

CarTech® Pyrowear® Alloy 53

Identification

UNS Number

• K71040

Type Analysis

Single figures are nominal except where noted.

Carbon	0.10 %	Manganese	0.35 %
Silicon	1.00 %	Chromium	1.00 %
Nickel	2.00 %	Molybdenum	3.25 %
Copper	2.00 %	Vanadium	0.10 %
Iron	Balance		

General Information

Description

CarTech Pyrowear alloy 53 is a carburizing steel possessing good temper resistance and high case hot hardness while maintaining high core impact strength and fracture toughness.

Applications

CarTech Pyrowear alloy 53 has been used in gears where temperature resistance is important.

Properties

Physical Properties

Mean CTE

75 to 200°F	6.26 x 10 ⁻⁶ in/in/°F
75 to 300°F	6.46 x 10 ⁻⁶ in/in/°F
75 to 400°F	6.59 x 10 ⁻⁶ in/in/°F
75 to 500°F	6.70 x 10 ⁻⁶ in/in/°F
75 to 600°F	6.81 x 10 ⁻⁶ in/in/°F
75 to 700°F	6.90 x 10 ⁻⁶ in/in/°F
75 to 800°F	7.06 x 10 ⁻⁶ in/in/°F
75 to 900°F	7.16 x 10 ⁻⁶ in/in/°F
75 to 1000°F	7.25 x 10 ⁻⁶ in/in/°F
75 to 1100°F	7.33 x 10 ⁻⁶ in/in/°F
75 to 1200°F	7.41 x 10 ⁻⁶ in/in/°F
75 to 1300°F	7.48 x 10 ⁻⁶ in/in/°F
75 to 1400°F	7.51 x 10 ⁻⁶ in/in/°F

Coefficient of thermal expansion

Temperature		Coefficient	
From 75°F to	From 24°C to	10 ⁴ /°F	10 ⁴ /°C
200	93	6.26	11.26
300	149	6.46	11.62
400	204	6.59	11.82
500	260	6.70	12.06
600	316	6.81	12.25
700	371	6.90	12.42
800	427	7.06	12.70
900	482	7.16	12.88
1000	538	7.25	13.05
1100	593	7.33	13.19
1200	649	7.41	13.33
1300	704	7.48	13.46
1400	760	7.51	13.51

Critical Temperature (AC1) 1505 °F

Critical Temperature (AC3) 1605 °F

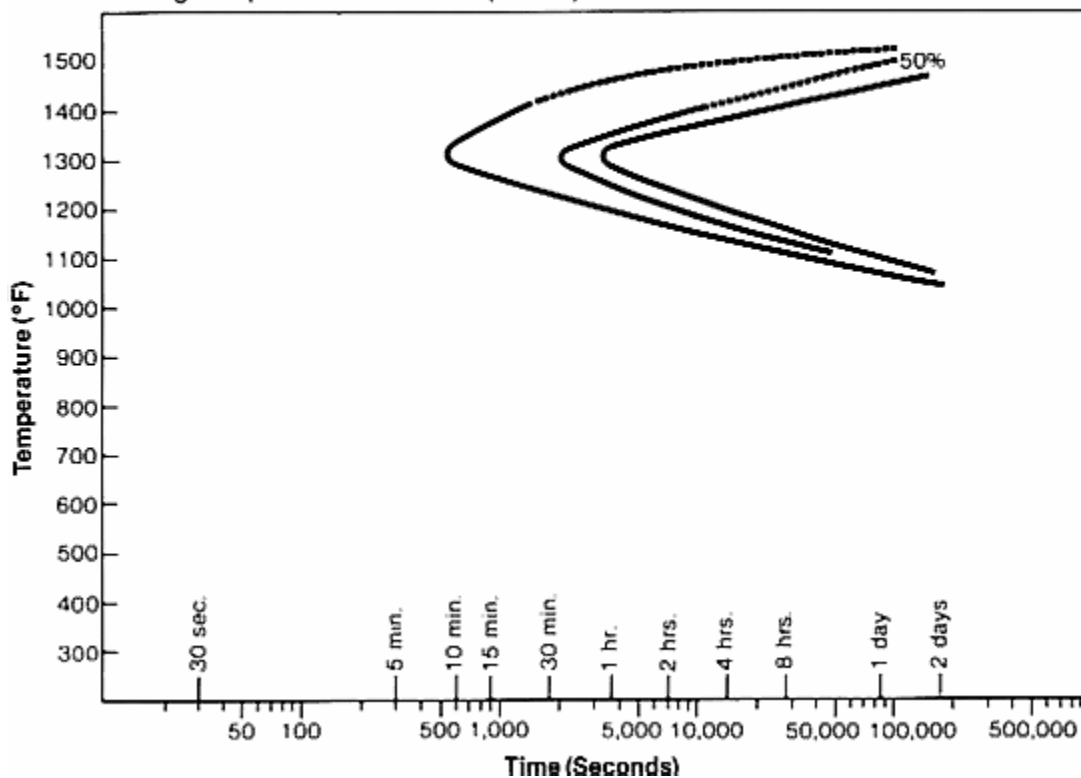
Martensite Start 950 °F

Martensite Finish 675 °F

Critical points

Critical Point	Core		Case	
	°F	°C	°F	°C
A _{C1}	1505	819	1340	727
A _{C3}	1605	874	1455	791
M _S	950	510	265	130
M _f	675	357	-155	-104

TTT Curves for Pyrowear alloy 53
Austenitizing temperature—1675°F (913°C)



Typical Mechanical Properties

Core Mechanical Properties

Test material prepared as follows: Pseudocarbured (in inert atmosphere) 1700°F (927°C), 7 hours. Hardened 1675°F (913°C) 25 minutes, oil quench. Refrigerated -100°F (-73°C), 1/2 hour. Tempered 400°F (204°C), 2 hours + 2 hours.

Test Temperature		Yield Strength		Ultimate Tensile Strength		% Elongation in 4D	% Reduction of Area	Charpy V-Notch Impact	
°F	°C	ksi	MPa	ksi	MPa			ft-lbs	J
-65	-54	160	1103	193	1331	18	63	39-41	53-56
	R.T.	140	965	170	1172	16	66.5	87-95	118-129
212	100	—	—	—	—	—	—	103-120	140-163
350	177	130	896	175	1207	12	46	114-116	155-157

Effect of Austenitizing Temperature

The room temperature Charpy V-Notch impact strength for various austenitizing temperatures and for the two indicated quenching procedures are shown in the chart below. Test material prepared as follows: Pseudocarbured (in inert atmosphere) 1700°F (927°C), 7 hours. Hardened from temperature indicated on chart below by oil quenching or air cooling. Refrigerated -100°F (-73°C), 1/2 hour. Tempered 500°F (260°C), 2 hours + 2 hours.

Austenitizing Temperature (25 min. at Temp.)		Oil Quenched			Air Cooled		
		CVN Impact		Rockwell C Hardness	CVN Impact		Rockwell C Hardness
°F	°C	ft-lbs	J		ft-lbs	J	
1650	899	106,97,93	144,132,126	34	91,91,84	123,123,114	34.5
1700	927	96,98,84	130,133,114	37.5	73,75,67	99,102,91	36.5
1750	954	54,54,64	73,73,87	36.5	40,52,44	54,71,60	36
1800	982	71,67,62	96,91,84	38.5	56,44,51	76,60,69	38
1850	1010	68		39	54,61,65	73,83,88	39

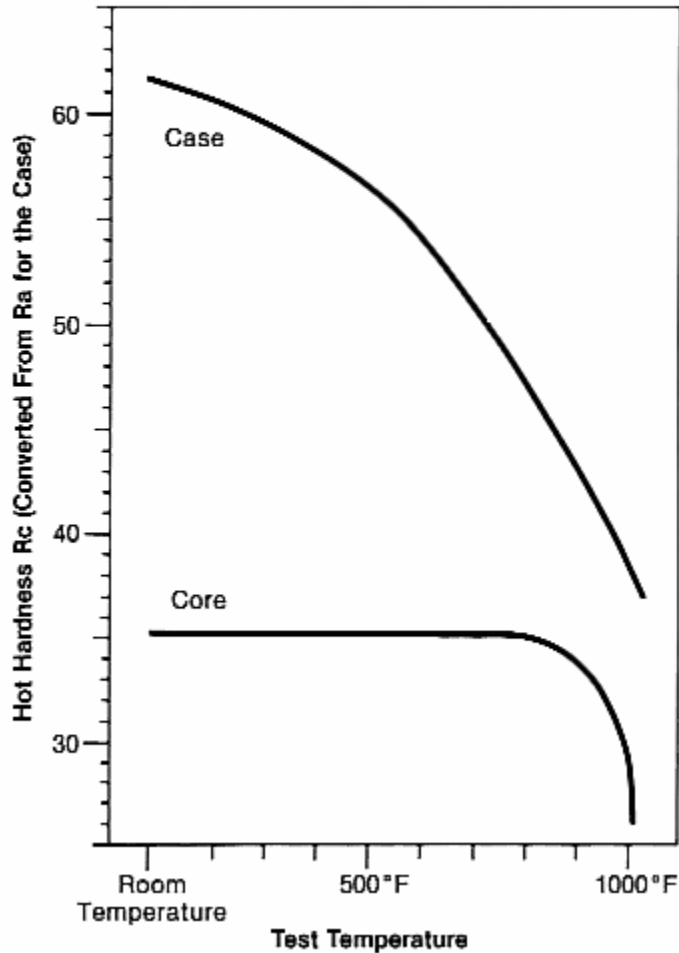
Fracture Toughness

Fracture toughness tests were conducted on samples taken from an 8-3/4" round bar. Samples were austenitized in neutral salt at 1675°F (913°C) for 35 minutes, oil quenched, deep frozen at -100°F (-73°C) for 1 hour, and tempered at 500°F (260°C) for 4 hours. Testing was done per ASTM E399 at room temperature.

Sample Orientation	Hardness HRc	K _{IC} ksi√in.
L-R	36	115/120
R-L	36	115/120
C-R	36	115/120

Hot Hardness

Hot hardness tests were conducted on the case and core of Pyrowear alloy 53. The test samples were prepared as follows: Carburized (7°F [-14°C] dew point) or pseudocarburized (in inert atmosphere) 1700°F (927°C), 7 hours. Hardened 1675°F (913°C), 25 minutes, oil quench. Refrigerated -100°F (-73°C), 1/2 hour. Tempered 400°F (204°C), 2 hours + 2 hours.



Heat Treatment

Decarburization

Pyrowear alloy 53 must be carburized to produce a carbon-rich case prior to hardening. As with all carburizing alloys, precautions must be taken to avoid decarburization during the hardening operation. A controlled-atmosphere furnace or neutral salt bath is suggested for hardening carburized parts.

Normalizing

Forgings are normalized by heating rapidly to 1850°F (1010°C) and cooling in air.

Annealing

Heat to 1285/1315°F (696/713°C), hold 4 to 8 hours and cool slowly in the furnace. Maximum hardness is 248 Brinell. To relieve machining stresses, heat to 1100°F (593°C), hold for 1 hour at heat, then air cool.

Carburizing

Carburizing may be performed in a pack or in gas. A more uniform gas carburization may be obtained by heating to carburizing temperatures before introducing the carburizing atmosphere. Carburize between 1600/1700°F (871/927°C) for a period long enough to secure the desired case. A Rockwell C 55 case depth of about 0.040" and a total case depth of about 0.065" with a maximum carbon content in the case of about 0.80% were obtained by gas carburizing at 1700°F (927°C) for seven hours in a laboratory endothermic atmosphere furnace at a dew point of +7°F (-14°C). The part may be hardened directly from carburizing by furnace cooling to 1675°F (913°C), followed by oil quenching to room temperature. Direct hardening after carburizing does not result in an

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ideal case structure of optimum impact properties. For improved toughness, cool to room temperature after carburizing, anneal and harden by oil quenching from 1675°F (913°C). Expected core hardness is Rockwell C 34/37.

Hardening

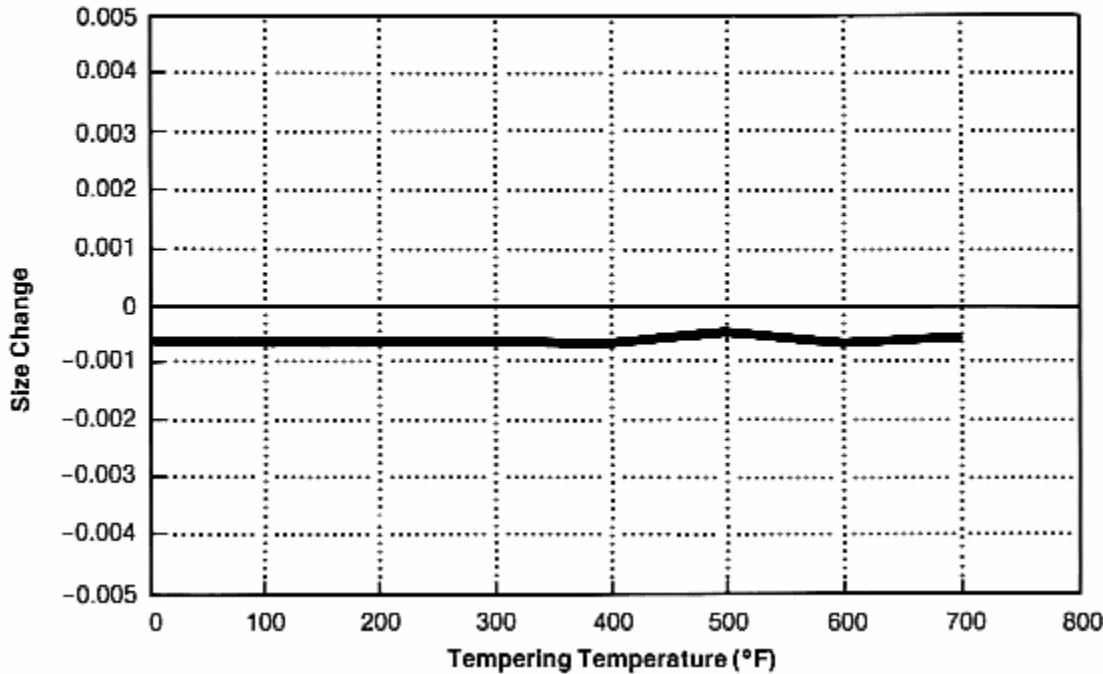
Pyrowear alloy 53 can be hardened by air cooling or oil quenching from 1660/1690°F (904/921°C). Oil quenching produces the optimum core impact strength.

Deformation (Size Change) in Hardening

Although Pyrowear alloy 53 is air hardenable, oil quenching is recommended for optimum impact properties. To minimize size change and warpage during heat treatment, the alloy may be air hardened, but with some loss of impact strength.

Size Change of Pyrowear Alloy 53

Samples oil quenched from 1675°F (913°C) and tempered 4 hours at temperature indicated on chart below. Size change in in./in.



Cold Treatment

To obtain maximum case hardness and dimensional stability, cold treating after hardening is recommended. This is performed by holding the material for one hour at a temperature below -100°F (-73°C) and allowing a natural return to room temperature. The part should be tempered after the sub-zero treatment.

Tempering

Pyrowear alloy 53 is designed to possess significantly greater case temper resistance than conventional alloys such as AISI 9310, 3310 or 8620.

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Case and Core Hardnesses

The following table lists the case and core hardnesses obtained after tempering for one hour or for two hours + two hours after the hardening and sub-zero treatments. For applications requiring greater dimensional stability, the two hour + two hour temper is suggested.

Tempering Temperature		Hardness Rockwell C			
		Core		Case	
°F	°C	Tempered 1 hr.	Tempered 2 + 2 hrs.	Tempered 1 hr.	Tempered 2 + 2 hrs.
As quenched + refrigerated		—	34	—	66.5
300	149	35	34.5	63	62.5
350	177	35	35	62	62
400	204	34.5	35	61.5	62
450	232	35	35	61.5	61.5
500	260	35	—	61	—
550	288	35	—	61	—

Workability

Forging

Heat uniformly to a temperature of 2000/2050°F (1093/1121°C). Do not forge below 1700°F (927°C). Forgings may be individually air cooled. Intricate forgings may be buried in vermiculite or furnace cooled.

Other Information

Applicable Specifications

- AMS 6308

Forms Manufactured

- Bar-Rounds

Disclaimer:

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