

CarTech® 31V Alloy

Identification

UNS Number
• N07032

Type Analysis

Single figures are nominal except where noted.

Carbon	0.04 %	Manganese (Maximum)	0.20 %
Phosphorus (Maximum)	0.015 %	Sulfur (Maximum)	0.010 %
Silicon (Maximum)	0.20 %	Chromium	22.70 %
Nickel	57.00 %	Molybdenum	2.00 %
Titanium	2.30 %	Columbium/Niobium	0.85 %
Aluminum	1.30 %	Boron	0.005 %
Iron	Balance		

General Information

Description

CarTech 31V alloy is a sulfidation and corrosion resistant precipitation hardenable alloy possessing an unusual combination of corrosion resistance and strength to temperatures as high as 1500°F (816°C).

This alloy displays good resistance to hot sulfidizing and oxidizing environments such as those encountered in diesel engine service, as well as sour environments such as those encountered in deep sour gas and oil wells.

Applications

Because of its excellent balance of properties, CarTech 31V alloy has been considered a candidate for many demanding applications, including rapid fire military gun barrels, hardware in coal gasification units and exhaust valves in heavy-duty internal combustion engines.

Corrosion Resistance

Laboratory crucible tests aimed at assessing the capability of Pyromet alloy 31V to withstand high temperature sulfidation attack were carried out in a mixture of 10 CaSO4 - 6 BaSO4 - 2 Na2SO4 - 1 C at 1600°F (871°C) for up to 80 hours. The results shown in the hyperlink titled "Comparative Sulfidation Test Results-Various Alloys" indicate that Pyromet alloy 31V has superior resistance compared to commercial diesel valve alloys like Pyromet alloys 751 and 80A, which suffered catastrophic attack. All three alloys have excellent resistance to hot corrosion by lead oxide at 1675°F (913°C).

In a molten mixture of 90% Na2SO4 / 10% NaCl at 1700°F (927°C) / 100 hours, Pyromet alloy 31V showed only slight attack while alloy 751 suffered catastrophic attack.

Evaluations in both laboratory and field environments have been conducted to establish Pyromet alloy 31V as a candidate for consideration as a sulfide stress cracking resistant material for oil field applications in sour environments.

Comparative tests have shown that Pyromet alloy 31V is superior to Pyromet alloy X-750 (an established alloy for sour service) in the NACE TM-01-77 solution, which consists of an acidified, deoxygenated sour brine solution saturated with hydrogen sulfide.

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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	Excellent	Sulfuric Acid	Good
Phosphoric Acid	Good	Acetic Acid	Good
Sodium Hydroxide	Good	Salt Spray (NaCl)	Excellent
Sea Water	Moderate	Humidity	Excellent

Comparative Sulfidation Test Results—Various Alloys 1600°F (871°C)

Alloy	Duration (hours)	Weight Loss (g/dm ²)
Pyromet 80A	5	1
	30	72
	80	Catastrophic (>100)
Pyromet 751	5	1
	30	58
	80	Catastrophic (>100)
Pyromet 31V	5	0
	30	1
	80	52

Properties

Physical Properties

Density	0.2890 lb/in ³
Mean Specific Heat (70 to 150°F)	0.1200 Btu/lb/°F
Mean CTE	
70 to 300°F	6.17 x 10 ⁻⁶ in/in/°F
70 to 500°F	7.66 x 10 ⁻⁶ in/in/°F
70 to 700°F	7.92 x 10 ⁻⁶ in/in/°F
70 to 900°F	8.09 x 10 ⁻⁶ in/in/°F
70 to 1100°F	8.28 x 10 ⁻⁶ in/in/°F
70 to 1300°F	8.50 x 10 ⁻⁶ in/in/°F
70 to 1500°F	8.96 x 10 ⁻⁶ in/in/°F

Mean coefficient of thermal expansion

Temperature Range		Coefficient	
70°F to	21°C to	10 ⁻⁶ /°F	10 ⁻⁶ /°C
300	149	6.17	11.11
500	260	7.66	13.79
700	371	7.92	14.26
900	482	8.09	14.56
1100	593	8.28	14.90
1300	704	8.50	15.30
1500	816	8.96	16.13

Thermal Conductivity

70 to 212°F	86.73 BTU-in/hr/ft ² /°F
70 to 700°F	115.2 BTU-in/hr/ft ² /°F
70 to 1099°F	137.4 BTU-in/hr/ft ² /°F
70 to 1501°F	161.0 BTU-in/hr/ft ² /°F

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Thermal conductivity

Temperature		Btu•in/ft ² •hr•°F)	W/m•K
70°F to	21°C to		
212	100	87	12.5
700	371	115	16.6
1100	593	138	19.8
1500	816	161	23.2

Modulus of Elasticity (E)

70°F	30.1 x 10 ³ ksi
100°F	30.0 x 10 ³ ksi
200°F	29.5 x 10 ³ ksi
300°F	29.2 x 10 ³ ksi
500°F	28.1 x 10 ³ ksi
700°F	27.1 x 10 ³ ksi
900°F	26.1 x 10 ³ ksi
1100°F	25.0 x 10 ³ ksi
1300°F	23.8 x 10 ³ ksi
1500°F	22.3 x 10 ³ ksi

Modulus of elasticity

Temperature		psi x 10 ⁶	MPa x 10 ³
°F	°C		
70	21	30.08	207
100	38	30.00	207
200	93	29.48	203
300	149	29.23	202
500	260	28.12	194
700	371	27.11	187
900	482	26.08	180
1100	593	25.04	173
1300	704	23.77	164
1500	816	22.32	154

Electrical Resistivity

70°F	734.0 ohm-cir-mil/ft
212°F	758.0 ohm-cir-mil/ft
700°F	800.0 ohm-cir-mil/ft
1099°F	830.0 ohm-cir-mil/ft
1501°F	842.0 ohm-cir-mil/ft

Electrical resistivity

Temperature		ohm-cir/mil ft	microhm-mm
°F	°C		
70	21	734	1220
212	100	758	1260
700	371	800	1330
1100	593	830	1380
1500	816	842	1400

Melting Range

2250 to 2420 °F

Magnetic Properties

Magnetic Permeability (Solution Treated and Aged)

1.0016 Mu

Typical Mechanical Properties

Elevated Temperature Creep Strength—Pyromet Alloy 31V

Heat treated 2050°F (1121°C) 1 hour, air cooled + 1550°F (843°C) 4 hours, air cooled + 1350°F (732°C) 4 hours, air cooled.

Test Temperature		Stress to Produce 1% Total Creep in 100 Hours	
°F	°C	ksi	MPa
1200	649	65	448
1350	732	40	276
1400	760	35	241

Elevated Temperature Stress Rupture Strength—Pyromet Alloy 31V

Heat treated 2050°F (1121°C) 1 hour, air cooled + 1550°F (843°C) 4 hours, air cooled + 1350°F (732°C) 4 hours, air cooled.

Test Temperature		Stress for Rupture in:					
		10 Hours		100 Hours		1000 Hours	
°F	°C	ksi	MPa	ksi	MPa	ksi	MPa
1200	649	100	690	85	586	68	469
1350	732	70	483	52	359	38	262
1500	816	40	276	27	186	17	117

Rotating Beam Fatigue Properties at 1400°F (760°C)—Pyromet Alloy 31V

Heat treated 2000°F (1093°C) 4 hours, air cooled + 1600°F (871°C) 4 hours, air cooled + 1350°F (732°C) 4 hours, air cooled.

Stress for Fracture in 10 ⁶ Cycles			
As Heat Treated		Exposed 1350°F (732°C) for 1500 Hours	
ksi	MPa	ksi	MPa
42	288	47	322

Typical Room and Elevated Temperature Mechanical Properties—Pyromet Alloy 31V

0.75" (19 mm) round bar

Heat Treatment*	Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 4D	% Reduction of Area
	°F	°C	ksi	MPa	ksi	MPa		
1	70	21	105	724	176	1214	25.0	27.4
2	70	21	100	690	166	1145	33.9	36.5
3	70	21	122	841	181	1248	30.0	38.5
1	1000	538	95	655	157	1083	19.2	30.6
2	1000	538	91	627	141	972	31.4	45.2
3	1000	538	108	745	155	1069	25.1	45.6
1	1200	649	94	648	153	1055	20.0	29.3
2	1200	649	92	634	139	958	22.8	33.7
3	1200	649	111	765	152	1048	18.5	25.2
1	1400	760	95	655	110	758	25.0	33.4
2	1400	760	82	565	112	772	23.8	25.2
1	1500	816	84	579	86	593	28.4	37.1
2	1500	816	79	544	94	648	24.6	30.6

*Heat Treatment

- 1 - 2050°F (1121°C) 1 hour, air cooled + 1550°F (843°C) 4 hours, air cooled + 1350°F (732°C) 4 hours, air cooled
- 2 - 2050°F (1121°C) 1 hour, air cooled + 1300°F (704°C) 24 hours, air cooled
- 3 - 1875°F (1024°C) 1 hour, oil quenched + 1300°F (704°C) 24 hours, air cooled

Heat Treatment

Pyromet alloy 31V is strengthened by solid solution strengthening and by controlled precipitation of gamma prime phase of general composition Ni₃ (Al, Ti, Cb). The optimum heat treatment for Pyromet alloy 31V varies with property requirements.

For a good combination of ambient and elevated temperature properties up to 1500°F (816°C), stock is solution treated in the range 1950/2050°F (1065/1120°C) for 0.5 to 4 hours and air cooled.

Solution Treatment

A lower solution temperature, 1875°F (1025°C), will result in somewhat finer grain size and is sometimes employed to optimize properties below 1200°F (649°C).

Note: For lower temperature service, another version of this alloy, Pyromet alloy 31 which was specifically designed to resist sulfide-containing environments, should be considered.

Age

Solution treated stock may be given a single or double age for optimum compatibility with manufacturing processes. The single-age cycle is 1300°F (704°C) for 24 hours, followed by an air cool. The double-age cycle includes a stabilizing age in the range from 1550/1600°F (843/871°C) for four hours, air cool, plus a final age at 1350°F (732°C) for four hours, air cool.

Workability

Hot Working

Pyromet alloy 31V can be hot worked within the temperature range of 1800/2100°F (980°/1150°C). Careful control of the forging temperature and frictional heat build-up should be maintained.

Large amounts of deformation below 1800°F (980°C) should be avoided.

Forgings may be air or fan cooled. Water quenching should be avoided, especially for large sections.

Machinability

The machinability of this alloy is similar to other iron-nickel base precipitation hardened alloys, such as Pyromet alloy X-750.

The alloy can be machined in either the solution annealed or age hardened condition. Machine tools should have ample power, and cutting speeds should be slow.

For better chip action on chip breakers and an improved finish, use material in the age hardened condition.

Weldability

Pyromet alloy 31V can be readily joined by the welding processes ordinarily used for high temperature precipitation hardening alloys.

For best results, the alloys should be in the solution annealed condition prior to welding and should be reannealed after welding. Matching filler metal should be used, if required.

The solution anneal plus age heat treatment procedures as described above are preferred for postweld heat treatment of welded structures.

Other Information

Forms Manufactured

- Bar-Rounds
- Billet

Technical Articles

- [A Designer's Manual On Specialty Alloys For Critical Automotive Components](#)

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