SALOMON'S METALEN B.V.

INVAR 36

Identification
UNS Number K93601/K93603

Type Analyses

Carbon	0.02 %	**Manganese**	0.35 %
Silicon	0.20 %	**Nickel**	36.00 %
Iron	Balance		

General Information
- Description:

Invar 36 is a nickel-iron alloy possessing a rate of thermal expansion approximately one-tenth that of carbon steel at temperatures up to 400°F (204°C).

- Applications

Invar 36 has been used for applications where dimensional changes due to temperature variation must be minimized such as in radio and electronic devices, aircraft controls, optical and laser systems, etc.

Invar 36 has also been used in conjunction with high expansion alloys in applications where a motion is desired when the temperature changes, such as in bimetallic thermostats and in rod and tube assemblies for temperature regulators.

Corrosion Resistance
Important note: *The following 4-level rating scale is intended for comparative purposes only. Corrosion testing is recommended; factors which affect corrosion resistance include temperature, concentration, pH, impurities, aeration, velocity, crevice, deposits, metallurgical condition, stress, surface finish and dissimilar metal contact.*

Humidity Good

Properties

Physical Properties

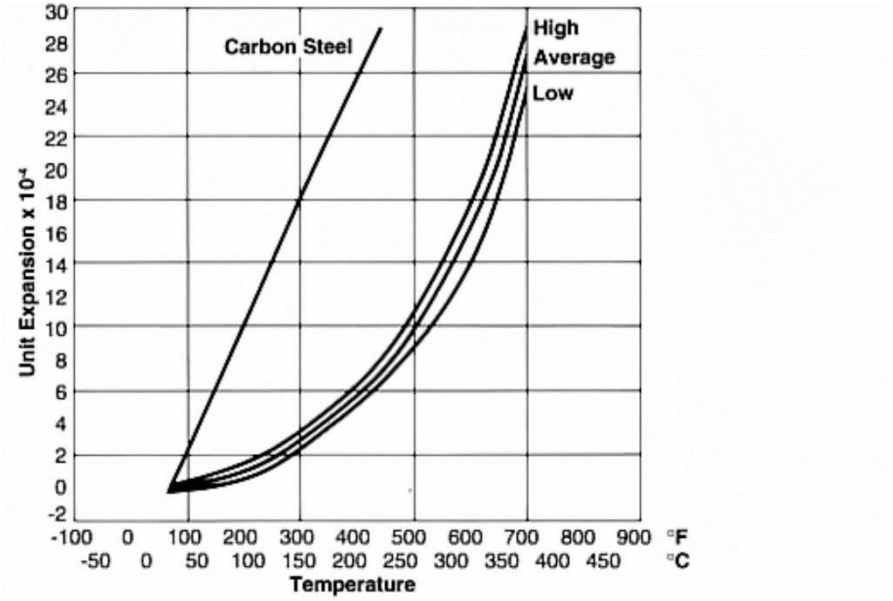
Specific Gravity	8.05	
Density	0.2910	lb/in³
Mean Specific Heat	0.1230	Btu/lb/°F
Mean CTE		
200°F	0.720	x 10 $^{-6}$ in/in/°F
300°F	1.17	x 10 $^{-6}$ in/in/°F
500°F	2.32	x 10 $^{-6}$ in/in/°F
700°F	4.22	x 10 $^{-6}$ in/in/°F

Mean coefficient of thermal expansion

Temperature		Coefficient	
°F	°C	in/in/°F x 10^{-6}	cm/cm/°C x 10^{-6}
200	93	0.72	1.30
300	149	1.17	2.11
500	260	2.32	4.18
700	371	4.22	7.60

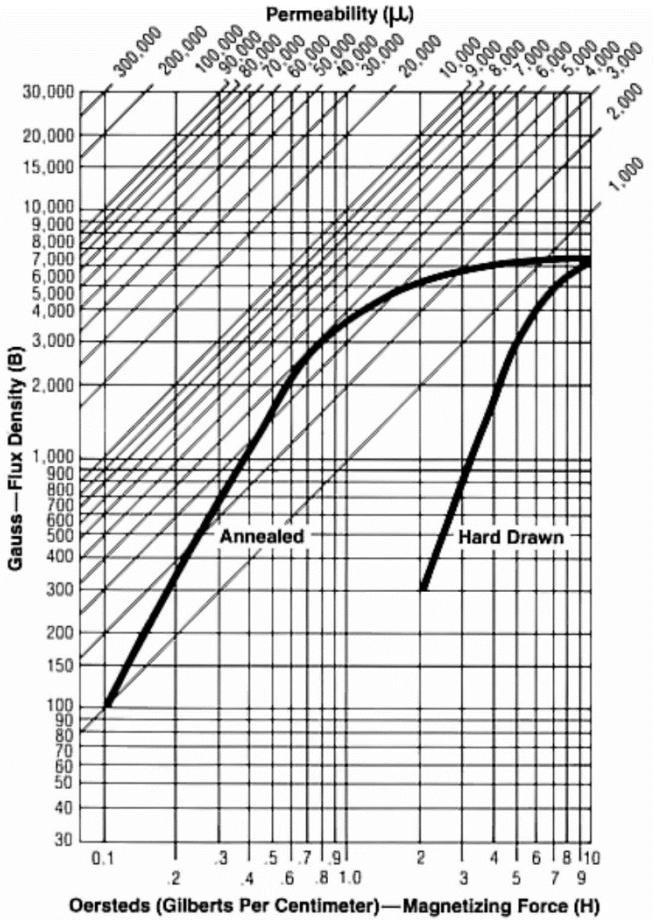
Thermal Conductivity	72.85	BTU-in/hr/ft²/°F
Modulus of Elasticity (E)		
Annealed Bar and Strip	20.5	x 10^{3} ksi
Cold Rolled	21.5	x 10^{3} ksi
Electrical Resistivity (70°F)	495.0	ohm-cir-mil/ft
Temperature Coeff of Electrical Resist (70 to 212°F)	6.11	x 10^{-4} Ohm/Ohm/°F
Curie Temperature	535	°F
Melting Range	2600	°F

Comparative Expansion Curves Invar 36 vs. Carbon Steel

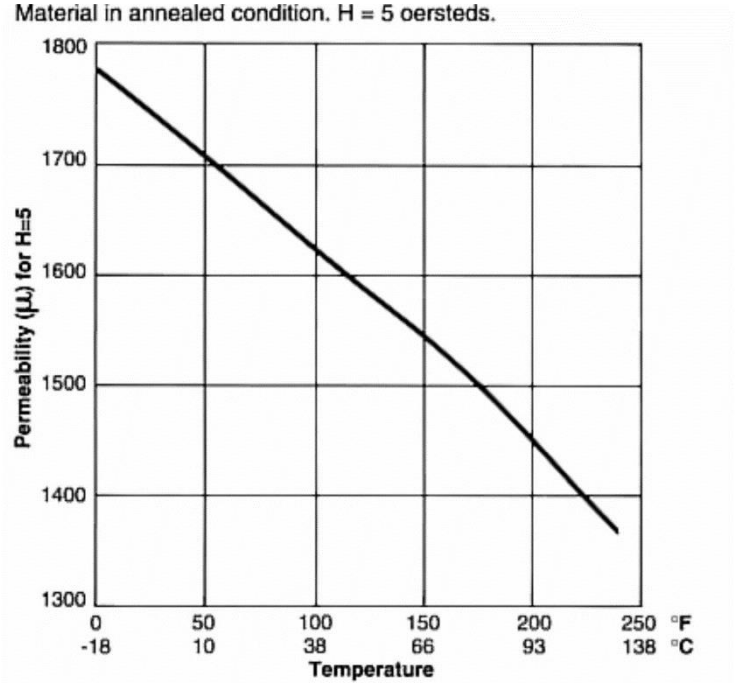


Magnetic Properties

DC Magnetic Permeability Curves – Invar 36



Permeability vs Temperature Characteristics – Invar 36



Typical Mechanical Properties

Tensile Strength		Yield Strength		% Reduction in Area	% Elongation in 2" (50.8 mm)	Hardness Rockwell B
ksi	MPa	ksi	MPa			
Cold Drawn Bars						
90	621	70	483	60	20	90
Cold Rolled Strip						
104	717	98.5	679	-	5.5	98
Annealed Bars and Strip						
65	448	40	276	65	35	70

Heat Treatment
Heat Treatment for Optimal Dimensional Stability.

The presence of cold work stresses very slight changes in dimensional stability with respect to time and temperature. This change can be detected only with exceedingly sensitive devices.

To assure optimal dimensional stability, heat to 1500°F (315°C) holding one hour at heat, then air cool.

To promote temporal stability (when necessary), Invar 36 has been aged for 24 to 48 hours at 200°F (92°C).

Annealing:
Heat to 1450°F (790°C) and hold at heat 30 minutes per inch of thickness, then air cool. Heating to temperatures above 1000°F (538°C) relieves the presence of cold work stresses. The higher the temperature, the lower the annealed hardness, as shown in the following table.

Specimen held 5 minutes at heat:

Temperature Air Treat		Hardness Rockwell B
°F	°C	
1200	650	87/88
1500	815	77/78
1800	980	70/71
1900	1040	66/68

Workability

- Forging:

The principal precaution to observe in forging is to heat quickly and avoid soaking in the furnace. Long soaking may result in a checked surface due to absorption of sulfar from the furnace atmosphere and/or oxide penetration. A forging temperature of 2000/2150°F (1100/1180°C) is preferred.
Blanking and Forming
Invar 36 presents no unusual problems in blanking and forming. For cleanest blanking properties, a Rockwell hardness of B 90 is suggested. This hardness will allow mild bending and forming operations. Where deep drawing operations are involved a finish annealed strip of a Rockwell hardness of abut B 75 is usually desirable.

- Grinding and Polishing:

A silicon carbide wheel is desirable, preferably a soft wheel which will wear without loading. For finish grinding, a satisfactory grade to start with is No.80 grit.

- Weld ability:

Invar 36 can be welded by the conventional methods. Caution must be taken so as not to overheat the molten metal. This will avoid spattering of the molten metal and pits in the welded area. When filler rod is required, invarrod has been used.

- Brazing

Silver and zinc-free alloys have been used for brazing Invar 36. This alloy should be annealed prior to brazing. Joints should be designed to avoid placing Invar 36 in tension during brazing.

- Plating:

Invar 36 can be chromium, cadmium and nickel plated or zinc coated by the usual methods used for ferrous alloys.

Other Information

Applicable Specifications
Invar 36 meets the requirement of specifications ASTM B753 Alloy T36.

- ASTM B753 Alloy T36