Technical Datasheet

CarTech® Low Expansion 43-PH

Type Analysis

Single figures are nominal except where noted.

Carbon	0.03 %	**Manganese**	0.50 %
Silicon	0.50 %	**Chromium**	5.25 %
Nickel	42.50 %	**Titanium**	2.50 %
Aluminum	0.50 %	**Iron**	Balance

General Information

Description

Most metals and alloys have a negative temperature coefficient of modulus of elasticity, resulting in the loss of stiffness when heated. CarTech Low Expansion 43-PH, an age hardenable, ferromagnetic, austenitic alloy, is different because it has a constant modulus of elasticity.

The alloy's constant modulus of elasticity, inherent high strength, good formability, adjustable elastic coefficient and low mechanical hysteresis have been factors in its consideration for use in a wide variety of applications in precision devices in which the effects of ambient temperature variations must be held to low limits.

Due to its insensitivity to temperature changes, the temperature compensation of CarTech Low Expansion 43-PH is extremely reliable and, in some cases, mechanical linkage corrections may be unnecessary.

The thermal elastic coefficient (TEC) of this alloy can be adjusted to zero, or some value near zero, by varying the aging temperature and the degree of prior cold work applied to the material.

Applications

CarTech Low Expansion 43-PH could be considered for use in many precision devices where a stressed member must maintain a constant stiffness or deflection, deliver a constant force, or where a vibrating member must maintain a constant frequency regardless of the ambient temperature in the range of -50°F to 150°F (-47°C to 66°C).

Typical applications have included springs, diaphragms and supports in timing and measuring devices, continuous weighing systems, flow meters, gyro suspensions, motor speed switches, bourdon tubes and tuning forks.

Corrosion Resistance

Low Expansion 43-PH has a reasonably high degree of corrosion resistance in mild industrial atmospheres but will rust in moist air.

Properties

Physical Properties

Specific Gravity	8.15	
Density	0.2950	lb/in³
Mean CTE		
75 to 200°F	4.20	x 10 $^{-6}$ in/in/°F
75 to 300°F	4.60	x 10 $^{-6}$ in/in/°F
75 to 500°F	6.00	x 10 $^{-6}$ in/in/°F
Thermal Conductivity	85.00	BTU-in/hr/ft²/°F

Modulus of Elasticity (E)		
50% Cold Worked	26.0	x 10 ³ ksi
Solution Treated	24.0	x 10 ³ ksi
Solution Treated, 50% Cold Worked & Aged 800°F (427°C) 4 Hrs.	27.0	x 10 ³ ksi
Solution Treated, 50% Cold Worked & Aged 1000°F (538°C) 4 Hrs.	27.0	x 10 ³ ksi
Solution Treated, 50% Cold Worked & Aged 1200°F (649°C) 4 Hrs.	27.0	x 10 ³ ksi
Electrical Resistivity (70°F)	610.0	ohm-cir-mil/ft
Curie Temperature	350	°F

Typical Mechanical Properties

Condition	Tensile Strength (ksi)	Yield Strength 0.2% Offset (ksi)	% Elong. In 2"	Hardness	Modulus of Elasticity x 10^6 psi	Thermal* Elastic Coefficient x 10^{-6}/°F
Solution Treated	90	35	40	75Rb	24	~ + 30
50% Cold Worked	130	125	6	26Rc	26	~ - 20
Solution Treated, Cold Worked 50% & Aged 800°F (427°C) 4 Hrs.	140	135	10	30Rc	27	~ 0
Solution Treated, Cold Worked 50% & Aged 1000°F (538°C) 4 Hrs.	150	137	12	33Rc	27	~ + 5
Solution Treated, Cold Worked 50% & Aged 1200°F (649°C) 4 Hrs.	190	175	9	40Rc	27	~ + 25

*These approximate TEC values are provided as examples only and may vary from approximately + 30 to −30 x 10^{-6}/°F.

Heat Treatment

As with most nickel-iron alloys, parts must be thoroughly degreased before heat treatment.

Age

Age hardening is a result of a two step treatment; solution annealing and aging.

Step 1.) Solution annealing
This is normally performed by the supplier during process anneals before shipment. It consists of rapid cooling from a temperature of 1750/1950°F (954/1066°C) to retain certain constituents in a supersaturated solution in the alloy matrix. The product can be purchased in the solution treated and cold worked condition so that only aging is required to achieve the desired strength levels.

Step 2.) Aging
This step consists of heat treating at a selected temperature in the range of 700/1350°F (371/732°C) which permits an inter-metallic compound of nickel and titanium to be precipitated within the alloy.

It is this precipitate practice that causes the material to become stronger and also controls the thermal elastic coefficient.

The preferred aging temperature range is 1100/1350°F (593/732°C) and is generally performed after all forming operations are completed. It may also be carried out before or after joining processes such as welding or brazing.

Typical aging times vary from 3 hours to 5 hours at heat.

A hard vacuum is the only method of producing bright annealed parts. Dry hydrogen, dissociated ammonia, helium or argon with low dew points will yield parts with a thin adherent gray to blue oxide film which is suitable for most products. Cracked city gas is not recommended.

Workability

Machinability

Low Expansion 43-PH can be readily machined but is tough and requires low cutting speeds, shallow feeds and ample cutting fluid. A soluble oil and water coolant should be used with cement-carbide cutting tools and a sulfur base cutting fluid with high-speed steel cutting tools. Chip breakers or chip curlers are recommended.

Following are typical feeds and speeds for Low Expansion 43-PH.

Turning—Single Point and Box Tools

Condition	Depth of Cut, Inches	High-Speed Tools			Carbide Tools			
		Speed, fpm	Feed, ipr	Tool Mtl.	Speed, fpm		Feed, ipr	Tool Mtl.
					Brazed	Throw Away		
Solution Treated	.150	60	.015	M-42	145	175	.010	C-6
Aged	.150	20	.010	M-42	70	80	.010	C-6

Turning—Cut-Off and Form Tools

Condition	Speed, fpm	Feed, ipr						Tool Mtl.
		Cut-Off Tool Width, Inches				Form Tool Width, Inches		
		1/16	1/8	1/4	1/2	1	1-1/2	2
Solution Treated	45 110	.0015 .0015	.002 .002	.0025 .0025	.0025 .0025	.002 .002	.0015 .0015	.001 .001	M-42 C-6
Aged	15 45	.001 .001	.001 .001	.0015 .0015	.0015 .0015	.001 .001	.0007 .0007	.0007 .0007	M-42 C-6

Drilling

Condition	Speed, fpm	Feed, ipr							Tool Mtl.
		Nominal Hole Diameter, Inches							
		1/8	1/4	1/2	3/4	1	1-1/2	2	
Solution Treated	30	.003	.005	.009	.012	.014	.017	.020	M-42
Aged	15	—	.004	.007	.009	.011	.013	.015	M-42

Additional Machinability Notes

Figures used for all metal removal operations reported 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.

Other Information

Applicable Specifications

Low Expansion 43-PH meets the chemistry requirements of the following specifications:

- AMS 5221C
- AMS 5223C
- AMS 5225C

Forms Manufactured

- Bar-Rounds
- Billet
- Strip
- Wire

Technical Articles

- After 100 Years, the Uses for Invar Continue to Multiply
- Selecting Controlled Expansion Alloys

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