Inconel X-750 Alloy

Introduction

The **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 paired with the standard milling offers useful applications in the diverse sectors.

Chemical composition of Inconel X-750 alloy

Ni + Co	Cr	Fe	Ti	Al	Nb + Ta	Mn	Si	S	Cu	C	Co
70	14-17	5-9	2.25-2.75	0.40-1.00	0.70-1.20	1.00	0.50	0.01	0.50	0.08	1.00

Physical properties of alloy

Density	8.28 g/cm3
Melting Range	1393-1427oC or 2540-2600oF
Curie Temperature of hot-rolled	-225oF
Magnetic Permeability at 70oF	200H
Emissivity, oxidized surface at 600oF	0.895

Tensile properties of annealed Inconel X- 750 alloy

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

Thermal properties of Inconel X-750 alloy

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	6.5	67	0.073	0.150	-
-200	6.6	70	0.080	0.143	-
-100	6.7	74	0.090	0.135	-
70	-	83	0.103	0.132	731
200	7.0	89	0.109	0.133	739

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Modulus of elasticity of Inconel X-750

Temperature, oF	Modulus of Elasticity, 10-3 ksi		
	Tension		Torsion
	Static	Dynamic	Static
80	31.0	31.0	11.0
500	28.7	29.1	10.2
1000	25.0	26.7	9.0
1200	23.0	25.5	8.1
1350	21.0	24.4	-
1500	18.5	23.2	-
1600	-	22.1	-

Heat Processing

Depending on the applications and features required in Inconel X 750, different heat treatment methods are used. To get the service temperature over 1100oF, during which the alloy needs to retain load for long time, the sufficient features are developed through solution treatment at 2100oF. The stabilization processing is done at 1550oF and precipitation at 1300oF. For the service temperature lower than 1100oF, the alloy X-750 is strengthened through precipitation processing immediately after the hot and cold processing or through precipitation processing subsequent to equalizing or solution treatment. The furnace cooling is followed to improve the suitable properties for certain operations. Similarly other heat processing methods are followed to produce special properties in the alloy that make it suitable for the certain objectives. In every condition, the Inconel X-750 retains its high temperature corrosion features up to 1800oC.

Inconel X-750 -Resistance to corrosion features

The Inconel 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, Inconel 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.

Forging of Inconel X-750

The moderate temperature service of alloy X-750 includes processing at temperature lower than 1100oF and equalized plus precipitation and processed material. For the applications that need excellent strength and ductility, alloy X-750 alloy is heated at 1625oF for 24 hours and air cooling is done. It is also heated up to 1300oF for 20 hours subsequently the air cooling is done.

The above heat processing is mentioned in AMS 5667 that needs that heat processed alloy must possess the below mentioned room temperature mechanical features.

Size, In	Tensile Strength, Ksi	Yield Strength, ksi	Elongation %	Reduced Area%
Under 4.0	165.0	105.0	20	25
4.0 and over	160.0	100.0	15	17

The consequences of double analysis series performed at higher temperature limits on the tensile properties of Inconel X-750 alloy are described in the below table:

Temperature, oF	Tensile strength, ksi	Yield strength, ksi	Elongation, %	Reduced area, %	Modulus of elasticity in tension, ksi
85	174.0	118.5	26.8	45.4	30.2
300	168.3	113.3	26.0	44.1	31.3
400	165.5	111.5	26.0	42.7	29.1
800	156.0	107.5	26.5	44.8	25.9
1000	152.0	105.0	25.5	40.7	23.2

Forging of Inconel X-750 Rod/Bar

Processing at Moderate temperatures-Solution processing and furnace quenching precipitation processed alloy.

The alloy X-750 is heated at temperature lower than 1100oF and its forging is done by the following heat processing to get the required tensile strength:

Solution heat processing at 1800oF, heating at 1350oF for 8 hours and furnace cooling up to 1150oF and retained at this temperature for 18 hours then furnace quenching is conducted. The precipitation heat processing needs that heat processed alloy has the below mentioned room temperature features:

Size, in.	Tensile Strength, Ksi	Yield Strength, ksi	Elongation in 2 in.,%	Reduced Area %
Under 2.50	170	115	18	18
2.5 to 4.00, excl.	170	115	15	15
4.0 and over	-	-		

The typical properties of **Inconel X-750 resistance alloy** in the processed and furnace quenched precipitation processed at 1800oF for 1 hr and 1350oF for 8 hr are described in the below table: The minimum heat processing of corrosion resistance alloy can be utilized for the little tensile features that can be obtained by following the heat processing of 1800oF for one hour and 1400oF for one hour, furnace quenched up to 1150oF and retains at 1150oF for the whole precipitation processing of six hours.

The tensile characteristics of Inconel resistance alloy obtained at the room temperature by the above processing are provided in this table:

Diameter	Tensile Strength, ksi	Yield Strength, ksi	Elongation, %	Hardness, Rockwell
½	199.0	146.0	25.0	36.0
21/32	194.0	139.0	27.0	38.0
¾	193.5	137.5	25.0	38.0
7/8	194.5	140.0	24.0	40.0
1	187.5	130.5	25.0	33.0

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The room temperature and elevated temperature features of both the solution processed and solution processed and furnace cooled precipitation processed material are described in the below table:

Diameter,in.	Solution- processed	Solution-processed, Precipitation- processed
0.875	21	36
1.250	31	38
1.937	25	36

The top potential of the alloy material of 3.4 inch diameter of hot treated for 1800oF for one hour and at 1350oF for 8 hours then the furnace quenched at 1150oF for the total precipitation period of 18 hours is 246.0 ksi. The material possesses high tensile strength of 192.5 ksi and yield strength of 137.0 ksi and the elongation 25% and reduction area 42%. The tensile features of welded precipitated alloy in the minimum furnace quenched treatment are provided in the below table:

Condition	Temperature, oF	Tensile Strength, ksi	Yield Strength, ksi	Elongation, %
Plates were annealed & precipitation-treated (1800oF/1 hr, +1400oF/1 hr, F.C. to 1150oF	80	124.0	87.0	21
	80	122.5	85.8	20
	800	109.0	80.5	21
	800	108.0	79.0	19
	1000	102.5	78.5	17
	1000	103.5	79.5	18

To obtain the highest creep and cracking potential and large relaxation resistance at the processing temperature of 1100oF, the **Inconel X-750 alloy** are provided after three times heat processing:

2100oF for 2 to 4 hours – Solution Processing

155oF for 24 hours – Stabilization Heat Processing

1300 oF for 20 hours – Precipitation Heat Processing

The heat processing is demonstrated by the AMS system 5668 that needs the heat processed sample evaluated at the temperature of 1350oF under the pressure of 45 ksi with the least rupture strength of 100 hours. The high potential at the elevated temperatures and large resistance, the **Inconel X-750 high resistance alloy** is produced by following the single precipitation processing at 1300oF for 20 hours.

The elevated and low temperatures features are hot toughness, impact strength that are shown in the following table:

Temperature, oF	-320	-109	75	400	800	1000	1200	1350	1500	1600
Impact Strength, ft-lb	33	36	37	42	50	49	45	49	67	113

The low temperature tensile properties of alloy are shown in the following table:

Specimen	RoomTemp. Hardness, Rc	Temp. oF	Tensile Strength, ksi	Yield Strength, ksi	Elongation in 1 in. %	Reduction of Area,%
Smooth	33	79	173.5	101.5	25.0	28.5
	32	-104	186.0	115.0	22.5	25.7
	34	-320	208.8	118.0	19.0	19.0
	34	-423	208.15	130.0	14.5	14.5
Notched (60oV, 0.037 in. deep, 0.005 in radius)	33	78	200.5	-	-	-
	35	-104	200.0	-	-	-
	35	-320	218.5	-	-	-
	36	-423	225.0	-	-	-

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Inconel X-750 Sheet, Strip and Plate

Excellent strength to 1300oF - The high strength at the elevated temperatures and large relaxation resistance, Inconel X-750 sheet are provided by following one step precipitation processing at 1300oF for 20 hours and air cooling. The tensile strength of annealed alloy X-750 sheet from room temperature to 1600oF are provided as following:

Temperature, oF	Tensile Strength, ksi	Yield Strength, ksi	Elongation, %
Room temp.	110.0	46.5	51
900	100.5	35.0	55
1000	91.0	35.0	55
1200	83.0	54.5	23
1350	77.0	67.5	6

The high temperature properties of cold treated annealed wire that is precipitation treated are shown in the below table.

Temperature, oF	Tensile Strength, ksi	Yield Strength, ksi	Elongation, %
Room temp.	177.0	122.5	27.0
400	167.0	112.0	30.0
800	151.0	112.0	33.0
1000	154.0	112.0	26.0
1100	135.0	105.5	10.5

The following table contains the tensile strength of cold rolled 67% and precipitation processed 1300oF for 20 hours Inconel X-750 sheet:

Temperature, oF	Tensile Strength, ksi	Yield Strength, ksi	Sharp-Edge Notch Tensile Strength, ksi	Ratio-Edge Notch Tensile/T.8
Room	245.0	233.0	180.0	0.7
-423	310.0	266.0	202.0	0.65

The cryogenic tensile features as well as high tensile strength of annealed and precipitated wire are provided in the below table:

Temperature, oF	Orientation	Tensile Strength, ksi	Yield Strength ksi
78	Longitudinal	174	118
78	Transverse	174	118
-100	Longitudinal	189	122
-100	Transverse	-	-
-320	Longitudinal	214	130
-320	Transverse	212	130

The compressive features of **Inconel X-750 wire** at the room temperature in the annealed and precipitation processed form for the different thickness values are described in the below table:

Orientation, oF	Tensile Properties		Compressive Properties	
	Tensile Strength, ksi	Yield Strength, ksi	Yield Strength, ksi	Modulus of Elasticity,10(3), ksi
Longitudinal	170.5	116.0	121.0	29.7
Transverse	166.0	116.0	122.5	30.5
Longitudinal	179.5	124.0	127.0	30.4
Transverse	180.0	128.0	130.0	31.0

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The shear potential of annealed and precipitation processed **Inconel X-750 sheet** at the room temperature to 423oF are provided in the below table:

Orientation, oF	Tensile Properties		Shear Strength, ksi	
	Tensile Strength, ksi	Yield Strength, ksi	Single Shear	Double Shear
Longitudinal	165.0	115.0	123.5	111.0
	170.5	116.0	-	111.5
	171.5	116.0	125.	112.5
Transverse	166.0	116.0	123.0	112.0
	172.0	114.5	-	112.5
	175.0	122.0	122.5	111.5

The shear strength of annealed and precipitation processed Inconel X-750 sheet at the room temperature and -423oF is shown as following:

Temp, oF	Tensile Strength, ksi	Shear Strength, ksi	Ratio, Shear Strength/Tensile Strength
Room	175.1	118.0	0.674
-423	253.3	152.8	0.603

The following table shows bearing strength, resistance to tearing, at the room and high temperatures:

Distance from Pin Centerline to Edge	Temp , oF	Bearing		Ratio of Bearing	
		Yield Strength, ksi	Ultimate Strength, ksi	Yield Strength/ Tensile Yield Strength	Ultimate Strength/ Tensile Strength
1.5 x Pin Dia	80	175	258	1.63	1.57
	900	165	213	1.71	1.57
	1200	152	170	1.66	1.54
	1600	69	71.5	2.66	1.93
2.0 x Pin Dia	80	222	338	2.08	2.06
	900	218	274	2.26	2.02
	1200	175	217	1.91	1.99
	1600	70	72	2.69	1.94

Fatigue Strength

The following table shows the fatigue strength of Inconel X-750 alloy at the low temperature:

Material	Fatigue Strength (106 Cycles), ksi		
	-110°F	-320°F	-423°F
INCONEL alloy X-750	60	64	67
301 Stainless Steel	31	44	-
70/30 Brass	36	39	49
1075 Plain Carbon Steel	44	29	30
2800 (9% Ni) Steel	46	37	37
6 Al - 4V Titanium alloy	32	27	
347 Stainless Steel	47	50	67
Nickel 200	18	21	37
INCONEL alloy 600	40	40	47

The large strength at 1300oF, the furnace quenching precipitation processed material:-

To get large strength at the elevated temperatures and large relaxation resistance, high tensile features at 1300oF, the alloy X-750 is furnace cooled.

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Precipitation processing at 1300oF for 8 hours, furnace cooling up to 1150oF for whole precipitation processing period of 18 hours, air cooling. Rupturing time of cold rolled annealed material in the different test conditions is described as following:

Thickness, in	Test Conditions, °F/ksi	Rupture Life, hr
0.031	1200/70	21.5
		17.0
	1350/40	42.8
		49.5
	1500/20	40.4
		43.9
0.093	1200/70	72.3
		98.9
	1350/40	130.4
		116.8
	1500/20	63.7
		77.6

Instead of processing at 1300oF for 20 hours and cooling, the furnace cold precipitation improves the mechanical strength however it brings minor change in the ductility of Inconel X-750. Nominal changes in the stress rupturing features of alloy are noticed at 1200oF, 1350oF and 1500oF. The standard mechanical features of annealed and furnace quenched alloy are shown as following:

Temperature,oF	Tensile Strength, ksi	Yield Strength, ksi	Elongation,%
Room	186.5	132.0	25.0
400	176.5	123.0	25.0
800	162.0	120.0	29.5
1000	155.0	116.0	25.0
1100	145.0	116.5	9.0

The rupturing service life of Inconel X-750 at 1200oF to 1500oF is shown in the following table:

Thickness	Test Conditions, oF/ksi	Rupture Life, hours
0.031	1200/70	24.6
	1350/40	43.6
	1500/20	55.5
0.093	1200/70	83.6
	1200/70	131.8
	1500/20	76.5

The following table shows the impact characteristics of Inconel X-750 at the room temperature:

Size, in.	Impact Strength, ft-lb	
	V-Notch	Keyhole Notch
½ x 48 x 96	47.5	31
¾ x 48 x 120	50.5	35
1 x 36 x 96	40.5	26
1¼ x 37 x 82	34	24
2 x 48 x 120	48.5	28.5

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Mechanical Characteristics of Inconel X-750

Inconel X-750 alloy can be processed through different heat processing methods. Different methods develop specific characteristics and give alloy in the suitable form for the particular operations. In each form, the Inconel X-750 offers superior resistance to oxidation at the elevated temperatures up to 1800oF. The heat processing, specification and products are provided in the following table:

Product Form	AMS Specif.	Heat Processing	Feedback
Wire, No. 1 temper	5698	1350oF/16 hr, AC (Constant temp. ppt process).	For springs need appropriate resistance to relaxation from about 700oF to 850oF and at low to reasonable stresses to about 1000oF.
Wire, spring temper	5699	1200oF/4 hr, AC (Constant-temp. Ppt process)	High strength up to about 700°F
Wire, spring temper	5699	2100oF anneal + 1550oF/24 hr, AC + 1300oF/20 hr, AC (Triple heat process).	For springs for service requiring maximum relaxation resistance at about 850°F to 1200°F
Sheet, strip & plate annealed)	-	1400oF/1 hr, FC to 1150oF, Hold at 1150oF for 6 hr, AC	Increased tensile properties and reduced heating time for service up to about 1100°F
Sheet, strip and plate	5542	1300°F/20 hr, AC Constant-temp. ppt process	High strength to 1300°F.
Rods, bars and forgings	5667	1625oF per 24 hr, AC, + 1300oF per 20 hr, AC	High strength and notch rupture ductility up to 1100°F
Rods, bars and forgings	5670, 5671, 5747	1800oF anneal + 1350oF/8 hr, FC to 1150oF, Hold at 1150oF for total precipitation-treating time of 18 hr, AC	Improved tensile features and reduced heat processing time for service up to about 1100oF

Various Precipitation Processing Formulas

The properties of **Inconel X-750 resistance alloy** that are obtained by the processing at 1300oF for 20 hours can be obtained in the short period by following the furnace quenching treatments like processing at 1400oF for one hour, furnace quenched to 1150oF, retained at the same temperature for precipitation processing about six hours.

The entire enhancements in the rupture characteristics can be obtained in the Inconel rod and other products by following the three heat processing methods like processing at 2100oF for two to four hours, processing at 1550oF for 24 hours and processing at 1300oF for 20 hours. The methods are generally not applied on the Inconel sheet, if the heat processed subsequent to formation parts sag or lose their symmetry in an exposure up to 2100oF. If the heat processing is done prior to formation, production processes may vanish the produced properties.

Spring Properties

The excellent service of Inconel X-750 springs, a heat processing method should be chosen that develops the necessary properties for the operations. The Inconel wire and strip utilized for the helical and flat springs are made during the two kinds of tempers. The first temper that shows the alloy is cold reduction by 15 to 20% after the whole process of annealing. The spring temper is cold reduction by 30 to 65% after the whole annealing process.

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Few springs are also produced from the hot treated alloy. With decrease in temperature lower than the room temperature, the force and modulus of alloy increase. The **Inconel X-750 alloy** helical springs chosen by the AMS specifications are shown in the below table:

Temper	Heat Treatment, oF/hour	Service Temp.,oF	AMS Specification
No. 1	1350/16	Up to 1000	5698
Spring	1200/4	Up to 700	5699
Spring	2100/2+ 1550/24+ 1300/20	900 - 1200	5699

The shear properties of **Inconel X-750 alloy** in the different conditions are described in the below table:

Temper	Solution Treatment, oF/hour	Shear Modulus, 10(3) ksi
Spring	2100/2	11.1
Spring	2100/1,	11.1
Spring	None	11.2
No. 1	None	9.9

The spring temper wire is cold treated to the limit to increase the load sustaining capacity of the springs. The enhanced cold processing provides more force and large processing stress though only up to processing temperatures.

The **Inconel X-750 alloy** springs offer the large proportional limit.

The number 1 temper **Inconel X-750 resistance alloy** is toughened with the minor degree of cold reduction however its firmness is adequate to allow uniform coiling on the automatic machines. The spring temper wire has been cold processed to the limit that the spring's heavy weight sustaining feature is considerably increased. Therefore the cold processing provides large potential and more working stress though not about the service temperature ranges to the stress mitigating temperature.

The room temperature features of **Inconel X-750 resistance alloy** spring are mentioned here:

Condition	Tensile strength, ksi, dia 0.020"	Yield Strength, ksi, dia 0.020"	Proportional Limit, ksi, dia 0.020"	Modulus of Elasticity, 10(3) ksi
No. 1 Temper				
1950oF/15 min	120	43	34	31.0
1350oF/16 hr	202	141	93	31.2
1200oF/4 hr	178	109	77	30.4
Spring Temper				
1950oF/15 min	130	104	81	30.8
1300oF/16 hr	274	268	168	31.6

The spring temper alloy offers higher proportional limit without causing much resistance to relaxation at the intermediate temperature limits. The number 1 temper spring is precipitation processed at 1350oF for 16 hours, weighted at 70 ksi and relaxed for 3% in 500 hours at the temperature of 800oF. On the other side the same spring is produced of spring temper wire and precipitated by the same temperature of 1350oF for 16 hours and relaxed by 12%. The difference in relaxation is supposed to be the result of difference in the residual stress due to cold processing. The room temperature shear characteristics of spring solution are provided in the below table:

Temper	Solution processing, oF/ hr	Precipitation Treatment oF/ hr	Proportional Limit, ksi	Shear Modulus, 10 (3), ksi
Spring	2100/2,	1550/24,+ 1300/20	67.5	11.1
Spring	2100/1	1400/4	54.0	11.1
Spring	None	1350/16	93.5	11.2
No. 1	None	1350/16	90.5	9.9

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The higher resistance to relaxation at temperature of 900oF, the number 1 temper is readily precipitation processed at 1350oF for 16 hours is recommended for springs. For the service temperature limits from 900oF to 1200oF, the spring should be prepared of spring temper alloy that is solution processed as well as stabilized and precipitation processed at 2100oF for 2 hours, 1550oF for 24 hours and 1300oF for 20 hours. The processed alloy wire provided by the three times heat treatment offers reduced proportional limit though the highest relaxation resistance at the 900oF to 1200oF under stress is lesser than the proportional range.

The high resistance to relaxation is obtained from the cold processing. The limit of cold processing on the wire is minimized by 15% on its periphery. During the solution treatment the grain size is enhanced that was obtained while cold processing. When the wire is cold reduced by 30 to 65% symmetrical grains are produced through the cross section. Basically the relaxation force of **Inconel X-750 alloy** is higher with the uniform grain dimensions.
Generally the relaxation force of **Inconel X-750 resistance wire** is higher with the symmetric coarse grain dimensions. The relaxation of springs cold processed by following the number 1 temper wire precipitation processed at the 1350oF for 16 hours and the springs cold processed from the spring cold coiled by following the Spring Temper wire and the triple heat processed by following the heating at 2100oF for 2 hours and at 1550oF for 24 hours and 1300oF for 20 hours.

The analysis is made on the flat springs at the same conditions where the relaxation is the reduction of weight that is important to keep the spring at the fix height. In the production of springs for low temperature applications, they are cold treated after precipitation to slightly enhance the weight sustaining capability. The process includes the additional cold processing. The cold processing of springs for elevated temperature treatment is not essential though it increases the cold processing so the relaxation is increased ultimately.

The heat loading at temperature is an advantage for the helical springs in the elevated temperature operations. The prestressing is accomplished through clamping the spring when pressed by a load of 10% more than the highest performance load, placing the assembly in the furnace at a temperature of 100oF that is more than the highest service temperature range. It is kept at this temperature for one hour. The springs should be saved from sagging while the triple heat processing preferably the 2100oF solution processing.

It is performed by keeping the spring on an arbor that creates a snug fit with its internal diameter. Second factor in manufacturing of flat spring is the fatigue strength of material. The fatigue force is utilized with the design stress to create the original limiting stress. In order to produce the torsion wires, the internal friction is an essential aspect. The decrease in damping in torsion is provided for the different heating conditions in the below table:

Size, in.	Condition	Modulus of Rigidity,10(3) Ksi	Damping Decrement in Torsion x 10 -4
0.037	No.1 Temper	10.50	12.30
0.037	No. 1 Temper+1350°F/16 hr	10.95	6.01
0.037	No. 1 Temper+2100oF/2 hr.+ 1550oF/24 hr, A.C.+1300oF/20 hr	11.91	10.06
0.149	1900oF+C.D.15%+1350oF/16 hr	11.21	9.12
0.149	2000oF+C.D.15%+1350oF/16 hr	11.24	7.16
0.149	1900oF+C.D.15%+2100oF/2 hr, + 1550oF/24 hr, +1300oF/20 hr	11.77	6.66

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Subsequent to heat processing, the alloy X-750 spring offers the thin oxide coating, that is advantageous in increasing the resistance to corrosion in the different conditions and do not require to be discarded. The pickling later then the precipitation processing may produce the acid attack on the grain limits or cause pitting. The eradication of oxides through mechanical pressures reduces the resistance to relaxation. If it is possible, the springs should be utilized in the oxidized form. However for its cleaning, the processing of alloy is done in the reducing bath, then water cooling and rinsing provides the better alloy surface.

Resistance to corrosion features of Inconel X-750

The **Inconel X-750 alloy** is resistant to the large range of corrosive media that is found on the industrial scale varying from the oxidizing to reducing conditions. The wire resists the oxidation and corrosion in the elevated temperature conditions. The Inconel X-750 wire shows almost similar performance like other Inconel alloy corrosion resistance wires.

In the hot corrosion analysis made for the automotive operations, the loss of weight due to extensive exposure for 100 hours in the environments of 90% of sodium sulphate and 10% sodium chloride by subjecting in the furnace at the temperature of 1700oF and set for 100 hours to the dynamic gas stream of air comprising of 1% sulphur dioxide attacked by the corrosion and corroded is 0.007 inch.

The fascinating characteristics of **Inconel X-750 resistance alloy** are its extensive resistance to the chloride ion stress corrosion cracking in the completely precipitation hardened form. The regular U curve samples of precipitation hardened alloy with the toughness of 33 Rc show no symptoms of cracking when set into boiling solution of 42% magnesium chloride for 30 days.

Microstructure

The Inconel X-750 consists of aluminum and titanium and it is precipitation toughened through a combination of these constituents in the heat processing with addition of nickel to produce gamma prime that is an intermetallic compound of nickel, aluminum and titanium. When the alloy wire is solution processed at temperature of 2100oF, several dislocations and crystal defects are minimized and the gamma prime and the dissolved carbides move to the solution.

To obtain the best outcomes, the sample alloy should be in the significantly heavy processing conditions before the treatment to assure the quick and complete recrystalization of wire. After the solution processing of alloy, it is sent for cold processing to avoid the production of new dislocations and uneven rupturing.

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. The gamma particles take over the motion of dislocations 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.

Inconel X-750 Alloy

Heat Processing of Inconel X-750 alloy

The standard methods and cautions for heating the **Inconel X-750 alloy** for the hot processing or to receive the specific set of mechanical features. To remove the thermal cracking, the localized heating is not suggested. The whole material should be heated up to the hot processing temperature.

The Inconel alloy should be air quenched subsequent to heating. The liquid cooling is not suggested, especially for the wider parts or complex components because it may cause the thermal cracking after heating the alloy. The extensively large parts of alloy may need the furnace quenching. The heat processing generally required to be used for **inconel X-750 resistance alloy** is provided following. The hardness obtained by the alloy due to processing is described in the below table:

Condition	Hardness	
As-Rolled or As-Forged	228-298 BHN	20C-32C Rockwell
Hot-Worked+1300°F/24 hr	313-400	34C-44C
2100oF/2 hr	140-277	77B-29C
2100oF/2 hr+1550oF/24 hr+ 1300oF/20 hr	262-340	26C-37C
1625oF/24 hr	200-298	13C-32C

The heating of alloy at the moderate temperature ranges from 900oF to 1600oF, the alloy is precipitation hardened instead of softening. The annealing or solution treatment of **Inconel X-750 resistance alloy** at this temperature causes the wire toughening contraction vaguely. Moreover the ductility is reduced if the wire is set into this temperature under pressure. On the base of kind of use, the alloy is precipitation treated in the solution, annealed, hot processed or cold processed. The service of alloy at temperature lower than 1100oF, the large firmness of alloy is received by the cold processing as well as precipitation processing.

Pickling of Inconel X-750

The heat processed Inconel X-750 alloy produces oxide layer when it is heated and quenched in the natural conditions. The production of oxide layer is a common condition for pickling. Preprocessing in the mixed salt bath is preferred to remove the rigorous scaling. The pickling bath in nitric- hydrofluoric acid is preferred to eradicate different kinds of scaling. The alloy X-750 is inclined to intergranular corrosion when it is in the precipitation toughened condition. The bath period should be least and its temperature must not be more than 125oF. The pickling container should be ventilated as it releases the harmful fumes. The scale can be properly discarded through barrel tumbling and vapor rupturing.

Fabrication of Inconel X-750

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 25o 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
The **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 Inconel alloye 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 the 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.

On the base of specific features demanded, the bolts may be threaded in advance or subsequent to heat processing. If threading is performed before precipitation processing, tools and dies wear will be minimized and the producer gets the additional benefits. Moreover the firmness will be increased by threading subsequent to precipitation treatment. The assessment of the impacts on the fatigue strength of threading prior and after the precipitation of treatment is made.

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. The 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.

Inconel X-750 Alloy

The Inconel X-750 welds must be solution processed before precipitation processing. The heating rate of welded part should be quick and symmetric to reduce the exposure period in the precipitation toughening range. Experimentally the means of getting quick heating rate is to subject the forging component into preheated incinerator.

In few cases the pre welding heat processing is advantageous when the specimen is welded in the controlled conditions or weldment is complicated, particularly if assembly is tough to conduct the postweld annealing of alloy. The following pre weld processing methods produce the adequate results:

1. Heating up to 1550oF for 16 hours and air cooling
2. Heating up to 1950oF for one hour at 25oF to 100oF per hour to 1200oF then air cooling.

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.

Brazing of Inconel X-750

The Inconel X-750 alloy is brazed through traditional methods. The precipitation processing is done after brazing. Thus alloy X-750 is chosen that melts at precipitation processing temperatures.

Applications of Inconel X-750

1. Rocket Engine thrust chambers
2. Hot air ducting systems
3. Large pressure tubes and dies
4. Spring fasteners
5. Airframe operations