KOVAR

Kovar is an iron-nickel-cobalt alloy with a coefficient of thermal expansion similar to that of hard (borosilicate) glass. This makes it especially suitable for uses which require a matched-expansion seal between metal and glass parts. Thus kovar finds wide usage in the electronics industry for metal parts bonded to hard glass envelopes for such devices as power tubes, x-ray tubes, etc., and other applications requiring glass-to-metal seals.

Typical Analysis in Percent:

Ni	29	Co	17
Fe	Balance	Si	0.10
Mn	0.30	C	0.02 maximum

Typical Physical Properties:

Density: .302 lb/in^3
Specific Gravity: 8.36

Curie Temperature: 435 ^oC
Melting Point: 1450 ^oC

Specific Heat: .105 cal/gm/ ^oC at 0 ^oC
.155 cal/gm/ ^oC at 430 ^oC

Heat of Fusion: 64 cal/gm
Thermal Conductivity: 17.3 W/m · K

Electrical Resistivity: 490 microhm/mm

Typical Mechanical Properties:

Shear Modulus: $7.5 \cdot 10^6$
Modulus of Elasticity: $20 \cdot 10^6$

Ultimate Strength: 75,000 psi
Yield Strength: 50,000 psi

Kink Point: 430 ^oC

Poisson's Ratio: 317
Elongation: 30%

Velocity of Sound: 16,300 ft/sec
Hardness (Rockwell B): 78

Coefficient of Thermal Expansion (Nominal):

30 ^oC - 200 ^oC	5.5 (x 10^{-6} m/m · K)	30 ^oC - 600 ^oC	7.9
30 ^oC - 300 ^oC	5.1	30 ^oC - 700 ^oC	9.3
30 ^oC - 400 ^oC	4.9	30 ^oC - 800 ^oC	10.4
30 ^oC - 450 ^oC	5.3	30 ^oC - 900 ^oC	11.5
30 ^oC - 500 ^oC	6.2		

Heat Treatment:

Because of its effect on the actual structure of the material, there is a distinction made between heat treating the material to facilitate fabrication and heat treating the material to insure optimum conditions for glass sealing, plating or brazing.

Stress Relief Annealing:

To relieve stress and work hardening of parts at intermediate stages of fabrication. It is intended particularly for drawing, forming and spinning operations.

1. Wash and degrease parts.

2. Anneal in atmosphere controlled furnace. Atmosphere may be wet or dry hydrogen, dissociated ammonia, cracked gas or similar neutral atmosphere.

3. Annealing temperature is not critical; however, high temperatures (greater than 900 °C) or extended time periods (longer than 60 minutes) should be avoided because such treatments promote grain growth. Typical cycle: 850 °C for 30 minutes.

4. Parts should be held at temperature for the indicated time and then furnace cooled to less than 175 °C to avoid oxidation and/or thermal shock (which may cause distortion).

Heat Treatment for Oxidation:

1. Make sure that proper methods are used to clean, degrease and bright dip parts.

2. Oxidation - Heat treat in an electric air furnace to 850 °C to 900 °C until parts are cherry red (dull red heat). The length of heat cycle is approximately 3 minutes, but due to differences in humidity and furnaces, the proper cycle has to be varied. Then reduce heat approximately 10 °C per minute. When parts are cooled, oxide will be formed. The oxide may appear from light grey to black in color. Black is normally considered to be over oxidation and is not necessarily desirable for a good glass to metal seal.