Technical Datasheet

CarTech® A-286 Alloy

Identification

UNS Number

• S66286

AISI Number

• No. 660

DIN Number

• 1.4980

Type Analysis

Single figures are nominal except where noted.

Carbon (Maximum)	0.08 %	**Manganese (Maximum)**	2.00 %
Silicon (Maximum)	1.00 %	**Chromium**	13.50 to 16.00 %
Nickel	24.00 to 27.00 %	**Molybdenum**	1.00 to 1.50 %
Titanium	1.90 to 2.30 %	**Aluminum (Maximum)**	0.35 %
Vanadium	0.10 to 0.50 %	**Boron**	0.003 to 0.010 %
Iron	Balance		

General Information

Description

CarTech A-286 alloy is designed for applications requiring high strength and good corrosion resistance at temperatures up to 1300°F (704°C).

This alloy offers high ductility in notched sections. In fact, the notched rupture strength of CarTech A-286 is superior to many other commercial alloys with comparable high temperature properties.

An advantage of this alloy is that it can be precipitation hardened and strengthened by heat treatment. This makes possible a high degree of uniformity in developing maximum strength, which can be duplicated application after application.

Applications

CarTech A-286 alloy has been used in jet engines, superchargers and various high temperature applications such as turbine wheels and blades, frames, casings, afterburner parts and fasteners.

Corrosion Resistance

The corrosion resistance of this alloy is excellent up to 1300°F (704°C) against many atmospheres encountered in jet engine service. Up to 1500°F (816°C), the oxidation resistance of Pyromet alloy A-286 is similar to that of Type 310 stainless.

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

Properties

Physical Properties

Density	0.2860	lb/in³

Mean Specific Heat (104 to 1299°F)	0.1100	Btu/lb/°F
Mean CTE		
200°F	9.17	x 10 $^{-6}$ in/in/°F
400°F	9.35	x 10 $^{-6}$ in/in/°F
600°F	9.47	x 10 $^{-6}$ in/in/°F
800°F	9.64	x 10 $^{-6}$ in/in/°F
1000°F	9.78	x 10 $^{-6}$ in/in/°F
1200°F	9.88	x 10 $^{-6}$ in/in/°F
1300°F	9.94	x 10 $^{-6}$ in/in/°F
1400°F	10.3	x 10 $^{-6}$ in/in/°F

Mean coefficient of thermal expansion

Temperature		Coefficient	
°F	°C	10^{-6}/°F	10^{-6}/°C
200	93	9.17	16.5
400	204	9.35	16.8
600	316	9.47	17.0
800	427	9.64	17.4
1000	538	9.78	17.6
1200	649	9.88	17.8
1300	704	9.94	17.9
1400	760	10.32	18.6

Thermal Conductivity		
302°F	104.2	BTU-in/hr/ft²/°F
1112°F	165.0	BTU-in/hr/ft²/°F
Modulus of Elasticity (E)		
70°F	28.8	x 10 ^{3} ksi
1000°F	23.7	x 10 ^{3} ksi
1100°F	22.8	x 10 ^{3} ksi
1200°F	21.9	x 10 ^{3} ksi
1300°F	21.1	x 10 ^{3} ksi
1400°F	20.1	x 10 ^{3} ksi
1500°F	18.7	x 10 ^{3} ksi

Modulus of elasticity

Temperature		psi x 10^{6}	MPa x 10^{3}
°F	°C		
70	21.1	28.8	199
1000	538	23.7	163
1100	593	22.8	157
1200	649	21.9	151
1300	704	21.1	145
1400	760	20.1	139
1500	816	18.7	129

Electrical Resistivity		
87°F	545.0	ohm-cir-mil/ft
1000°F	692.0	ohm-cir-mil/ft
1200°F	712.0	ohm-cir-mil/ft
1350°F	719.0	ohm-cir-mil/ft
1500°F	732.0	ohm-cir-mil/ft
Melting Range	2500 to 2600	°F

Magnetic Properties

Magnetic Permeability		
Solution Treated	1.0100	Mu
Solution Treated and Aged	1.0070	Mu

Typical Mechanical Properties

Creep Strength—Pyromet Alloy A-286

Test Temperature		Stress for Creep of							
		0.5% in 100 Hours		1.0% in 100 Hours		0.5% in 1000 Hours		1.0% in 1000 Hours	
°F	°C	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
1000	538	81	558	92	634	78	538	85	586
1100	593	76	524	80	552	68	469	70	483
1200	649	53	365	60	414	35	241	41	283
1300	704	30	207	35.5	245	—	—	—	—

Stress Rupture Properties—Pyromet Alloy A-286

Solution treated 1800°F (982°C), 1 hour, oil quenched, aged 1325°F (718°C), 16 hours, air cooled

Test Temperature		Stress for Rupture			Stress for Rupture		
		100 Hours		% Elongation in 4D	1000 Hours		% Elongation in 4D
°F	°C	ksi	MPa		ksi	MPa	
1000	538	99	683	3.0	88	607	3.0
1100	593	81.5	562	3.0	71.5	493	3.0
1200	649	61*	421	5.0	46***	317	8.5
1300	704	44.5	307	12.0	29	200	30.0
1350	732	35**	241	29.0	21	145	35.0
1500	816	13	90	55.0	7.7	53	—

Note: Comparative values for 1650°F (899°C), 1 hour, oil quenched and 1325°F (718°C), 16 hours, air cooled

*53 ksi
**32 ksi
***39 ksi

Tensile Properties—Pyromet Alloy A-286

Tests on 7/8" (22.2 mm) diameter bar stock solution treated to 1800°F (982°C), 1 hour, oil quenched, aged 1325°F (719°C), 16 hours, air cooled

Test Temperature		0.02% Offset Yield Strength		0.2% Offset Yield Strength		Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area
°F	°C	ksi	MPa	ksi	MPa	ksi	MPa		
70	21.1	90	621	95	655	145	1000	24.0	45.0
400	204	76	524	93.5	645	143	986	21.5	52.0
800	427	72	496	93	641	138	951	18.5	35.0
1000	538	62	427	87.5	603	131	903	18.5	31.0
1100	593	64.5	445	90	621	122	841	21.0	23.0
1200	649	62.5	431	88	607	103.5	714	13.0	14.5
1300	704	68.5	472	86	593	86.5	596	11.0	10.0
1400	760	44.5	307	62	427	64	441	18.5	23.0
1500	816	31	214	33	228	36.5	252	68.5	37.5

Note: Approximately 10 ksi higher strength and increased elongation may be obtained with 1650°F (899°C) solution treatment and 1325°F (718°C) age

Typical Values Hot Hardness Data—Pyromet Alloy A-286

Test Temperature		Rockwell C Hardness	Ultimate Tensile Strength		0.2% Yield Strength	
°F	°C		ksi	MPa	ksi	MPa
Room Temperature		30/35	155	1069	100	689
1000	538	32/33	131	903	87	600
1100	593	29/30	122	841	90	621
1200	649	28/29	103	710	88	607
1300	704	26/27	86	593	86	593
1400	760	18/20	64	441	62	427
1500	816	10/15	36	248	33	228

V-Notch Charpy Impact Strength—Pyromet Alloy A-286

Test Temperature		ft-lb	J
°F	°C		
-310	-190	57.0	77.3
-100	-73	68.0	92.2
70	21.1	64.0	86.8
400	204	59.0	80.0
800	427	51.5	69.8
1000	538	45.5	61.7
1100	593	44.0	59.7
1200	649	35.0	47.5
1300	704	44.0	59.7

Heat Treatment

Solution Treatment

Two methods of heat treatment are suggested for this alloy:

1. Heat to 1800°F (982°C), hold 1 hour at heat, then cool rapidly.

2. Heat to 1650°F (899°C), hold 2 hours at heat, then cool rapidly.

The first solution treatment method results in increased rupture strength after aging, while the second results in better ductility and higher hardness.

Age

Heat to 1300/1400°F (704/760°C), hold 12 to 16 hours at heat, then air cool. Hardness is approximately 300 BHN.

A two cycle precipitation hardening treatment is occasionally specified after solution treatment at 1650°F (899°C). This treatment of 1300/1400°F (704/760°C), hold at heat for 16 hours, then air cool plus 1200°F (649°C), hold at heat for 8 to 12 hours, then air cool is intended to improve notch rupture strength while gaining the ductility and hardness advantages of a 1650°F (899°C) solution treatment.

Size Change Upon Aging - Contraction 0.001 in/in.

Workability

Hot Working

Pyromet alloy A-286 is rolled or forged from temperatures of 1900/2050°F (1038/1121°C) using a short soaking period. It is slightly more resistant to deformation than the austenitic stainless steels during hot working. Do not forge below 1700°F (927°C).

Cold Working

In the solution treated condition, Pyromet alloy A-286 can be satisfactorily cold drawn and formed. It is somewhat stiffer than stainless steels such as Types 316 and 310, and it work hardens rapidly.

Machinability

In general, the high temperature alloys are more difficult to machine than stainless steels. However, the iron-base alloy group, of which Pyromet alloy A-286 is a member, is easier to machine than the nickel-base precipitation-hardening grades such as Pyromet alloy 718 or cobalt-bearing grades such as Pyromet alloy 41. Carbide insert tools are commonly used where possible.

Following are typical feeds and speeds for Pyromet Alloy A-286.

Turning—Single Point and Box Tools

Condition	Depth of Cut, In.	High Speed Tools			Carbide Tools			
		Speed, fpm	Feed, ipr	Tool Mtl.	Speed, fpm		Feed, ipr	Tool Mtl.
					Brazed	Throw Away		
Solution Treated	.100	35	.015	M-42	135	160	.015	C-2
	.025	40	.007		160	190	.007	C-3
Aged	.100	30	.010		120	140	.010	C-2
	.025	35	.007		140	165	.007	C-3

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	25	.002	.004	.005	.003	.002	.002	.001	M-42
	95	.003	.005	.007	.004	.003	.003	.002	C-2
Aged	20	.002	.004	.005	.003	.002	.002	.001	M-42
	80	.003	.005	.007	.004	.003	.002	.0015	C-2

Drilling

Condition	Speed, fpm	Feed, ipr								Tool Mtl.
		Nominal Hole Diameter, Inches								
		1/16	1/8	1/4	1/2	3/4	1	1-1/2	2	
Solution Treated	25	—	.002	.004	.006	.008	.010	—	—	M-42
Aged	20	—	.002	.004	.006	.008	.008	—	—	

Reaming

Condition	High Speed Tools							Carbide Tools	
	Speed, fpm	Feed, Inches per Rev.						Tool Mtl.	Speed, fpm	Tool Mtl.
		Reamer Diameter, Inches								
		1/8	1/4	1/2	1	1-1/2	2			
Solution Treated	30	.003	.006	.010	.012	.014	.016	M-42	100	C-2
Aged	25	.003	.006	.010	.012	.014	.016	M-42	80	

Die Threading

Condition	Speed, fpm				Tool Mtl.
	7 or Less	8 to 15	16 to 24	25 and up T.P.I.	
Annealed	4-6	5-8	6-10	8-12	M-2; M-7; M-10
Aged	3-4	3-5	4-8	5-10	M-42

Tapping

Condition	Speed, fpm	Tool Mtl.
Solution Treated	10	M-1; M-7; M-10
Aged	7	M-1; M-7; M-10; Nitrided

Milling—End-Peripheral

Condition	Depth of Cut, In.	High Speed Tools						Carbide Tools					
		Speed, fpm	Feed—Inches per Tooth, Cutter Diameter, Inches				Tool Mtl.	Speed, fpm	Feed—Inches per Tooth, Cutter Diameter, Inches				Tool Mtl.
			1/4	1/2	3/4	1-2			1/4	1/2	3/4	1-2	
Solution Treated	.050	30	.002	.002	.003	.004	M-42	120	.001	.002	.003	.004	C-2
Aged		20	.002	.002	.003	.004		80	.001	.002	.003	.004	

Broaching

Condition	Speed, fpm	Chip Load, Inches per Tooth	Tool Mtl.
Solution Treated	12	.002	M-42
Aged	10	.002	

Figures used for all metal removal operations 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 increments.

Additional Machinability Notes

Figures used for all metal removal operations 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 increments.

Weldability

Pyromet alloy A-286 is prone to heat affected zone cracking when welded with any of the fusion processes. If welding is absolutely necessary, consideration should be given to using JBK-75 alloy instead of Pyromet A-286 for the components to be welded.

Other Information

Applicable Specifications

Bars and Forgings-
AMS 5731
AMS 5732
AMS 5734
AMS 5735
AMS 5736
AMS 5737
ASTM A 638
PWA 1029
GE B50T1181
GE B50T81
GE C50TF78
GE C50TF27
GE C50TF20

Strip-
AMS 5525

- AMS 5525 (Strip)
- AMS 5732
- AMS 5735
- AMS 5737
- ASTM A453
- MR0175
- AMS 5731
- AMS 5734
- AMS 5736
- AMS 5895
- ASTM A638

Forms Manufactured

- Bar-Flats
- Bar-Rounds
- Billet
- Wire
- Bar-Hexagons
- Bar-Shapes
- Strip

Technical Articles

- A Designer's Manual On Specialty Alloys For Critical Automotive Components
- A Guide to Etching Specialty Alloys for Microstructural Evaluation
- Alloy Selection for Cold Forming (Part I)
- Alloy Selection for Cold Forming (Part II)
- Carpenter 286-LNi Alloy - A Lower Cost Option for High Temperature Auto and Truck Fasteners
- How to Select the Right Stainless Steel or High Temperature Alloy for Heading
- Machining Stainless Steel - Ideas for Improving Machinability, Productivity and Profitability
- New Engineering University Research Study Simplifies Selection of Coatings for Cold Heading
- New Stainless for Fasteners Combines Corrosion Resistance, High Hardness and Cold Formability
- Selecting High Temperature Alloys for Fasteners in Automotive Exhaust Systems
- Selection of Age-Hardenable Superalloys

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