DATA SHEET
INVAR 36 FOR COMPOSITE TOOLING

APPLICATION

Re-Steel produces Invar 36 in accordance to the **ASTM-F-1684 specification**.
The constraints of these specifications limit the Sulfur and Phosphorus content of the material for increased weldability. This material has been specifically manufactured for composite tooling when low Coefficient of Thermal Expansion (CTE) is required.

CHEMISTRY – Typical Percent by Weight

Carbon	C	0.02%
Manganese	Mn	0.35%
Silicon	Si	0.20%
Nickel	Ni	36.00%
Iron	Fe	BAL.
Sulphur	S	0.002%
Phosphorus	P	0.002%

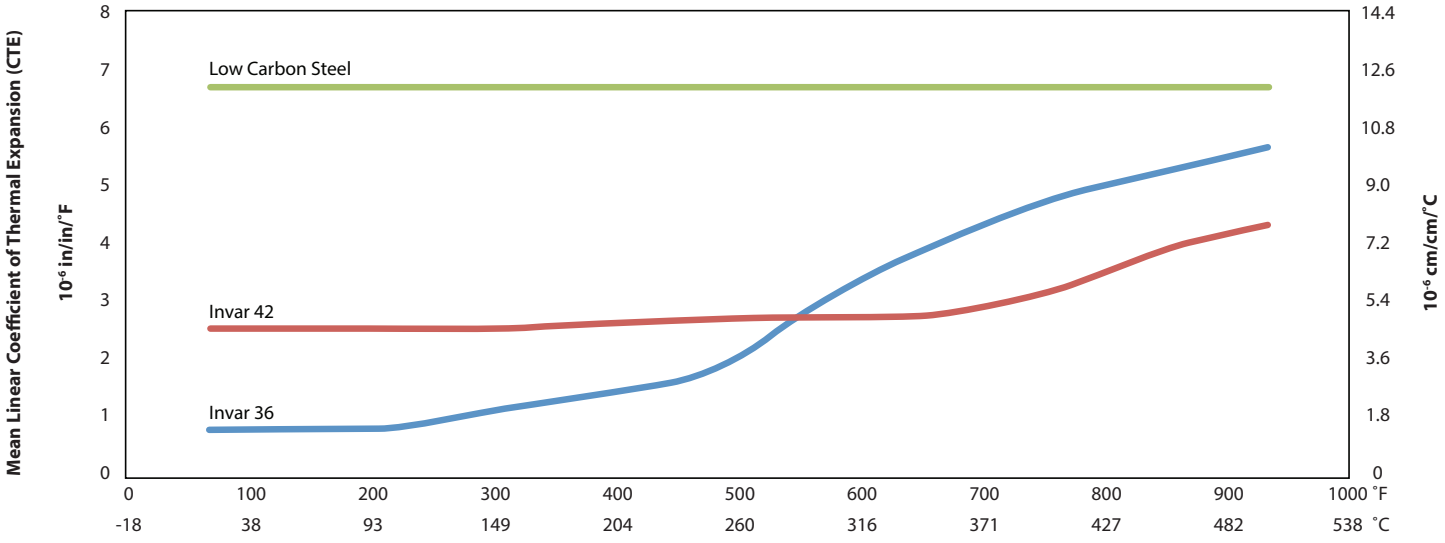
TYPICAL THERMAL EXPANSION

Temp. Range		Total Expansion	Mean Linear Coefficient	
°C	°F	10 E-3	10E-6/°C	10E-6/°F
-220	-396	-0.33	1.5	0.8
-120	-216	-0.16	1.3	0.7
20-100	68-212	0.12	1.5	0.8
20-150	68-302	0.26	2	1.1
20-200	68-392	0.47	2.6	1.4
20-250	68-482	0.8	3.5	1.9
20-300	68-572	1.54	5.5	3.1
20-350	68-662	2.37	7.2	4.0
20-400	68-752	3.19	8.4	4.7
20-450	68-842	4.01	9.3	5.2
20-500	68-932	4.85	10.1	5.6

TYPICAL PHYSICAL PROPERTIES

Density	lb/ in^3	0.293
	Kg / m^3	8055
Modulus of Elasticity @ Room Temp.	x10^6 PSI	20.5
	x10^3 MPa	141
Yield Strength 0.2%	KSI (MPa)	36 (248)
Tensile Strength	KSI (MPa)	71 (489)
Hardness	Rb	74
Curie Temp.	°F	535
	°C	279
Melting Point	°F	2600
	°C	1427
Thermal Conductivity	Btu-in/ft^2/hr/°F	72.6
	W/m • K	10.5

TYPICAL THERMAL EXPANSION



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ANNEALING

Type	Temp		Duration	Purpose
FULL ANNEAL	1550° F	843° C	60 min / 1" of Thickness	To be done following extensive forming or welding
STRESS RELIEF ANNEAL	600° F	315° C	120 mins.	To be done between rough and final machining or after minor repairs

WELDING

Three processes are typically used for welding Invar 36 for tooling applications*:

- Gas Metal Arc Welding (GMAW aka MIG)
- Gas Tungsten Arc Welding (GTAW aka TIG)
- Submerged Arc welding (SAW)

*Re-Steel supplies spooled and cut-to-length Invar weld wire conforming to Boeing D33028-2.

Additional welding processes may be used for Invar 36:

- Electron Beam Welding (EBW)
- Laser Beam Welding (LBW)

TYPICAL MACHINING PARAMETERS

Process		Tool Type		Surface Speed	Feed Rate	Axial Rake	Radial Rake
				fpm (m/min)	in/tooth (mm/tooth)		
Milling	Roughing	End Mill	Carbide	300 (91)	0.004 (0.10)	25°	12°
		Face Mill	Carbide	400 (122)	0.004 (0.10)		
	Finishing	End Mill	Carbide	300 (91)	0.005 (0.13)	45°	15°
		Face Mill	Carbide	400 (122)	0.004 (0.10)		
	Lubrication: Water soluble oil flood coolant						

Process	Tool Type		Hole Diameter	Speed	Feed Rate
			inches (mm)	RPM	IPR (mm/revolution)
Drilling	Twist Drill 2 Flute 118° Point Angle	High Speed Steel (HSS)	1/4 (6.4)	600	0.002 (0.051)
			3/8 (9.5)	300	0.003 (0.076)
			1/2 (12.7)	175	0.004 (0.102)
	Lubrication: Oil emulsion				