Technical Datasheet

CarTech® CTX-1 Alloy

Identification

UNS Number

• N19903

Type Analysis

Single figures are nominal except where noted.

Carbon (Maximum)	0.05 %	**Manganese (Maximum)**	0.50 %
Phosphorus (Maximum)	0.015 %	**Sulfur (Maximum)**	0.015 %
Silicon (Maximum)	0.50 %	**Chromium (Maximum)**	0.50 %
Nickel	38.00 to 40.00 %	**Molybdenum (Maximum)**	0.20 %
Copper (Maximum)	0.50 %	**Cobalt**	14.00 to 16.00 %
Titanium	1.25 to 1.75 %	**Aluminum**	0.70 to 1.20 %
Columbium + Tantalum	2.50 to 3.50 %	**Boron**	0.008 %
Iron	Balance		

General Information

(Pyromet Alloy 903)

Description

CarTech CTX-1 alloy is a precipitation hardenable, high temperature alloy exhibiting a low coefficient of thermal expansion and high strength at temperatures up to about 1200°F (649°C). This alloy also displays high hot hardness and good thermal fatigue resistance.

CarTech CTX-1 alloy develops stress rupture ductility through retained hot-cold work, resulting in directionality of properties.

Although CarTech CTX-1 alloy continues to provide the highest strength levels of the controlled expansion high temperature alloys, later generation alloys, such as CarTech CTX-3 alloy, should be considered for applications involving elevated temperature transverse stress conditions.

CarTech Thermo-Span® alloy should be considered if moderate oxidation resistance is desired.

Applications

CarTech CTX-1 alloy has been specified for applications such as casings, seals, and other gas turbine engine components; in hot work die applications, such as extrusion dies, punches and mandrels; and in high-pressure hydrogen environments.

Other applications have included:
Ordnance hardware
Steam turbine blades
Gauge blocks
Springs
Rocket thrust chambers
Die casting dies

Corrosion Resistance

Pyromet alloy CTX-1 contains only residual levels of chromium in order to achieve the desired expansion properties. As a result, it is readily oxidized and should be coated to prevent oxidation. Chromium plating may be used.

Properties

Physical Properties

Specific Gravity	8.13	
Density	0.2937	lb/in³

Mean CTE		
77 to 400°F	4.19 x 10^{-6}	in/in/°F
77 to 600°F	4.16 x 10^{-6}	in/in/°F
77 to 800°F	4.14 x 10^{-6}	in/in/°F
77 to 1000°F	4.84 x 10^{-6}	in/in/°F
77 to 1200°F	5.56 x 10^{-6}	in/in/°F

Mean coefficient of thermal expansion
Solution treated 1550/1600°F (843/871°C) 1 hr, AC and aged 1325°F (718°C) 8 hr, cooled at 100°F (56°C)/hr to 1150°F (621°C) and held 8 hrs, AC

Temperature Range		Coefficient	
°F	°C	microinches/inch • °F	micrometers/meter • °C
77-400	25-204	4.19	7.54
77-600	25-316	4.16	7.49
77-800*	25-427*	4.14	7.45
77-1000	25-538	4.84	8.71
77-1200	25-649	5.56	10.01

*Inflection temperature is typically 820°F (438°C)

Modulus of Elasticity (E) (77°F)	22.2 x 10^{3}	ksi
Inflection Temperature	820	°F
Melting Range	2400 to 2540	°F

Magnetic Properties

Pyromet alloy CTX-1 is ferromagnetic from below room temperature to approximately 800°F (427°C). Above 800°F (427°C) it is essentially nonmagnetic.

Typical Mechanical Properties

Effect of Solution Treating Temperature on 1150°F (621°C)/110 ksi (758 MPa) Stress Rupture Properties - Pyromet Alloy CTX-1
Combination specimens - 0.178" (4.52 mm) diameter x 0.712" (18.08 mm) long, with notch section K_t 3.8

Solution Treating Temperature		Life hrs	% Elongation in 2" (50.8 mm)	% Reduction of Area
°F	°C			
1550	843	22.6	15.5	54.0
1575	857	158.3	11.7	44.4
1600	871	237.3	14.3	37.3
1625	885	305.3	12.3	30.8
1650	899	4.3	1.4	2.0
1675	913	2.9	1.4	—
1700	927	172.6	1.4	3.2

Effect of Solution Treating Temperature on 1200°F (649°C) Tensile Properties - Pyromet Alloy CTX-1

Solution Treating Temperature		0.2% Yield Strength		Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area
°F	°C	ksi	MPa	ksi	MPa		
1550	843	140.1	966	152.3	1050	26.3	63.6
1575	857	147.2	1015	161.3	1112	20.2	60.0
1600	871	146.5	1010	158.1	1090	22.6	56.8
1625	885	148.1	1021	164.3	1133	22.1	54.5
1650	899	137.3	947	161.5	1114	15.0	22.3
1675	913	132.9	916	158.2	1091	11.6	18.9
1700	927	130.9	903	155.0	1069	10.0	19.7

Effect of Solution Treating Temperature on Room Temperature Tensile Properties - Pyromet Alloy CTX-1

Solution Treating Temperature		0.2% Yield Strength		Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area
°F	°C	ksi	MPa	ksi	MPa		
1575	857	183.4	1264	208.8	1440	13.6	40.8
1600	871	187.1	1290	213.1	1469	13.7	43.0
1625	885	186.4	1285	213.2	1470	14.3	44.5

Elevated Temperature Stress Rupture Properties - Pyromet Alloy CTX-1

Combination specimens - 0.178" (4.52 mm) diameter x 0.712" (18.08 mm) long, with notch section K_t 3.8

Temperature		Stress		Life hrs	% Elongation in 2" (50.8 mm)	% Reduction of Area
°F	°C	ksi	MPa			
1150	621	110	758	320	14	45
1200	649	85	586	570	12	35
1200	649	95	655	285	10	33

Typical Room Temperature and Elevated Temperature Mechanical Properties - Pyromet Alloy CTX-1

All mechanical properties are based on 3/4" (19 mm) square warm worked bars heat treated in the following manner: 1600°F (871°C)/1 hr/AC + 1325°F (718°C)/8 hr/cool 100°F (56°C)/hr to 1150°F (621°C)/8 hr/AC.

Test Temperature		0.2% Yield Strength		Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area
°F	°C	ksi	MPa	ksi	MPa		
70	21	189	1303	216	1489	16	45
1000	538	152	1048	188	1296	14	44
1100	593	145	1000	172	1186	17	49
1200	649	137	945	156	1076	20	53
1300	704	112	772	123	848	26	66
1400	760	86	593	91	627	31	80

Hot-Hardness - Pyromet Alloy CTX-1

Temperature		Rockwell C Hardness
°F	°C	
70	21	45.5
1000	538	39
1100	593	39
1200	649	39
1300	704	34
1400	760	29

Heat Treatment

Warm worked stock is typically treated at 1550/1600°F (843/871°C) for 1 hour and air cooled. Water or oil quenching is suggested for large section sizes. Actual time at temperature is varied according to section size to assure thorough heating.

Age at 1325°F (718°C) for 8 hours, then cool 100°F (56°C) per hour to 1150°F (621 °C) and hold for 8 hours at heat, followed by air cooling.

Workability

Hot Working

The alloy should be hot worked at temperatures starting at approximately 2050°F (1121°C) and finishing slightly below 1600°F (871 °C).

Finishing operations should generally be carried out at temperatures below 1700°F (927°C) and should preferably involve at least 40% reduction over a falling temperature range, with a finishing temperature of less than 1600°F (871°C).

The use of low finishing temperatures provides a deformed grain structure which is required for stress rupture ductility. Workability of the alloy is similar to that of Pyromet alloy 901 or Pyromet alloy A-286.

Machinability

Pyromet alloy CTX-1 can be machined in either the solution treated or the age hardened condition. Machine tools should have ample power and cutting speeds should be slow.

Material in the age hardened condition yields better chip action on chip breaker tools and produces a better finish.

Weldability

Pyromet alloy CTX-1 can be readily joined by the welding processes ordinarily used for high temperature precipitation hardening alloys. It should be noted that the welded areas and the heat-affected zone may exhibit relatively low 1200°F (649°C) tensile and stress-rupture ductility.

Other Information

Forms Manufactured

- Bar-Rounds
- Bar-Shapes
- Billet
- Wire

Technical Articles

- New Requirements for Ferrous-Base Aerospace Alloys
- Trends in High Temperature Alloys

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Edition Date: 02/01/1994

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