Technical Datasheet

CarTech® Temperature Compensator "32" (Type 1)

Type Analysis

Single figures are nominal except where noted.

Carbon	0.12 %	**Manganese**	0.60 %
Silicon	0.25 %	**Nickel**	32.50 %
Iron	Balance		

General Information

Description

CarTech Temperature Compensator "32" (Type 1) is a 32% nickel-iron alloy whose magnetic permeability decreases at a controlled rate with increase in temperature. It has been used in electrical circuits to compensate for the effect of variations in ambient temperature.

This material could be considered for use in "shunt" applications. A shunt is a conductor joining two points in a magnetic line circuit and forming a desired circuit or path through which some of the magnetic lines pass. At low temperatures the magnet is strong but the shunt, having high permeability, diverts a portion of the "flux" (magnetic current) away from the gap. As temperature increases the pole strength of the magnet decreases, but the permeability of the shunt decreases so less flux is diverted through the shunt.

If the shunt is properly designed, the flux in the gap can be held constant over a fairly wide temperature range, thereby compensating for temperature changes.

CarTech Temperature Compensator "32" (Type 1) has been especially useful where compensation is required over a wide range of temperatures and particularly at high temperatures as in the shunt used in automobile voltage regulators which are located close to the engine under the hood.

Applications

In addition to having been used in voltage regulators, CarTech Temperature Compensator "32" (Type 1) has also been used as shunt material in tachometers and speedometers which must maintain accuracy over a wide range of temperatures.

Stability at Low Temperature

Tests have been made on Carpenter Temperature Compensator "32" (Type 1) as low as -112°F (-80°C). After prolonged cooling at this temperature, no change has been found in magnetic properties. This indicates no transformation at low temperatures and that the temperature permeability characteristics are reversible.

Properties

Physical Properties

Specific Gravity	8.12	
Density	0.2930	lb/in³
Mean Specific Heat	0.1200	Btu/lb/°F
Mean CTE		
77 to 122°F	1.30	x 10 $^{-6}$ in/in/°F
77 to 212°F	1.98	x 10 $^{-6}$ in/in/°F
77 to 392°F	4.28	x 10 $^{-6}$ in/in/°F
77 to 572°F	6.00	x 10 $^{-6}$ in/in/°F
77 to 752°F	7.00	x 10 $^{-6}$ in/in/°F
77 to 932°F	7.61	x 10 $^{-6}$ in/in/°F

Mean coefficient of thermal expansion

Temperature		Coefficient	
77°F to	25°C to	10^{-6}/°F	10^{-6}/°C
122	50	1.3	2.34
212	100	1.98	3.56
392	200	4.28	7.70
572	300	6.0	10.8
752	400	7.0	12.6
932	500	7.61	13.7

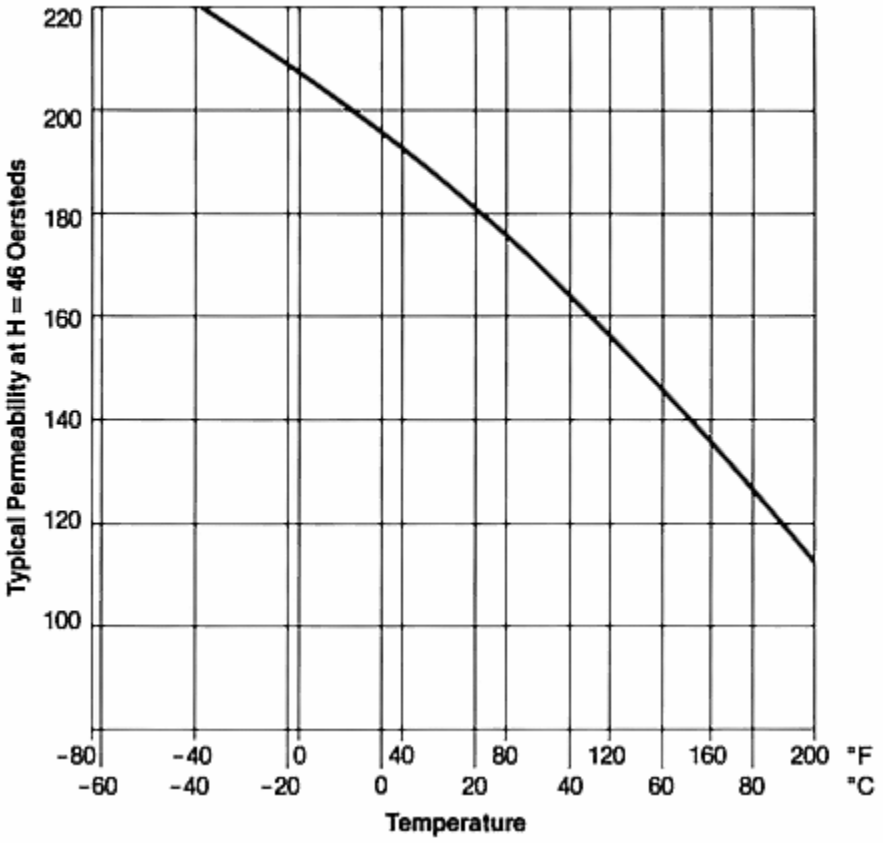
Thermal Conductivity	79.79	BTU-in/hr/ft²/°F
Modulus of Elasticity (E)	22.0	x 10^{3} ksi
Electrical Resistivity (70°F)	480.0	ohm-cir-mil/ft
Temperature Coeff of Electrical Resist (32 to 212°F)	7.00	x 10^{-4} Ohm/Ohm/°F
Inflection Temperature	210	°F
Curie Temperature	390	°F
Melting Range	2600	°F

Magnetic Properties

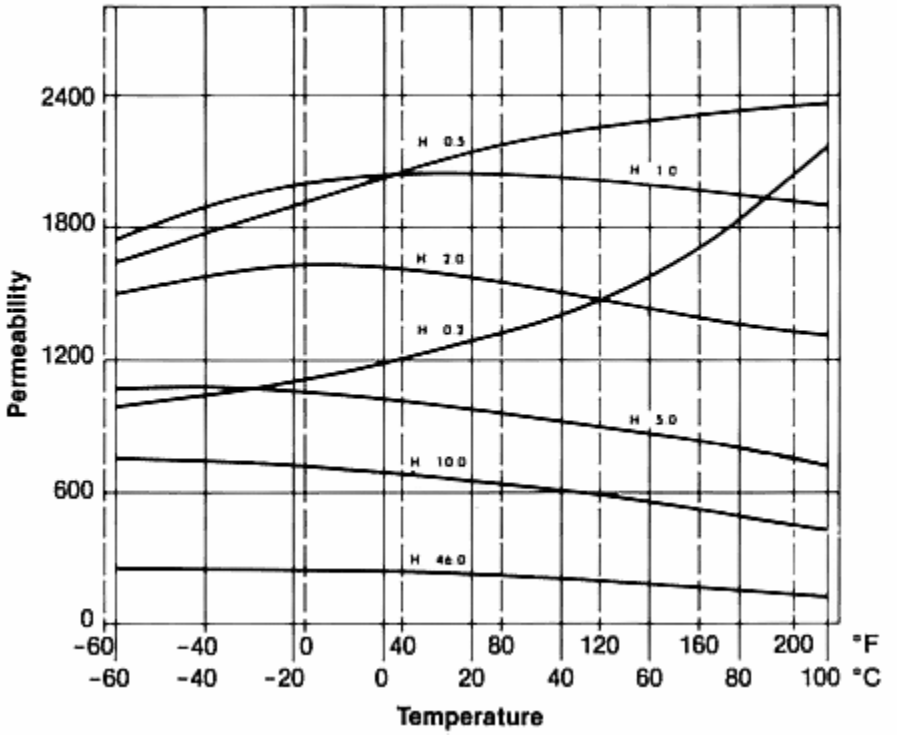
Temperature vs. Flux Density
Carpenter Temperature Compensator "32" (Type 1)
at various high magnetizing field strengths
Lines per cm²

Temperature		H = 46 Oersteds (kilogauss)	H = 500 Oersteds (kilogauss)	H = 1000 Oersteds (kilogauss)
°F	°C			
-76	-60	10.45	11.65	12.40
-40	-40	9.90	11.00	11.75
-4	-20	9.35	10.40	11.20
32	0	8.70	9.75	10.60
68	20	8.05	9.10	10.00
77	25	7.80	8.90	9.80
104	40	7.25	8.28	9.15
140	60	6.53	7.40	8.36
176	80	5.45	6.45	7.38
194	90	4.80	5.93	6.92
212	100	4.30	5.50	6.42

Typical Temperature-Permeability Curve
Carpenter Temperature Compensator "32" (Type 1)
H = 46 oersteds



Typical Temperature-Permeability Curves
Carpenter Temperature Compensator "32" (Type 1)
at various magnetizing forces below 46 oersteds



Induction	
212°F, 46 Oe	4300 G
194°F, 46 Oe	4800 G
176°F, 46 Oe	5450 G
212°F, 500 Oe	5500 G
194°F, 500 Oe	5930 G
212°F, 1000 Oe	6420 G
176°F, 500 Oe	6450 G
140°F, 46 Oe	6530 G
194°F, 1000 Oe	6920 G
104°F, 46 Oe	7250 G
176°F, 1000 Oe	7380 G
140°F, 500 Oe	7400 G
77.0°F, 46 Oe	7800 G
68.0°F, 46 Oe	8050 G
104°F, 500 Oe	8280 G
140°F, 1000 Oe	8360 G
32.0°F, 46 Oe	8700 G
77.0°F, 500 Oe	8900 G
68.0°F, 500 Oe	9100 G
104°F, 1000 Oe	9150 G
-4.00°F, 46 Oe	9350 G
32.0°F, 500 Oe	9750 G
77.0°F, 1000 Oe	9800 G
-40.0°F, 46 Oe	9900 G
68.0°F, 1000 Oe	10000 G
-4.00°F, 500 Oe	10400 G
-76.0°F, 46 Oe	10500 G
32.0°F, 1000 Oe	10600 G
-40.0°F, 500 Oe	11000 G
-4.00°F, 1000 Oe	11200 G
-76.0°F, 500 Oe	11700 G
-40.0°F, 1000 Oe	11800 G
-76.0°F, 1000 Oe	12400 G

Typical Mechanical Properties

As annealed

Tensile Strength		Yield Strength 0.2% offset		% Elongation in 2" (50.8 mm)	Hardness Rockwell B	Modulus of Elasticity	
ksi	MPa	ksi	MPa			psi x 10^6	MPa x 10^3
70	483	40	276	35	75	22.0	152.0

Workability

Cold Working

Carpenter Temperature Compensator "32" (Type 1) can be readily blanked and formed in the annealed condition. If cold forming is required, the magnetic properties will change but can be restored by heat treatment. Cold working stresses produced by forming or drawing can be eliminated and temperature permeability properties can be restored by heating to 1800/1850°F (982/1010°C) for two to five minutes at heat followed by a cooling rate equivalent to an air cool.

Other Information

Forms Manufactured

- Bar-Rounds
- Strip

Technical Articles

- A Simplified Method of Selecting Soft Magnetic Alloys
- Soft Magnetic Alloys with Improved Corrosion Resistance

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