Technical Datasheet

CarTech® H-46

Type Analysis

Single figures are nominal except where noted.

Carbon	0.15 to 0.20 %	**Manganese**	0.50 to 0.80 %
Silicon	0.20 to 0.60 %	**Chromium**	10.00 to 14.00 %
Nickel	0.30 to 0.60 %	**Molybdenum**	0.50 to 1.00 %
Columbium + Tantalum	0.20 to 0.60 %	**Vanadium**	0.20 to 0.40 %
Nitrogen	0.04 to 0.10 %	**Iron**	Balance

General Information

Description

CarTech H-46 is a martensitic, 12% chromium steel designed primarily for high strength applications in the 900/1200°F (482/649°C) temperature range.

The creep resisting properties of this alloy compare favorably with those of several of the lower grades of austenitic, heat resisting steels in the 1000/1200°F (538/649°C) temperature range.

CarTech H-46 exhibits low thermal expansion properties. This has been a factor for its consideration for use in structural applications where standard austenitic stainless steels have been inadequate due to excessive expansion when heated.

Applications

CarTech H-46 has been used in compressor blades and rotor discs in jet aircraft engines, as well as in other applications requiring high strength in the 900/1200°F (482/649°C) temperature range.

Corrosion Resistance

H-46 exhibits good resistance to scaling and oxidation at temperatures up to 1200°F (649°C). Resistance to nitric and organic acids is very good.

Resistance to pitting by dilute reducing acids is similar to that of Type 410 stainless.

Properties

Physical Properties

Specific Gravity	7.75	
Density	0.2800	lb/in³
Mean Specific Heat	0.1100	Btu/lb/°F
Mean CTE		
70 to 200°F	5.90	x 10^{-6} in/in/°F
70 to 400°F	6.10	x 10^{-6} in/in/°F
70 to 600°F	6.20	x 10^{-6} in/in/°F
70 to 800°F	6.30	x 10^{-6} in/in/°F
70 to 1000°F	6.50	x 10^{-6} in/in/°F
70 to 1100°F	6.60	x 10^{-6} in/in/°F
70 to 1200°F	6.70	x 10^{-6} in/in/°F

Mean coefficient of thermal expansion

Temperature		Coefficient	
70°F to	21°C to	10^{-6}/°F	10^{-6}/°C
200	93	5.9	10.6
400	204	6.1	11.0
600	316	6.2	11.2
800	427	6.3	11.3
1000	538	6.5	11.7
1100	593	6.6	11.9
1200	649	6.7	12.1

Thermal Conductivity (60°F)	166.0	BTU-in/hr/ft²/°F
Modulus of Elasticity (E)	31.3	x 10^{3} ksi
Electrical Resistivity (60°F)	483.5	ohm-cir-mil/ft
Critical Temperature (AC1)	1480	°F
Martensite Start	590	°F
Martensite Finish	340	°F

Typical Mechanical Properties

Elevated Temperature Creep Properties

Creep Strain + Time	Stress to Produce Deformation					
	1000°F (538°C)		1100°F (593°C)		1200°F (649°C)	
	ksi	MPa	ksi	MPa	ksi	MPa
0.1% — 300 Hrs.	29.1	201	20.0	138	11.6	80
0.1% — 1,000 Hrs.	23.8	164	16.2	112	7.5	52
0.1% — 5,000 Hrs.	17.9	123	11.3	78	—	—
0.1% — 10,000 Hrs.	14.8	102	8.3	57	—	—
0.2% — 300 Hrs.	43.2	298	33.7	232	18.7	129
0.2% — 1,000 Hrs.	32.0	221	23.1	159	15.0	103
0.2% — 5,000 Hrs.	21.8	150	15.0	103	5.2	36
0.2% — 10,000 Hrs.	16.2	112	9.2	63	—	—
0.5% — 300 Hrs.	50.5	348	39.0	269	24.0	165
0.5% — 1,000 Hrs.	47.1	325	34.9	241	18.2	125
0.5% — 5,000 Hrs.	32.2	222	20.0	138	6.2	43
0.5% — 10,000 Hrs.	25.5	176	13.1	90	—	—

Elevated Temperature Stress Rupture Properties

2100°F (1149°C) 1 hour, air cooled + 1200°F (649°C) 2 hours, air cooled

Test Temperature		Stress to Produce Rupture in					
		100 hours		1000 hours		10,000 hours	
°F	°C	ksi	MPa	ksi	MPa	ksi	MPa
1000	538	75	517	65	448	49	338
1100	593	55	379	43	296	22	152
1200	649	35	241	25	172	—	—

Elevated Temperature Tensile Properties
2100°F (1149°C) 1 hour, air cooled + 1200°F (649°C) 2 hours, air cooled

Test Temperature		Tensile Strength		Yield Strength 0.2%		Proportional Limit		% Elongation in 2" (50.8 mm)	% Reduction of Area
°F	°C	ksi	MPa	ksi	MPa	ksi	MPa		
Room Temperature		150.7	1039	128	883	89.8	619	20.5	56.5
200	93	144.2	994	124.2	856	89	614	20.4	57.9
300	149	139.3	960	122.1	842	83	572	20.2	57.5
400	204	135	931	118.7	818	76.3	526	19.9	56.2
500	260	131.2	905	113.3	781	75.2	518	19.6	54.8
600	316	127.8	881	107.4	740	74.2	512	19.2	54.1
700	371	126.1	869	104.5	721	70.5	486	18.1	53.9
800	427	122.3	843	103	710	64.4	444	18.2	54.6
900	482	112.8	778	98.3	678	60.8	419	20.7	56.5
1000	538	99.6	687	88	607	53.3	367	25.2	61.7
1100	593	82.7	570	73	503	37.6	259	30.6	70.9
1200	649	60.5	417	56.2	387	11.4	79	30.1	76.2

Heat Treatment

Annealing

Heat to 1550°F (843°C), furnace cool to 1100°F (593°C), then air cool. To subcritical anneal, heat to 1450°F (788°C) 4 hours, then air cool. Alloy structure will be tempered martensite in the hardness range Rockwell C 21/23.

H-46 will also respond to isothermal annealing. Heat to 2100°F (1149°C), cool to 1300/1350°F (704/732°C), hold at this heat for 24 hours, then air cool. Following this type of anneal, the alloy structure will be alpha ferrite plus carbide. Hardness will be Rockwell B 85/90.

After isothermal annealing has been employed, the alloy must be rehardened at a minimum temperature of 1900/1950°F (1038/1066°C), then tempered to develop optimum mechanical properties.

Hardening

Oil quench or air cool from 2100°F (1149°C).

Avoid numerous rehardening treatments in open atmosphere as severe decarburization can result.

During hardening, be certain that the part has cooled to a temperature below the Mf temperature (preferably room temperature) before tempering.

Tempering

Tempering is recommended immediately after the alloy has reached room temperature after hardening treatments.

Typical Hardnesses of H-46
Following 2 hour tempering.
As hot worked or hardened 2100°F (1149°C) 1 hour, air cooled

Tempering Temperature		Rockwell C Hardness
°F	°C	
1000	538	43
1100	593	37
1200	649	34
1300	704	31
1350	732	27
1400	760	23
1450	788	22

Workability

Forging

Large sections should be preheated to 1200/1400°F (649/760°C) or heated slowly in the furnace. Initial forging should be conducted in the 1900/2150°F (1038/1177°C) range. Billets should not be finish forged below 1600/1650°F (871/899°C).

Avoid long heating cycles as this can result in excessive decarburization.

Forgings should be cooled slowly and annealed or tempered as soon as possible after reaching room temperature.

Do not harden without performing an intermediate anneal or preheating in the temperature range 1200/1400°F (649/760°C).

Machinability

Best machining characteristics for H-46 are achieved when the alloy is in the hardened and tempered condition (subcritical anneal). In this condition, its machinability is comparable to that of Type 420 Stainless.

Weldability

With the exception of forge welding, H-46 is weldable by most common welding practices. Generally, gas-tungsten-arc welding offers an advantage over shielded metal arc welding for this material. Preheating to 300/400°F(149/204°C) is recommended.

When the mechanical properties of the weld must approach those of the base metal, a consumable of similar composition is suggested. Post-weld heat treatment will be required in this instance.

When the mechanical properties of the weld are not required to meet those of the base metal, then a consumable such as E/ER 309 or E/ER 310 may be acceptable.

Other Information

Descaling (Cleaning)

Pickle in either a 10% by weight nitric acid solution or a 20% by weight hydrochloric acid solution at 120/140°F (49/60°C).

After pickling, the alloy should be rinsed thoroughly, dipped in a warm acid solution, then rinsed again.

Molten sodium hydride descaling is recommended where available.

Forms Manufactured

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

Technical Articles

- Trends in High Temperature Alloys

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