25 max.
Silicon	0.20-0.50
Chromium	20.0-24.0
Nickel	20.0-24.0
Tungsten	13.0-16.0
Lanthanum	0.02-0.12
Boron	0.015 max.
Iron	3.0 max.
Cobalt	Balance*

*Reference to the 'balance' of a composition does not guarantee this is exclusively of the element mentioned but that it predominates and others are present only in minimal quantities.

Physical Constants and Thermal Properties

Table 2 - Physical Constants

Density, lb/in^3	0.330
g/cm^3	9.14
Melting Range, °F	2375-2425
°C	1300-1330
Specific Heat at 70°F, Btu/lb°F	0.097
at 21 °C, J/kg°C	405
Permeability at 200 oersted	1.0007
Coefficient of Expansion, 0 - 200°F, 10^{-6} in/in•°F	6.6
21 - 93°C, µm/m•°C	11.9
Thermal Conductivity, Btu•in/ft^2•h•°F	84
W/m•°C	12.1
Electrical Resistivity, ohm•circ mil/ft	613
microhm-cm	102.0

LION® ALLOY 188

Mechanical Properties (continued)

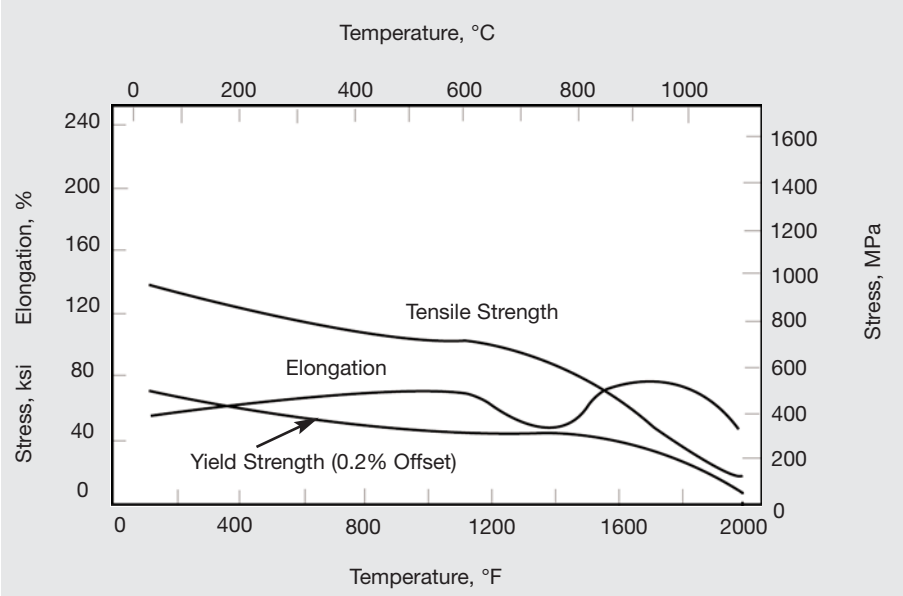

Figure 1 = Tensile strength, elongation and yield strength of LION alloy 188.

LION alloy 188 retains excellent strength and ductility even at elevated temperatures. The ductility dip at 1400°F (760°C) is due to precipitation of carbides around this temperature.

LION alloy 188 work hardens rapidly after cold working due to the abundant carbides. Material can be worked to great extents though and the alloy is not particularly notch sensitive. The hardness also quickly increases in response to cold work and will plateau in the lower 50 Rc range.

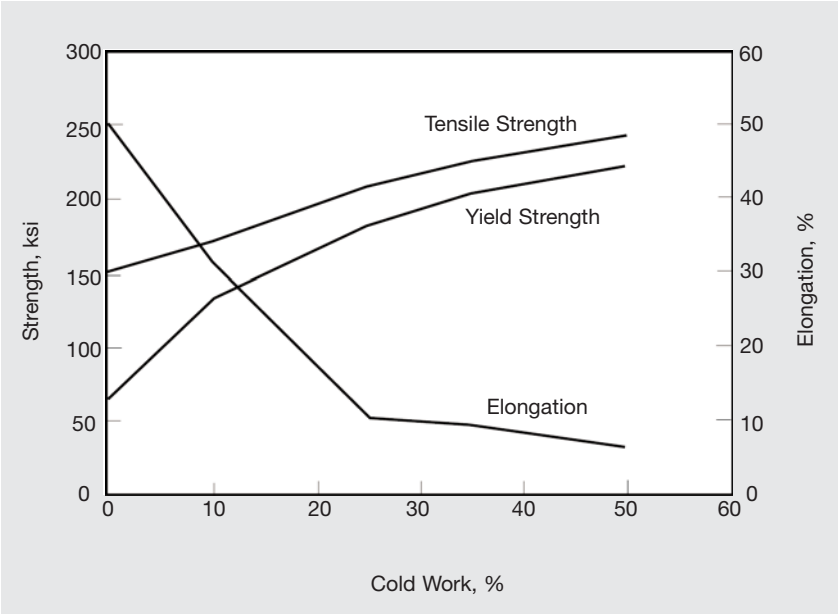

Figure 2 = Effect of cold work on mechanical properties of LION alloy 188.

Microstructure

LION alloy 188 has a stabilized face-centered cubic matrix. Chromium (22%), lanthanum (0.05%) and silicon (0.4%) promote oxidation resistance. Solid solution strengthening is provided by tungsten (14%). Strengthening (see heat treatment details) is further enhanced by the precipitation of M_6C and $M_{23}C_6$ type carbides.

Fabricating

LION alloy 188 has good fabricability. Forming, machining and welding can be carried out by standard methods.

Cold Forming

It is preferable to cold-work the alloy for bending, deep drawing and spinning of components. This is facilitated by the excellent ductility of the alloy, however, high forces may be required to achieve such processing, due to the inherent strength of the alloy. It may therefore be necessary to interstage anneal the material after each step of processing due to the high work hardening rate of the alloy.

Joining

LION alloy 188 can be welded by both manual and automatic welding methods, including shielded metal-arc, gas tungsten-arc (TIG) and gas metal-arc (MIG).

Heat Treatment

LION alloy 188 is normally annealed at 1177°C (2150°F) and rapid air-cooled or water-quenched.

The material can be further strengthened by cold deformation, with enhancement of strength achieved by aging at 540°C (1000°F) for 4 to 16 hours. Note that cold working prior to aging significantly increases the rate at which age hardening can be achieved.

Applicable Specifications

LION alloy 188 is designated as UNS R30188. Contact LION for information on available product forms.

Flat products: AMS 5608

Bar: AMS 5772