Controlled Expansion Alloys

Alloy 36 (Invar®) / K93603
Alloy 52 (Nilo®) / N14052
Alloy 42 / K94100
Alloy K (Kovar®) / K94610

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Controlled thermal expansion alloys are iron-nickel alloys that exhibit an extremely low expansion rate at room temperature. These materials are utilised in modern applications that require metal to be joined to glass or ceramic, and areas where the thermal expansion rates of the materials must coincide to prevent differential expansion within the joint area. They are used in industries such as electronics, medical (laser and x-ray machines), aerospace engineering, telecommunications and cryogenic components.

Iron and nickel have very similar coefficients of thermal expansion. The addition of nickel to iron can result in the creation of an alloy in which the coefficient is reduced by an order of magnitude. Research in the 1920s found that an iron-nickel alloy containing around 36% nickel exhibited virtually no thermal expansion at, or close to, room temperature. This type of material became noted for its invariability or lack of expansion and contraction with temperature changes. By modifying the composition of this 36% nickel alloy, metallurgists have created a number of special materials with unique expansion characteristics to suit particular applications.

Alloy 36 (Invar®) / K93603 / ASTM F1684

Widely known under several trades names such as Invar®* and Nilo 36**, this grade is a 36% nickel-iron alloy. It exhibits a near zero rate of thermal expansion from around –100°C up to 200°C. This is around a tenth of the expansion rate of carbon steels. Alloy 36 also demonstrates a high retention of strength and toughness at cryogenic temperatures, making it suitable for a variety of low temperature or low expansion applications. The alloy is ideally suited to areas where dimensional changes due to temperature must be minimal, such as tooling for aerospace composites, radio and electronic devices and structural members in precision equipment such as lasers, measuring devices, thermostats and cryogenic instrumentation. Alloy 36 can also be utilised in combination with a high expansion material to crate mechanical movement with temperature in thermomechanical controls and switchgear.

Alloy 42 / K94100 / ASTM F30

A binary nickel-iron containing around 41% nickel, this grade exhibits a low and normally consistent coefficient of thermal expansion over the range 20-300°C. This enables its use in glass-to-metal or ceramic-to-metal sealing applications and tooling for aerospace composites. Alloy 42 also has a coefficient of thermal expansion matched to silicon, and ceramic materials such as alumina, beryllia and vitreous glass compounds. It can be found as a sealing material in semiconductor packages, electronic tubes, CRT electron guns, microelectronic components, thermostat rods, vacuum devices and electric industrial lamps.

Alloy 52 / N14052

Alloy 52 contains 52% nickel and 48% iron and is widely used in the telecommunications industry. It also finds application in a wide variety of electronic applications, especially for glass seals.

Alloy K / K94610 / ASTM F15

Also known as Kovar®*** and Nilo K**, this alloy contains 29% nickel with a 17% cobalt addition. Its composition is tightly controlled within narrow limits to ensure precise and universal thermal expansion and mechanical characteristics. This helps the material provide high integrity glass-to-metal and ceramic-to-metal seals in applications requiring reliability and resistance to thermal shock. Alloy K is often used for the manufacture of hermetic seals with both the harder Pyrex or borosilicate glasses and alumina-type ceramic materials. It finds extensive application in the production of transistors and diodes for lids and closures in a variety of hybrid electronic circuit packages and also in the manufacture of microwave tubes.

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Controlled Expansion Alloys

Technical Data

Coefficient of Thermal Expansion

	Alloy 36	Alloy 42	Alloy 52	Alloy K
30-150°C (µm/m°C)	1.2 - 2.7			
30-300°C (µm/m°C)		4.0 - 4.7		
30-400°C (µm/m°C)				4.6 - 5.2
30-450°C (µm/m°C)		6.7 - 7.4	9.7 - 10.2	5.1 - 5.5
30-550°C (µm/m°C)			10.0 - 10.5	

Typical Physical Properties

	Alloy 36	Alloy 42	Alloy 52	Alloy K
Density (g/cm^3)	8.13	8.15	8.30	8.25
Melting Point (°C)	1450	1425	1425	1450
Curie Point (°C)	230	330	510	425
Thermal conductivity (W/m°C)	10.5	12.5	13.4	17.0
Specific Heat (J/g°C)	0.51	0.50	0.50	0.50
Young's Modulus (MPA)	140,000	145,000	165,000	139,000

Round Bar Weight and Stock Sizes

Diameter	Weight		Diameter	Weight		Diameter	Weight	
mm	kg/ft	kg/m	mm	kg/ft	kg/m	mm	kg/ft	kg/m
3	0.02	0.06	16	0.50	1.64	50	4.88	16.00
6	0.07	0.23	20	0.78	2.56	60	7.02	23.04
8	0.13	0.41	25	1.22	4.00	70	9.56	31.37
9.5	0.18	0.58	30	1.76	5.76	75	10.98	36.01
10	0.20	0.64	35	2.39	7.84	80	12.49	40.97
12	0.28	0.92	40	3.12	10.24	90	15.80	51.85
12.7	0.32	1.03	45	3.95	12.96	100	19.51	64.01

NB Weight data for guidance only

*Invar® is a registered trademark of Arcelor Mittal
** The Nilo® alloy family is a registered trademark of Special Metals Ltd
***Kovar® is a registered trademark of Carpenter Technology Corporation