Technical Datasheet

CarTech® 706 Alloy

Identification

UNS Number

• N09706

Type Analysis

Single figures are nominal except where noted.

Carbon (Maximum)	0.06 %	**Manganese (Maximum)**	0.35 %
Phosphorus (Maximum)	0.020 %	**Sulfur (Maximum)**	0.015 %
Silicon (Maximum)	0.35 %	**Chromium**	14.50 to 17.50 %
Nickel	39.00 to 44.00 %	**Copper (Maximum)**	0.30 %
Titanium	1.50 to 2.00 %	**Aluminum (Maximum)**	0.40 %
Columbium + Tantalum	2.50 to 3.30 %	**Boron (Maximum)**	0.006 %
Iron	Balance		

General Information

Description

CarTech 706 alloy is a precipitation-hardenable nickel-base alloy with high strength from cryogenic temperatures to about 1200°F (650°C). The alloy has similar characteristics to those of alloy 718 but has improved fabricability and can be processed into larger ingots and forgings than other superalloys. The alloy has excellent resistance to strain-age cracking of weldments.

Applications

CarTech 706 alloy has been used for a variety of applications that require high elevated-temperature strength in larger section sizes along with good fabricability. The alloy has been used for turbine discs in large industrial gas turbines as well as aerospace turbines. Other turbine engine parts include shafts, cases, mounts, and fasteners.

The alloy is also a candidate for oil and gas industry applications because of its good combination of strength and corrosion resistance. Non-magnetic oil drilling components, such as drill collars, stabilizers, and measuring/logging-while-drilling (MWD/LWD) housings, are typically made using Cr-Mn-N austenitic stainless steels. In harsh drilling environments where pitting and stress corrosion cracking are concerns, CarTech 706 alloy has been shown to be superior in laboratory tests.

Corrosion Resistance

Pyromet Alloy 706 has good resistance to oxidation and corrosion over a broad range of temperatures and environments.

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

Nitric Acid	Moderate	Sulfuric Acid	Restricted
Phosphoric Acid	Moderate	Acetic Acid	Good
Sodium Hydroxide	Good	Salt Spray (NaCl)	Excellent
Sea Water	Moderate	Sour Oil/Gas	Good
Humidity	Excellent		

Pitting Corrosion Resistance – Pyromet® Alloy 706

7" (178mm) dia. bar, solution treated and double aged

Alloy	Pitting Potential (mV at current shown)		
	50 micro A/cm²	100 micro A/cm²	200 micro A/cm²
Pyromet Alloy 706	1170	1195	1220
Competitive Cr-Mn-N Stainless	-23	-2	23

Test solution: Nitrogen purged 8% Cl (as NaCl) at room temperature.
Stirred solution at 20–23°C (68–73°F), initial pH of 6.8–7.0, scan rate at 0.1 mV/sec.
Higher potential is indicative of higher pitting resistance.

Stress Corrosion Cracking Resistance – Pyromet® Alloy 706

7" (178mm) dia. bar, solution treated and double aged

Alloy	Tensile Stress		Fracture Time
	ksi	MPa	
Pyromet Alloy 706	120	827	1000 hours - no failure
Competitive Cr-Mn-N Stainless	80	552	215 hours

Test solution: Boiling saturated sodium chloride with 2.5 wt% ammonium bisulfate (simulated drilling fluid). Note that 706 alloy resisted higher stress level.

Properties

Physical Properties

Density		
Age-hardened	0.2920	lb/in³
Annealed	0.2910	lb/in³
Mean Specific Heat	0.1060	Btu/lb/°F
Mean CTE		
77 to 200°F	7.40	x 10⁻⁶ in/in/°F
77 to 400°F	8.07	x 10⁻⁶ in/in/°F
77 to 600°F	8.42	x 10⁻⁶ in/in/°F
77 to 800°F	8.57	x 10⁻⁶ in/in/°F
77 to 1000°F	8.73	x 10⁻⁶ in/in/°F
77 to 1200°F	8.97	x 10⁻⁶ in/in/°F
77 to 1300°F	9.11	x 10⁻⁶ in/in/°F
Thermal Conductivity	87.00	BTU-in/hr/ft²/°F
Poisson's Ratio	0.382	
Modulus of Elasticity (E)	30.4	x 10³ ksi
Electrical Resistivity	592.0	ohm-cir-mil/ft
Curie Temperature	< -100	°F
Melting Range	2440 to 2500	°F

Magnetic Properties

Magnetic Permeability (200 Oe)	1.0100 Mu

Typical Mechanical Properties

Charpy V-Notch Impact Strength - Pyromet® Alloy 706

Averages of three tests at 70°F

Size		Location	Orientation	Charpy V-Notch Impact Strength	
in.	mm			ft-lb	J
0.75 square	19	Center	Longitudinal	75	102
3.5 dia.	89	Center	Longitudinal	69	94
		Center	Transverse	45	61
		Mid-Radius	Longitudinal	67	91
		Mid-Radius	Transverse	53	72
7.0 dia.	178	Center	Longitudinal	65	88
		Center	Transverse	45	61
		Mid-Radius	Longitudinal	64	87
		Mid-Radius	Transverse	46	62

Heat treatment: Solution treated 1800°F (982°C) 1 hour, air cooled, aged 1350°F (732°C) 8 hours, furnace cooled to 1150°F (621°C) 8 hours, air cooled.

Effect of Heat Treatment on Tensile Properties - Pyromet® Alloy 706 Forged Bar

Mid-Radius of bar - longitudinal

Heat Treatment	Test Temperature	0.2% Yield Strength		Tensile Strength		% Elongation	% Reduction of Area
		ksi	MPa	ksi	MPa		
3.5 in. (89 mm) Diameter Round							
A	70°F	160	1103	189	1303	23	49
A	1200°F	125	862	148	1020	25	52
B	70°F	158	1089	193	1331	16	28
B	1200°F	118	814	149	1027	22	53
7.0 in. (178 mm) Diameter Round							
Solution Treated	70°F	38	262	101	696	57	76
A	70°F	157	1083	188	1296	26	53
A	1200°F	123	848	146	1007	25	54
B	70°F	156	1076	189	1303	16	29
B	1200°F	125	862	146	1007	22	57

Heat Treatment:

A - Solution treated 1800°F/1hr/AC + Aged 1350°F/8hr/FC to 1150°F/8hr/AC

B - Solution treated 1800°F/1hr/AC + Aged 1550°F/3hr/AC + 1325°F/8hr/FC to 1150°F/8hr/AC

Elevated Temperature Tensile Properties – Pyromet® Alloy 706

Mid-Radius of 7 in. (178 mm) diameter bar - longitudinal

Test Temperature		0.2% Yield Strength		Tensile Strength		% Elong.	% Reduction of Area
°F	°C	ksi	MPa	ksi	MPa		
70	21	157	1083	188	1296	26	53
350	177	147	1014	178	1227	20	52
500	260	140	965	172	1186	20	53
1000	538	130	896	157	1083	21	56
1200	649	123	848	146	1007	25	54

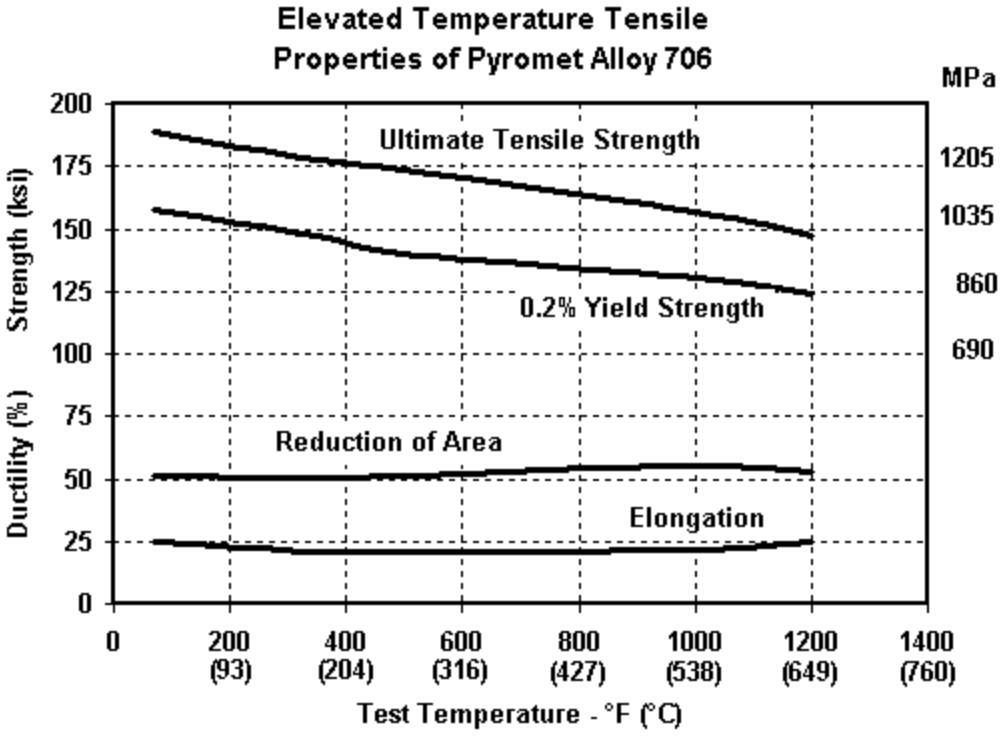
Heat Treatment: Solution treated 1800°F/1hr/AC + Aged 1350°F/8hr/FC to 1150°F/8hr/AC

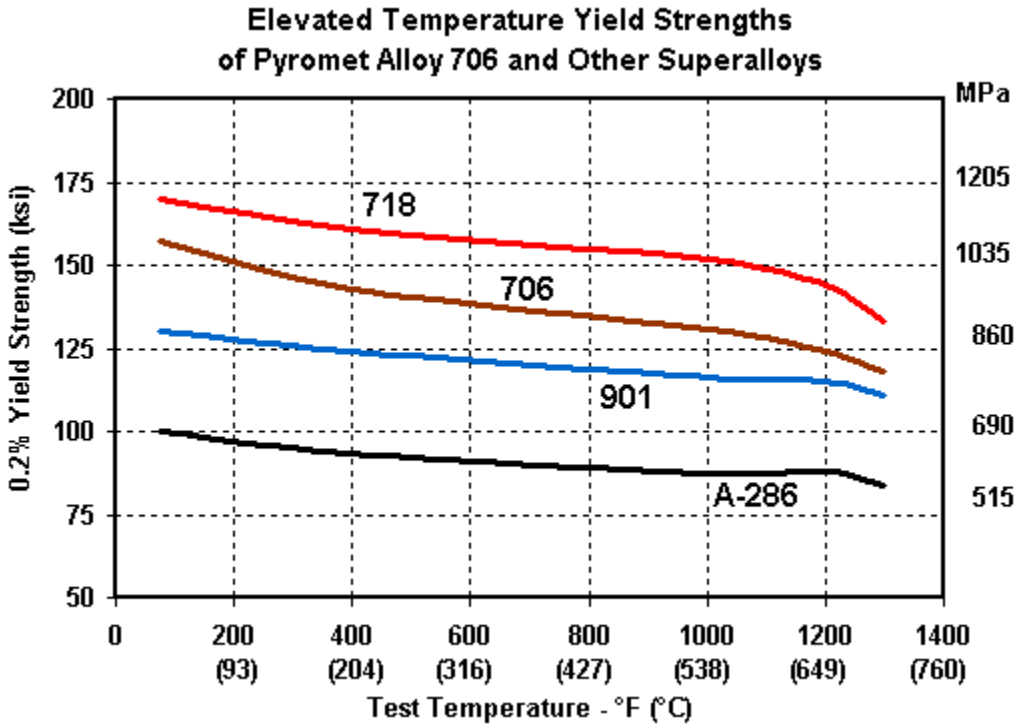
Elevated Temperature Tensile Properties – Pyromet® Alloy 706

Mid-Radius of 3.5" (89 mm) diameter bar - longitudinal

Test Temperature		0.2% Yield Strength		Tensile Strength		% Elong.	% Reduction of Area
°F	°C	ksi	MPa	ksi	MPa		
70	21	160	1103	189	1303	23	49
350	177	147	1014	178	1227	22	49
500	260	140	965	175	1207	22	49
1000	538	131	903	157	1083	22	54
1200	649	125	862	148	1020	25	52

Heat Treatment: Solution treated 1800°F/1hr/AC + Aged 1350°F/8hr/FC to 1150°F/8hr/AC





Room Temperature Tensile Properties – Pyromet® Alloy 706

Center of bar - longitudinal

Size		0.2% Yield Strength		Tensile Strength		% Elong.	% Reduction of Area
in	mm	ksi	MPa	ksi	MPa		
0.75 sq.	19 sq.	170	1172	200	1379	21	41
3.5 dia.	89 dia.	152	1048	188	1296	21	29
7.0 dia.	178 dia.	150	1034	184	1269	20	27

Heat treatment: Solution treated 1800°F (982°C) 1 hour, air cooled, aged 1350°F (732°C) 8 hours, furnace cooled to 1150°F (621°C) 8 hours, air cooled.

Stress Rupture Properties - Pyromet® Alloy 706

Mid-Radius of 3.5"-7.0" (89-178 mm) diameter bar - longitudinal

Test Temperature		Stress for Rupture			
		100 hours		1000 hours	
°F	°C	ksi	MPa	ksi	MPa
1200	649	104	717	83	572
1300	704	75	517	53	365

Heat Treatment: Solution treated 1800°F/1hr/AC + Aged 1550°F/3hr/AC + 1325°F/8hr/FC to 1150°F/8hr/AC.

Heat Treatment

Heat treatments used for this alloy consist of a solution treating/annealing step followed by a two-step precipitation-hardening (aging) treatment. An intermediate stabilization treatment may also be used to optimize creep-rupture properties.

For optimum creep and rupture properties:
1700-1850°F (925-1010°C) for a time commensurate with thickness, air cool +
1550°F (845°C)/3 hours/air cool + 1325°F (720°C)/8 hours/furnace cool at 100°F (55°C) per hour to 1150°F (620°C)/8 hours/air cool.

For optimum tensile properties:
1700-1850°F (925-1010°C) for a time commensurate with thickness, air cool +

1350°F (730°C)/8 hours/furnace cool at 100°F (55°C) per hour to 1150°F (620°C)/8 hours/air cool.

Size change during aging = 0.09% contraction.

Workability

Hot Working

Pyromet Alloy 706 has better hot workability and lower flow stress than most other superalloys. The hot working temperature range is 1600°F (870°C) to 2100°F (1150°C). Working in the lower portion of the hot working range is not required to obtain mechanical properties.

Cold Working

The cold working characteristics of Pyromet Alloy 706 are similar to those of 300-series stainless steels. In the annealed condition, Pyromet Alloy 706 is softer and easier to deform than Alloy 718 and other superalloys.

Machinability

One of the major advantages of Pyromet Alloy 706 is improved machinability compared to alloy 718 and other age-hardenable superalloys. Higher cutting speeds and longer tool lives are possible. This alloy can be readily machined in either the annealed or the age-hardened condition.

Weldability

Pyromet Alloy 706 has excellent weldability and resistance to post-weld cracking. Welding procedures are the same as those used for Alloy 718.

Other Information

Applicable Specifications

Note: While this material meets the following specifications, it may be capable of meeting or being manufactured to meet other general and customer-specific specifications.

- AMS 5701
- AMS 5702
- AMS 5703

Forms Manufactured

- Bar-Rounds
- Billet
- Ingot
- Strip
- Wire-Rod

Edition Date: 9/1/06

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