# Nickel-Cobalt-Chrome Alloy Inconel X750 (UNS N07750)

Inconel X-750 is suitable for use in the high temperature structural operations for gas turbines, aerospace engines, nuclear power plants, heat processing, formation apparatus and extrusion dies. It offers extreme resistance to chemical corrosion and oxidation. It has good stress rupture strength and offers service up to 1500oF or 816oC.

**Inconel X-750** is a precipitation hardened alloy that consists of Nickel and Chromium. It is broadly implemented in the industrial applications as it offers excellent resistance to oxidation and corrosion and high strength at wide temperature limits up to 1300oF. The precipitation effect of toughening reduces with an increase in temperature up to 1300oF. The heat processed alloy offers high strength up to 1800oF. Inconel X-750 comprises of excellent features that are sustained at cryogenic temperatures. The affordable alloy with the standard milling offers useful applications in the diverse sectors.

## Chemical Composition

| | |
|---|---|
| Carbon (C) | 0.08 % |
| Manganese (Mn) | 0.30 % |
| Silicon (Si) | 0.50 % |
| Sulfur (S) | 0.01 % |
| Nickel +Cobalt | 70 % |
| Chromium (Cr) | 14 to 17 % |
| Iron (Fe) | 5 to 9 % |
| Aluminum (Al) | 0.40 to 1 % |
| Titanium (Ti) | 2.25 to 2.70 % |
| Copper (Cu) | 0.50 % |
| Columbium + Tantalum | 0.70 to 1.20 % |

## Physical Properties

| | |
|---|---|
| Density | 0.300 lb/Cubic-inches or 8303 kh/cubic inches |
| Melting Point | 2540 to 2600oF or 1393 to 1427oC |
| Co-Efficient of Thermal Expansion | 12.6 m/m.oC at 20oC to 100oC or $7.0x10^{-6}$ in/in.oF |
| Modulus of Rigidity | 75.8 $kN/mm^2$ or 10994 ksi |
| Modulus of elasticity | 218.0 $kN/mm^2$ or 31619 ksi |
| | 212.4 kN/mm2 or 30806 ksi |
| | 213.7 kN/mm2 or 30995 ksi |

## Electric Resistivity

| Condition | ohm-cir mil/ft | microhm-mm |
|---|---|---|
| Hot rolled | 764 | 1270 |
| Solution Treated | 716 | 1190 |
| Solution Treated + aged | 746 | 1240 |

## Thermal Properties

| Temperature | | Thermal conductivity Btu-in/ft²-hr-°F | Thermal conductivity W/m-K |
|---|---|---|---|
| oF | oC | | |
| 300 oF | 149 oC | 117 | 16.9 |
| 600 oF | 316 oC | 142 | 20.5 |
| 1000 oF | 538 oC | 184 | 26.5 |
| 1200 oF | 649 oC | 199 | 28.7 |
| 1400 oF | 760 oC | 218 | 31.4 |
| 1600 oF | 871 oC | 245 | 35.3 |

## Modulus of Elasticity

| Temperature | | x 10(6) Psi | x 10(6) MPa |
|---|---|---|---|
| oF | oC | | |
| 80 oF | 26.7 oC | 31 x 10(6) Psi | 213.7 x 10(6) MPa |
| 500 oF | 260 oC | 28.7 x 10(6) Psi | 197.9 x 10(6) MPa |
| 1000 oF | 538 oC | 25 x 10(6) Psi | 172.4 x 10(6) MPa |
| 1350 oF | 732 oC | 21 x 10(6) Psi | 144.8 x 10(6) MPa |
| 1500 oF | 816 oC | 18.5 x 10(6) Psi | 127.6 x 10(6) MPa |

## Mean Coefficient of Thermal Expansion

| Temperature ranges | | 10 (-6)/oF | 10(-6)/°C |
|---|---|---|---|
| oF | oC | 6.7 | 12.1 |
| 80oF to 200oF | 26.7oC to 93oC | 7.5 | 13.5 |
| 80oF to 600oF | 26.7oC to 316oC | 7.9 | 14.2 |
| 80oF to 1000oF | 26.7oC to 538oC | 8.1 | 14.6 |

| | | | |
|---|---|---|---|
| 80oF to 1200oF | 26.7oC to 649oC | 9 | 16.2 |

## Thermal Properties

| Temp, oF | Mean Linear Expansion | Thermal Conductivity, Btu/in./hr/sq ft/°F | Specific Heat, Btu/lb/°F | Diffusivity, sq ft/hr | Electrical Resistivity, ohm/circ mil/ft |
|---|---|---|---|---|---|
| -250 oF | 6.5 | 67 | 0.073 | 0.150 | - |
| -200 oF | 6.6 | 70 | 0.080 | 0.143 | - |
| -100 oF | 6.7 | 74 | 0.090 | 0.135 | - |

## Mechanical Properties

**Annealed Inconel X750**

| Temperature, oF | Tensile Strength, ksi | Yield Strength, ksi | Elongation, % |
|---|---|---|---|
| Room temp. | 110.0 ksi | 46.5 ksi | 51 % |
| 900 oF | 100.5 ksi | 35.0 ksi | 55 % |
| 1000 oF | 91.0 ksi | 35.0 ksi | 55 % |
| 1200 oF | 83.0 ksi | 54.5 ksi | 23 % |

**Room Temperature Mechanical Properties**

| Temper | Tensile strength, psi | Yield strength, psi | Elongation in 2 inch, psi | Hardness, Brinell |
|---|---|---|---|---|
| Hot finished + 1300oF for 20 hours air cooled | 170,000 psi to 206,000 psi | 120,000 psi - 163,000 psi | 25 to 15 % | 313 to 40 |
| Hot-finished + Annealed 1800°F/1 hr, A.C + 1350°F/ 3 hr, F.C. 100°F/hr to 1150°F (total 18 hr), A.C | 162,000 psi - 193,000 psi | 115,000 psi - 142,000 psi | 30 to 15 % | 300 to 39 |
| Hot-finished + 1625°F/24 hr, A.C + 1300°F/20 hr, A.C. | 160,000 psi - 188,000 psi | 100,000 psi - 135,000 psi | 30 to 15 | 302 to 36 |
| Cold-rolled, annealed + 1300°F/20 hr, A.C. | 160,000 psi - 197,000 psi | 105,000 psi - 150,000 psi | 30 to 20 | 300 to 40 |

**Short Time Tensile Properties**

| Temperature | | Short Time Tensile Properties | | | | | |
|---|---|---|---|---|---|---|---|
| oF | oC | Yield Strength 0.2% offset | | Ultimate Tensile Strength | | % Elongation in 2 inch | % Reduction of Area |
| | | Ksi | Mpa | Ksi | Mpa | | |
| 70 oF | 21.1 oC | 92 Ksi | 634 Mpa | 161 Ksi | 1110 Mpa | 22 % | 30 % |
| 1000 oF | 538 oC | 83 Ksi | 572 Mpa | 140 Ksi | 965 Mpa | 20 % | 30 % |
| 1200 oF | 649 oC | 82 Ksi | 656 Mpa | 120 Ksi | 827 Mpa | 10 % | 21 % |
| 1400 oF | 760 oC | 68 Ksi | 469 Mpa | 80 Ksi | 552 Mpa | 10 % | 22 % |
| 1500 oF | 816 oC | 45 Ksi | 310 Mpa | 47 Ksi | 324 Mpa | 20 % | 32 % |

## Corrosion Resistance

Inconel X-750 has corrosion resistance properties similar to Inconel alloy 600. It offers good resistance to stress corrosion cracking. Alloy X-750 offers excellent resistance to the broad corrosion conditions such as oxidizing and reducing conditions on the commercial scale. It resists oxidation at the elevated temperatures. It shows equivalent functionality as like other Inconel alloys. In the hot corrosion conditions that occur during automotive processes, the weight loss of alloy X-750 in the exposure for 100 hours in the presence of 90% sodium sulphate and 10% sodium chloride in the furnace conditions at 1700oF and set for 100 hours in the dynamic gas stream of air of 1% sulphur dioxide is 0.007 inch.

The incredible features of Inconel X-750 are its resistance to chloride ion stress corrosion cracking in the precipitation hardened form. It doesn't show any cracks in the solution containing 42% magnesium chloride for one month.

Due to the presence of aluminum and titanium, alloy X-750 is precipitation hardened through heat treatment. These elements in the presence of nickel produce gamma prime that is an intermetallic compound. When alloy X-750 is solution processed at 2100oF, many dislocations and crystal issues are reduced. It offers high tensile strength and creep rupturing properties.

**Creeping Resistance**

The creeping resistance of **Inconel X-750 alloy** is excellent. The stabilization processing at the temperature of 1550oF for 24 hours in the triple heat processing, the refined gamma prime emerges in the grain internal side and M23C6 is precipitated in the grain near the grain boundary is a region stripped of gamma prime. With the precipitation processing at temperature of 1300oF for 20 hours the gamma prime is precipitated in the denuded region. So they increase the tensile strength and creep rupturing characteristics.

While in the M23C6 conversion at temperature of 1550oF, the carbon content is primarily stabilized and doesn't leave any chromium weakening regions around the grain limits. The stabilization obtained by now enhances the resistance nature of nickel **Inconel X-750 resistance alloy** in the particular corrosive conditions.

The reduction of precipitation temperature by 200oF is suitable for particular heat processing methods; moreover the prime gamma can also cause the combination of smaller particles that improves the effect of toughening so as increases the tensile strength.

## Fabrication

As the **Inconel X-750 resistance alloy** is readily formed by following the methods that are used on the industrial scale. The techniques and tools used for alloy formation should be suitable for the high firmness and featured strain toughening rate. The manufacturer should be cautious to ensure that the alloy is in the recommended stage of particular operation.

**Hot Forging**

For hot formation of Inconel X-750 alloy, you require the strong devices because it offers large resistance to distortion. The suggested temperature for the hot processing is more than 1900oF. The formation of alloy can be accomplished with few reductions in light at the temperature between 1800oF to 1900oF. The hot processing at the temperature lower than 1800oF makes it stiff and tough to stir. The cold formation of **Inconel X-750 resistance alloy** is done properly by following the different methods.

To avoid the rupturing, the alloy should be annealed at the specific level during the formation process with the particular diminutions.

The furnace cooling at the temperature of 25oF per hour or at 100oF per hour or 200oF per hour can be followed to eradicate the scales. The alloy is set to intergranular attack especially when it is in the precipitation toughened state. The shower time of alloy is kept slight. The shower temperature of **Inconel X-750 alloy** is significant; the highest temperature should not be more than 125oF.

**Machining of Inconel X-750**

**Inconel X-750 alloy** is machined cost effectively. Since the precipitation toughened alloy offers large strength and toughness, jagged machining is performed prior to precipitation hardening, The finished machining is followed after the precipitation treatment. The precipitation toughness avoids stress during machining, so the allowance should be made for the viable warpages. The little persistent contraction of alloy occurs in the precipitation treatment though the process provides fine stability in its size.

The correct size and superior finish are obtained from the different wire drawing and bolt manufacture of Inconel alloys annealed at the temperature of 1900oF. Almost 40% cold reduction is done prior to re-annealing. The hot heading is excellently performed at the temperatures between 1800oF to 2000oF. Normally the alloy is heated by induction or resistance and then subjected into die for formation. Different coatings are generally followed for X-750 alloy to restrict the sticking and seizing in the material die. The lead metal is widely used in the cold drawing and copper is used for cold heading and spring production.

The fields that cannot use lead, oxalates are preferred for them. The coating of alloy is done in groups or continually. To get the best coating, the Inconel alloy should be clean pickled or etched best. In the tough forming or coiling tasks, the chlorinated paraffin are used successfully with the copper coated wire. The cold upsetting of copper coated alloy wire is generally drawn by the mixture of soap and lime to increase lubrication capability of top layer.

The whole lead coatings are removed before beginning the heat processing or service at the elevated temperature to avoid the immediate cracking of alloy. The copper coating should

be removed before heating to avoid the copper dilution at the surface and reduction in the alloy's mechanical features. The recommended method for the removal of lead or copper is nitric acid bath of alloy in the 15 to 20% concentrated solution.

**Welding of Inconel X-750**

The welding techniques for **Inconel X-750 alloy** are gaseous tungsten arc, plasma-arc, electron-beam, resistance and pressure oxyacetylene welding. The welding of Inconel alloy by following the gas tungsten arc, the Inconel filler metal 718 is employed. The joint competencies are almost 100% at the room temperature though it decreases to 20% at the high temperature of 1300oF to 1500oF. Alloy X-750 should be annealed before welding. Its welding is feasible in the solution processed form but after welding it should not be precipitation processed or subjected into service temperatures. The precautions should be made while assembling and welding to decrease the stress.

The oxides produced during welding should be removed regularly otherwise these will enter into fusion and decrease the strength of welded part. The rate of cleaning is based on the quantity of oxides produced. The dust and grit should also be discarded completely prior to welding.

## Avaialble Forms

Wire, mesh, strip, foil, plate, sheet, rod, bar