SUPER INVAR 32-5

Applicable designation: ASTM F1684

Associated specifications: K93500

Type analysis

Single figures are nominal except where noted.

Iron	Balance	**Nickel**	32.00 %	**Cobalt**	5.50 %
Manganese	0.40 %	**Silicon**	0.25 %	**Carbon**	0.02 %

Forms manufactured

Bar-Flats	**Bar-Rounds**	**Bar-Squares**	**Billet**	**Strip**	**Wire**

Description

Super Invar 32-5, a magnetic, austenitic, solid solution alloy containing iron, nickel and cobalt, is designed to provide minimum thermal expansion at room temperatures.

The alloy also exhibits austenite stability to service temperatures at least -67°F (-55°C) and thermal expansion properties less than those of Invar 36 (36% nickel-iron) when used in the -67/203°F (-55/95°C) temperature range.

Key Properties:

- Minimal thermal expansion
- Austenite stability

Markets:

- Consumer
- Defense
- Industrial

Applications:

- Semiconductor components
- Optical and laser systems
- Wave guide tubes
- Other systems with low expansion glass/quartz assemblies

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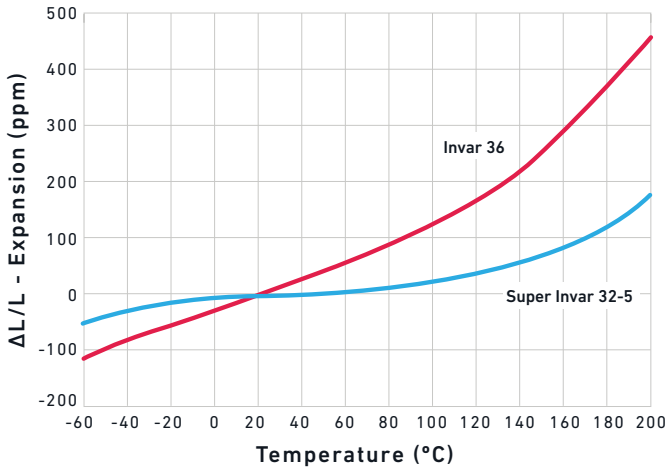
Physical properties

PROPERTY	At or From	English Units	Metric Units
SPECIFIC GRAVITY	—	8.15	8.15
DENSITY	—	0.2940 lb/in^3	—
MEAN COEFFICIENT OF THERMAL EXPANSION (CTE)	-67 to 203°F (-55 to 95°C)	0.350 x 10^{-6} in/in/°F	—
POISSON'S RATIO	—	0.230	.230
ELASTIC MODULUS	—	21.0 x 10^3 ksi	—
ELECTRICAL RESISTIVITY	73°F (23°C)	481.3 ohm-cir-mil/ft	—
MARTENSITE START	—	-112°F	-80°C

COMPARATIVE EXPANSION CURVES VS. CARBON STEEL



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Typical mechanical properties

HEAT TREATMENT	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION IN 2 IN (50.8 MM)	HARDNESS
	ksi	MPa	ksi	MPa	%	HRB
Annealed	40	276	70	483	40	75
Cold worked	40	276	70	483	40	90

Heat treatment

Fabricating practices such as machining, forming, and deep drawing introduce stresses in Super Invar 32-5 that promote variation in thermal expansion behavior. Consequently, parts should be heat treated at or as close to finish size as possible.

HEAT TREATING FOR LOWEST THERMAL EXPANSION AND OPTIMUM STABILITY:

The recommended heat treating practice for lowest thermal expansion and optimum stability is to heat at 1550°F (843°C) for 1 hour, water quench, followed by a stress relieving operation at 600°F (316°C) for 1 hour, air cool and age at 200°F (93°C) for 24 hours, then air cool.

Because this alloy oxidizes readily at heat treating temperatures above about 1000°F (538°C), it is recommended parts be heat treated in a protective environment such as vacuum, hydrogen, dissociated ammonia, or inert gases.

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.

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Workability

Forging	Suggested forging temperature is 2000/2150°F (1093/1177°C). Heat rapidly and avoid soaking in the forging furnace. Long soaking time may result in a checked surface due to oxygen and sulfur contamination.
Cold heading	This alloy may be swaged or cold upset.
Blanking and forming	Super Invar 32-5 presents no unusual problems in blanking and forming. For best blanking, a hardness of HRB 90 is suggested. This hardness will allow mild bending and forming operations. When deep drawing operations are involved, a mill annealed strip of HRB 75 is usually desirable.
Machinability	Super Invar 32-5 machines similar to, but not as well as, Type 316 austenitic stainless steel. Its machinability rating is approximately 25% that of AISI B1112. This alloy is somewhat difficult to machine because the machined chips are gummy and stringy. Work hardened bars can result in some improvement in machinability. Tool geometries normally used for austenitic stainless steels are suitable for this alloy. All tools should be kept sharp with a fine finish, be as large as possible, and rigidly supported. Recommended cutting fluids are 1 to 1 blend of a sulfachlorinated petroleum oil containing 8% to 10% fatty oil and a paraffin blending oil, or a water emulsifiable cutting fluid with polar and extreme pressure additives. Parts should be degreased and cleaned as soon after machining as possible to remove any residual sulfur, which can cause grain boundary embrittlement.
Additional machinability notes	When using carbide tools, surface speed feet/minute can be increased between 2 to 3 times over the high speed suggestions. Feeds can be increased between 50 and 100%. Figures used for all metal removal operations are average. On certain work, the nature of the part may require adjustment of speeds and feeds. Each job has to be developed for best production results with optimum tool life. Speeds or feeds should be increased or decreased in small steps.
Grinding and polishing	A soft silicon carbide wheel that will wear without loading is recommended. For finish grinding, a satisfactory wheel roughness to start with is No. 80 grit.
Plating	Super Invar 32-5 can be chromium, cadmium, and nickel plated or zinc coated by the usual methods used for ferrous alloys.

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Typical feeds and speeds

The feeds and speeds in the following charts are conservative recommendations for initial setup. Higher feeds and speeds may be attainable depending on machining environment. See the additional machinability notes above.

TURNING — SINGLE-POINT AND BOX TOOLS

DEPTH OF CUT, IN	SPEED, FPM	FEED, IPR
.100	30	.010 (Roughing)
.020	20	.002 (Finishing)

TURNING — CUT-OFF AND FORM TOOLS

SPEED, FPM	FEED, IPR				
	TOOL WIDTH, IN				
	1/8	*1/4*	*1/2*	*1*	*2*
20	.001	.001	.0015	.001	.0007

DRILLING

SPEED, FPM	FEED, IPR							
	DRILL DIAMETER, IN							
	1/16	*1/8*	*1/4*	*1/2*	*3/4*	*1*	*1-1/2*	*2*
35	.001	.003	.004	.008	.010	.012	.015	.018

TAPPING

SPEED, FPM	THREADS PER INCH
7 or less	6
8–15	8
16–24	12
Over 24	15

MILLING — END PERIPHERAL

RADIAL DEPTH OF CUT, IN	SPEED, FPM	FEED, IN PER TOOTH			
		CUTTER DIAMETER, IN			
		3/8	*1/2*	*3/4*	*1 TO 2*
.020	65	.002	.002	.003	.004
.060	50	.002	.003	.004	.005

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