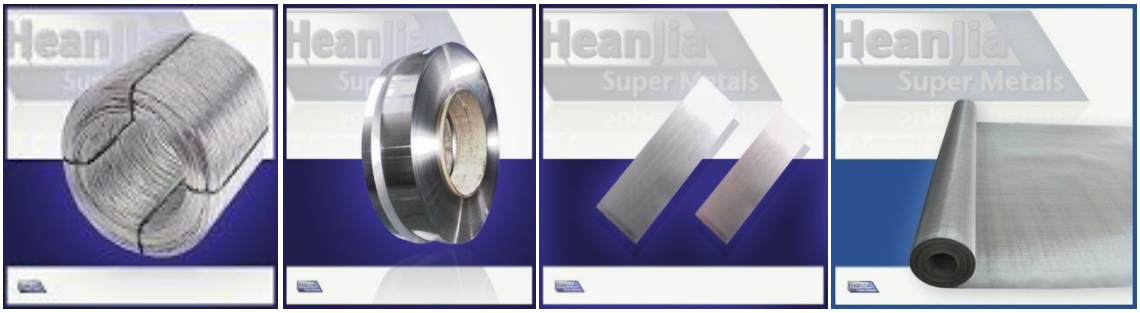
Thermoelastic Ni Span C902 (UNS N09902)



Ni Span C902 has constant thermoelastic coefficient and modulus of elasticity at the various temperatures from -50oF to 150oF. It is a nickel-iron-chromium alloy that offers high oxidation resistance and good mechanical strength. It has small magnetostrictive features. Alloy C902 is used in mechanical resonating equipments, precision elastic components and diaphragms.

Different forms of **Ni-span C902 alloy** are introduced such as wire, sheet, tape, plate, bar and strip. The methods have been developed to calculate the heat processing needed for producing the required thermal expansion coefficient for the particular magnitude of alloy. The pilot analysis is needed for the high precision operation.

Chemical Composition

Carbon (C)	0.06 %
Manganese (Mn)	0.80 %
Phosphorous (P)	0.04 %
Sulfur (S)	0.04 %
Silicon (Si)	1 %
Chromium (Cr)	4.9 to 5.75 %
Nickel (Ni)	41 to 43.5 %
Titanium (Ti)	2.20 to 2.75 %
Aluminum (Al)	0.30 to 0.80 %
Iron (Fe)	Rem %

Physical Properties

Density	0.291 lbs/in³
	8.05 g/cm³
Electrical Resistivity:	51 microhm-cm at 68 oF

Mean Coefficient of Thermal Expansion	4.2 x 10-6 (7.6) in/in/°F (mm/m/°C) at 70 to 212oF or 20 to 100oC
Specific heat	0.12 Btu/lb•°F at 32 to 212 oF or 500 J/kg•°C 0 to 100oC
Thermal Conductivity	9.0 BTU-ft/h-ft²-°F BTU/h-ft-°F at 70oF or 12.1 W/m-°K at 21 oC
Modulus of elasticity	24-29 x 10³ ksi or 165-200 x 10³ MPa
Melting temperature	2650 to 2700oF or 1450oC to 1480oC

Room temperature mechanical properties

Properties	Tensile strength	Yield strength, 0.2% offset	Elongation %	Hardness
Annealed	85 ksi or 586 Mpa	35 ksi or 241 Mpa	30 %	
Tempered, 20% reduction	90 to 110 ksi or 621 to 728 Mpa	-	15 %	83 to 98 Rb
Tempered 50 % reduction	125 to 140 ksi or 862 to 965 Mpa	-	3 %	24 to 32 Rc
Heat treated 1300oF/ AC	150 ksi or 1034 Mpa	-		27 to 35 Rc
10 % reduction plus 1300oF	165 ksi or 1138 MPa	120 ksi or 827 MPa	10 %	34 to 41 Rc
50 % reduction plus 1300oF	190 ksi or 1310 MPa	165 ksi or 1138 MPa	5 %	39 to 46 Rc

Tensile strength and hardness

Processing	Tensile strength	Yield strength	Elongation	Hardness Rc
As rolled	131 ksi	126 ksi	6.5 %	26 Rc
500oF for 5 hours	139 ksi	136 ksi	7 %	29 Rc
900oF for 5 hours	140.5 ksi	135 ksi	11 %	30 Rc
1000oF for 5 hours	150 ksi	137 ksi	12 %	33 Rc
1100oF for 5 hours	178.5 ksi	165 ksi	9.5 %	37 Rc
1200oF for 5 hours	192 ksi	176 ksi	9 %	40 Rc
1300oF for 5 hours	193 ksi	173 ksi	8.5 %	40 Rc

Low temperature properties

Property	Processing	Temperature		
		70 of	-200 of	-423 of
Tensile strength	Hot rolled plus aged	175 ksi	205 ksi	245 ksi
Yield strength	Hot rolled plus aged	110 ksi	125 ksi	145 ksi
Elongation, %	Hot rolled plus aged	25 %	29 %	30 %
Reduced Area, %	Hot rolled plus aged	50 %	48 %	44 %
Modulus of rigidity, 10(3) ksi	Hot rolled plus aged	10.2	10.1	10.1
Modulus of elasticity, 10(3) ksi	Hot rolled plus aged	25.1	24.8	24.8
Fatigue strength, ksi (10 (6) cycles)	Hot rolled plus aged	80	107	122
Impact strength, Charpy U, ft lbs	Hot rolled plus aged	18	17.6	17

Heat Processing

The analysis made on the **Ni Span C902 alloy** specimen has revealed that the thermo-elastic coefficient increases with an increase in analytical frequency to 800 cps. More than 800 cps the frequency doesn't have more impact. The analysis on the heating of material at the

1500 cps and 455,000 cps introduces the same results. The heat processing that gives zero coefficient of thermoelastic on the material is assessed in the torsion pendulum at the frequency of 1 cps giving a coefficient of thermoelastic over 40 on the specimen analyzed in the free vibration at the frequency of 1000 cps.

Due to influence of frequency, it is essential to delineate the double application areas of **Ni Span C902 alloy,** every area needs the variable processing to get the best outcomes. These are represented as following:

1. Slight frequency apparatus that groups springs, bourdon vessels, aneroid capsules and more.
2. Large Frequency apparatus that groups Tuning forks, vibrating reeds, mechanical filters and similar devices that are included in this class.

The uncontrolled variations in the chemical composition of alloy lead to the nominal variations in the elastic features. These differences are significantly lower than the whole accuracy of the most equipments in which the alloy is utilized in the order of more or less than 20 parts per million per degree F. In the highly precise operations, the effect of difference in the chemical composition may be recompensed by treatment to get the required thermoelastic coefficient.

Hysteresis

The low frequency equipments often need the low thermoelastic coefficient having lower mechanical hysteresis and drift. It can be received by the cold processing about 35% and heat processing at 1100oF to 1200oF for 5 hours. The heating of **Ni Span C902 alloy** provides suitable thermoelastic coefficient for high or nominal frequency operations. The nominal mechanical hysteresis is also achieved by this treatment. The maximum mechanical strength obtained is another required outcome.

The heat processing temperature should be kept nominal up to 700oF – 750oF for the **Ni Span C902 alloy** with extensive cold processing to get the minimum mechanical hysteresis. The heat processing causes reduction in the thermoelastic coefficient**.** Highly precise device needs analysis of every part of the specimen to conclude the specific heat processing required for the desirable thermoelastic coefficient. The method related to the heat processing temperature, composition and cold processing has been implemented to support in performing the pilot analysis.

The method that works on the high frequency operations put significant effect of processing variables on the large frequency thermoelastic coefficient. For the typical heating, 50% cold

processing for 5 hours at 860oF gives zero thermoelastic coefficient. The improved heat processing temperature up to 1100oF provides thermoelastic coefficient of 12 parts per million per oF.

If the extreme precision is not required, the processing is made to produce the large strength with the high fatigue resistance and nominal mechanical hysteresis about 30% to 50% cold processing and heating for 1100oF to 1200oF for 5 hours. The thermoelastic coefficient is approximately zero. The heat processing of **Ni Span C902 alloy** should be performed at temperature more than 600oF to ensure the process stability.

Applications

Ni Span C902 alloy is utilized in making the various kinds of accuracy devices in which the elastic materials are subjected to the dynamic temperatures. The resonant vibrating systems like electromechanical filters, tuning folks and vibration reeds are popular examples of vibrating reeds that need the constant frequency. The zero substance can be utilized for the vibrating material or nominally positive or negative values can be selected to recompense the thermal drift due to the parts of the equipments. Another significant application of Ni-span C902 alloy is spring. The constant features provide the temperature independent deflection. Other examples are Bourdon tubes, aneroid capsules, geophysical apparatus, hair spring for timing equipments, diaphragms and springs made for weighing machines.

Available Forms

Wire, Mesh, Sheet, Plate, Foil, Strip, Rod