Technical Datasheet

CarTech® 41 Alloy

Identification

UNS Number
- N07041

AISI Number
- 683

Type Analysis

Single figures are nominal except where noted.

Carbon	0.06 to 0.12 %	**Manganese (Maximum)**	0.10 %
Silicon (Maximum)	0.20 %	**Chromium**	18.00 to 20.00 %
Nickel	Balance	**Molybdenum**	9.00 to 10.50 %
Cobalt	10.00 to 12.00 %	**Titanium**	3.00 to 3.30 %
Aluminum	1.40 to 1.60 %	**Boron**	0.003 to 0.010 %
Iron (Maximum)	5.00 %		

General Information

Description

CarTech 41 alloy is a precipitation hardening, nickel-base high temperature alloy possessing high strength in the 1200/1800°F (649/982°C) temperature range. This alloy is designed for use in severely stressed high temperature applications.

Applications

CarTech 41 alloy has found applications in jet engine and high speed airframe components such as:

Afterburner parts
Turbine casings
Wheels
Buckets
Bolts
Fasteners

Corrosion Resistance

Pyromet alloy 41 is highly corrosion and oxidation resistant. It provides very good resistance to jet engine combustion gases up to 1800°F (982°C).

Properties

Physical Properties

Density	0.2980	lb/in³
Mean Specific Heat (70 to 600°F)	0.1080	Btu/lb/°F
Mean CTE		
70 to 200°F	6.70	x 10^{-6} in/in/°F
70 to 600°F	7.00	x 10^{-6} in/in/°F
70 to 1000°F	7.50	x 10^{-6} in/in/°F
70 to 1200°F	7.80	x 10^{-6} in/in/°F
70 to 1400°F	8.20	x 10^{-6} in/in/°F
70 to 1600°F	8.80	x 10^{-6} in/in/°F
70 to 1800°F	9.30	x 10^{-6} in/in/°F
70 to 2000°F	9.90	x 10^{-6} in/in/°F

Mean coefficient of thermal expansion

Temperature		10^{-6}/°F	10^{-6}/°C
70°F to	21°C to		
200	93	6.7	12.1
600	316	7.0	12.6
1000	538	7.5	13.5
1200	649	7.8	14.0
1400	760	8.2	14.8
1600	871	8.8	15.8
1800	982	9.3	16.7
2000	1093	9.9	17.8

Thermal Conductivity

300°F	80.00	BTU-in/hr/ft^2/°F
600°F	102.0	BTU-in/hr/ft^2/°F
1000°F	131.0	BTU-in/hr/ft^2/°F
1200°F	146.0	BTU-in/hr/ft^2/°F
1400°F	161.0	BTU-in/hr/ft^2/°F
1600°F	175.0	BTU-in/hr/ft^2/°F

Thermal conductivity

Temperature		Btu-in/ft^2 • hr • °F	W/m • K
°F	°C		
300	149	80	11.5
600	316	102	14.7
1000	538	131	18.9
1200	649	146	21.1
1400	760	161	23.2
1600	871	175	25.2

Modulus of Elasticity (E)

80°F	31.6	x 10^3 ksi
200°F	31.0	x 10^3 ksi
600°F	29.3	x 10^3 ksi
1000°F	27.3	x 10^3 ksi
1200°F	26.0	x 10^3 ksi
1400°F	24.8	x 10^3 ksi
1600°F	23.2	x 10^3 ksi

Modulus of elasticity

Temperature		ksi x 10^3	MPa x 10^3
°F	°C		
80	27	31.6	218
200	93	31.0	214
600	316	29.3	202
1000	538	27.3	188
1200	649	26.0	179
1400	760	24.8	171
1600	871	23.2	160

Electrical resistivity

Condition	0.075" (1.91 mm) strip at 68°F (20°C)	
	ohms c/mf	microhm-mm
A. Hot rolled	787.1	1310
B. A plus 1950°F (1066°C), 4 hrs., AC	751.6	1250
C. B plus 1400°F (760°C), 16 hrs., AC	761.4	1270
D. A plus 2150°F (1177°C), 30 min., AC	803.0	1330
E. D plus 1650°F (899°C), 4 hrs., AC	807.2	1340

Melting Range 2400 to 2500 °F

Typical Mechanical Properties

Elevated Temperature Creep Strength

Test Temperature		Stress to Produce 0.2% Plastic Creep:			
		100 hours		1000 hours	
°F	°C	ksi	MPa	ksi	MPa
1200	649	92	634	76	524
1350	732	56	386	34	234
1500	816	18.5	128	—	—

Elevated Temperature Stress Rupture Properties

Test Temperature		Stress for Rupture in:					
		10 hours		100 hours		1000 hours	
°F	°C	ksi	MPa	ksi	MPa	ksi	MPa
1200	649	—	—	—	—	100	689
1300	704	—	—	96	662	74	510
1400	760	90	621	64	441	40	276
1500	816	60	414	38	262	24	165
1600	871	37	255	23	159	14	97
1700	927	23	189	12	83	—	—

Typical Mechanical Properties — Pyromet Alloy 41

The following charts report mechanical properties from material solution treated 1950°F (1066°C), 4 hours, air cooled and aged 1400°F (760°C), 16 hours, air cooled.

Room and Elevated Temperature Tensile Properties

Test Temperature		0.2% Yield Strength		Tensile Strength		% Elongation in 2" (50.8 mm)
°F	°C	ksi	MPa	ksi	MPa	
70	21	154	1062	206	1420	14
1000	538	147	1014	203	1400	14
1100	593	146	1007	200	1379	14
1200	649	145	1000	194	1338	14
1400	760	136	938	160	1103	11
1500	816	118	814	126	869	14
1600	871	80	552	90	621	19
1700	927	50	345	58	400	26

Heat Treatment

Solution Temperatures

Gamma prime

solvus temp .... 1960/1980°F (1071/1082°C)
M6C carbide .... 2100°F (1149°C) and higher
M23C6 carbide .. .... 1800°F (982°C) and higher

Grain growth will be encountered at temperatures above gamma prime solvus temperatures. If fine grain size and best tensile ductility are desired, the solution treatment should be executed in the range of 1900/1925°F (1038/1052°C), hold 4 hours at temperature, then air cool.

Stress rupture properties may be improved if a temperature "above solvus" is employed - 1975°F (1080°C), hold 1 hour, then air cool.

In general, high temperature treatments should be avoided.

If the M6C carbide, normally present in this alloy, is solutioned by treating above 2100°F (1149°C), it will precipitate during cooling or aging as M23C6, a continuous grain boundary film which results in low ductility. Resolutioning - at least 1800°F (982°C) and preferably 1900°F (1038°C) - is required to restore ductility by reforming M6C.

Precipitation Hardening Treatment

Heat to 1400°F (760°C), hold at heat for 16 hours, then air cool. Hardness will be in the Rockwell C 40/45 range.

Annealing

Lowest hardness is obtained by quenching from temperatures above the gamma prime solvus temperature - 1950°F (1066°C) is usually satisfactory. Hardness will be in the Rockwell B 98/C 30 range, depending on the rapidity of the quench. It is unlikely that large sections can be quenched rapidly enough to obtain low hardnesses.

In some cases it may be desirable to anneal at lower temperatures, but preferably not lower than 1800°F (982°C).

Workability

Hot Working

Pyromet alloy 41 is best forged between an initial furnace temperature of 2100°F (1149°C) and an optical finishing temperature of 1850/1900°F (1010/1038°C).

Cold Working

Pyromet alloy 41 work hardens rapidly; frequent anneals will be required.

Aging after cold working can result in strain age cracking.

Cold worked sections must be heated rapidly through the aging temperature range, 1200/1700°F (649/927°C), to the solution or annealing temperature to prevent strain age cracking.

A sizable amount of cold reduction between anneals is mandatory. Small reductions, such as sizing passes, must be avoided.

Machinability

Pyromet alloy 41 is difficult to machine. Tungsten carbide tools are recommended. Suggested tool geometry, speeds and feeds are as follows:

0° back rake
6° side rake
7° clearance end and side
10° end cutting edge angle
45° side cutting edge angle
1 /16" (1.59 mm) nose radius

The following parameters have been found satisfactory:

Feed---0.005/0.011" (0.13/0.28 mm) per revolution
Depth of cut---1/32-1/8" (0.79/3.18 mm)

Speeds---30/60 ft. per minute (0.15/0.30 m/s)

Machined finishes are generally better when the alloy is in the fully treated or partially aged condition. Air cooling from the solution or annealing treatment is adequate.

If solution treating is required after finish machining, treating in a protective atmosphere to prevent intergranular surface oxidation is suggested.

Surface oxidation is minor at aging temperatures; thus, machining followed by aging may be useful for some applications.

CAUTION:

Aging will result in a size change (contraction) of about 0.0013 inch per inch if the stock is quenched from the prior solution treatment.

The following charts include typical machining parameters used to machine Pyromet alloy 41. The data listed should be used as a guide for initial machine setup only.

Turning—Single-Point and Box Tools

Condition	Depth of Cut, In.	High-Speed Tools			Carbide			
		Speed, fpm	Feed, ipr	Tool Material	Speed, fpm		Feed, ipr	Tool Material
					Brazed	Throw Away		
Solution Treated	.100	12	.010	M-42	60	70	.010	C-2
	.025	15	.005	M-47	70	80	.007	C-3

Turning—Cut-Off and Form Tools

Condition	Speed, fpm	Feed, ipr							Tool Material
		Cut-Off Tool Width, Inches			Form Tool Width, Inches				
		1/16	1/8	1/4	1/2	1	1-1/2	2	
Solution Treated	10	.002	.004	.005	.004	.003	.002	.001	M-42
	45	.003	.0045	.006	.004	.003	.0025	.0015	C-2

Drilling

Condition	Speed, fpm	Feed, ipr								Tool Material
		Nominal Hole Diameter, Inches								
		1/16	1/8	1/4	1/2	3/4	1	1-1/2	2	
Solution Treated	15	—	.002	.003	.003	.004	—	—	—	M-42

Tapping

Condition	Speed, fpm	Tool Material
Solution Treated	8	M-1; M-7; M-10; Nitrided

Die Threading

Condition	Speed, fpm				Tool Material
	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

Milling, End-Peripheral

Condition	Depth of Cut, In.	High-Speed Tools						Carbide Tools					
		Speed, fpm	Feed—Inches per Tooth, Cutter Diam. inches				Tool Material	Speed, fpm	Feed—Inches per Tooth, Cutter Diam. inches				Tool Material
			1/4	1/2	3/4	1-2			1/4	1/2	3/4	1-2	
Solution Treated	.050	15	.002	.002	.003	.004	M-42	50	.001	.002	.003	.004	C-2

Broaching

Condition	Speed, fpm	Chip Load, Inches per Tooth	Tool Material
Solution Treated	8	.002	M-42
Aged	6	.002	M-42

Reaming

Condition	High-Speed Tools								Carbide Tools	
	Speed, fpm	Feed, Inches per Rev, Reamer Diam. Inches						Tool Material	Speed, fpm	Tool Material
		1/8	1/4	1/2	1	1-1/2	2			
Solution Treated	15	.002	.004	.006	.008	.010	.012	M-42	60	C-2
Aged	12	.002	.004	.006	.008	.010	.012	M-42	40	C-2

Additional Machinability Notes

Figures used for all metal removal operations covered 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 and feeds should be increased or decreased in small steps.

Weldability

Pyromet alloy 41 can be welded by inert gas-arc methods. The part should be in the solution treated condition, 1950/1975°F (1066/1080°C) for 4 hours, and preferably water quenched.

The alloy should be re-solution treated, preferably 1900/1925°F (1038/1052°C), after welding. In addition, an aging treatment of 1650°F (899°C) for 1 hour, air cool, can be employed prior to the final 1400° (760°C) precipitation hardening treatment to minimize the potential for cracking.

Other Information

Applicable Specifications

- AMS 5712
- AMS 5713
- AMS 5800 (Weld Rod - Chem Only)

Forms Manufactured

- Bar-Rounds
- Billet
- Wire

Technical Articles

- Selection of Age-Hardenable Superalloys
- Trends in High Temperature Alloys

Disclaimer:
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