

INVAR 36

Applicable designation: ASTM B753 Alloy T36

Associated specifications: UNS K93601, UNS K93603

Type analysis

Single figures are nominal except where noted.

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

Forms manufactured

Bar-Flats	Bar-Rounds	Bar-Squares	Billet	Strip	Wire-Shapes
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Description

Invar 36 is a 36% nickel-iron alloy possessing a rate of thermal expansion approximately one-tenth that of carbon steel at temperatures up to 400°F (204°C). The alloy is used for applications where dimensional changes due to temperature variation must be minimized or in conjunction with high expansion alloys in applications where a motion is desired when the temperature changes.

Key Properties:

- Extremely low coefficient of thermal expansion
- Versatile across applications

Markets:

- Aerospace
- Consumer
- Medical
- Defense
- Industrial

Applications:

- Semiconductor components
- Electronic devices
- Optical and laser systems
- Temperature regulator components

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Corrosion resistance

IMPORTANT NOTE:

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

Humidity

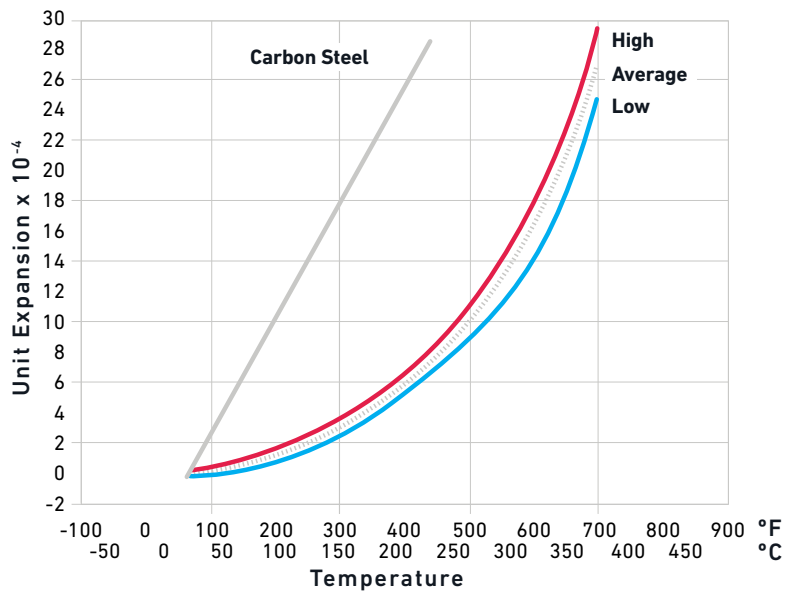
Good

Physical properties

PROPERTY		At or From	English Units	Metric Units
SPECIFIC GRAVITY		—	8.05	8.05
DENSITY		—	0.2910 lb/in ³	—
MEAN SPECIFIC HEAT		—	0.1230 Btu/lb/°F	—
MEAN COEFFICIENT OF THERMAL EXPANSION (CTE)		200°F (93°C)	0.72×10^{-6} in/in/°F	1.30×10^{-6} cm/cm/°C
		300°F (149°C)	1.17×10^{-6} in/in/°F	2.11×10^{-6} cm/cm/°C
		500°F (260°C)	2.32×10^{-6} in/in/°F	4.18×10^{-6} cm/cm/°C
		700°F (371°C)	4.22×10^{-6} in/in/°F	7.60×10^{-6} cm/cm/°C
THERMAL CONDUCTIVITY		—	72.85 Btu-in/hr/ft ² /°F	—
ELASTIC MODULUS	ANNEALED BAR AND STRIP	—	20.5×10^3 ksi	—
	COLD ROLLED	—	21.5×10^3 ksi	—
ELECTRICAL RESISTIVITY		70°F (21°C)	495.0 ohm-cir-mil/ft	—
TEMPERATURE COEFFICIENT OF ELECTRICAL RESISTANCE		70 to 212°F (21 to 100°C)	6.11×10^{-4} ohm/ohm/°F	—
CURIE TEMPERATURE		—	535°F	279°C
MELTING RANGE		—	2600°F	1427°C

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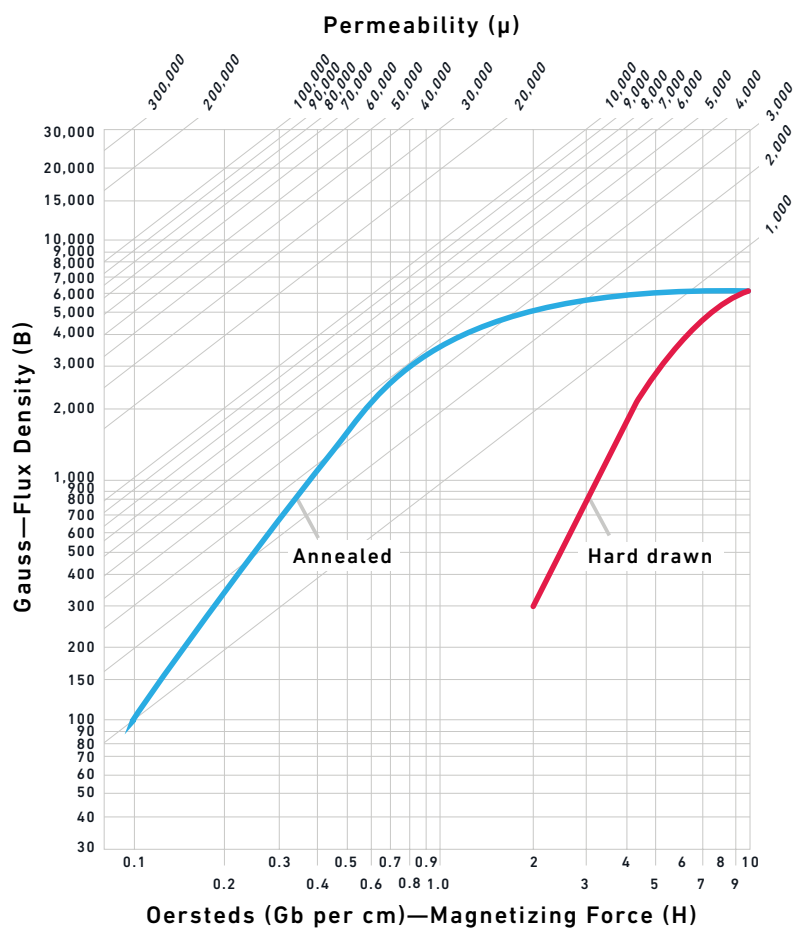
COMPARATIVE EXPANSION CURVES VS. CARBON STEEL



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Magnetic properties

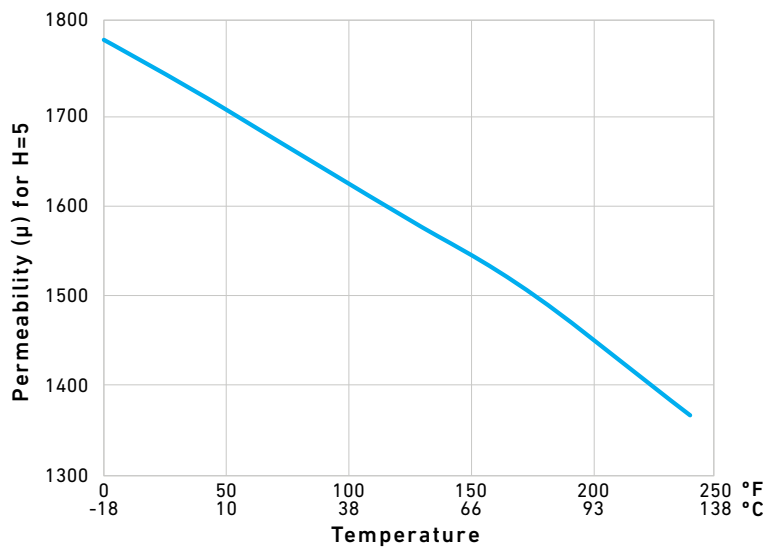
DC MAGNETIC PERMEABILITY CURVES



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PERMEABILITY VS. TEMPERATURE CHARACTERISTICS

Material in annealed condition. H = 5 Oe.



Typical mechanical properties

HEAT TREATMENT	YIELD STRENGTH		TENSILE STRENGTH		ELONGATION IN 2 IN (50.8 MM)	REDUCTION OF AREA	HARDNESS
	ksi	MPa	ksi	MPa	%	%	HRB
Cold drawn bars	70	483	90	621	20	60	90
Cold rolled strip	98.5	679	104	717	5.5	—	98
Annealed bars and strip	40	276	65	448	35	65	70

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Heat treatment

HEAT TREATMENT FOR OPTIMAL DIMENSIONAL STABILITY

The presence of cold work stresses causes 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 (815°C), hold at heat for 30 minutes per inch of thickness, water quench, reheat to 600°F (315°C) holding 1 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 (93°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	
°F	°C	HRB	
1200	650	87/88	
1500	815	77/78	
1800	980	70/71	
1900	1040	66/68	

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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 sulfur 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 about B 75 is usually desirable.
Grinding and polishing	A silicon carbide wheel is desirable, preferably a soft wheel that will wear without loading. For finish grinding, a satisfactory grade to start with is No. 80 grit.
Weldability	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, Invarod 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.

**For additional information, please
contact your nearest sales office:**

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