Technical Datasheet

CarTech® Temper Tough® Alloy

Identification

UNS Number

• K63835

Type Analysis

Single figures are nominal except where noted.

Carbon	0.40 %	**Manganese**	0.85 %
Silicon	1.50 %	**Chromium**	1.25 %
Nickel	3.80 %	**Molybdenum**	0.50 %
Copper	0.50 %	**Vanadium**	0.30 %
Iron	Balance		

General Information

Description

CarTech Temper Tough alloy is an air melted, cobalt-free, high strength, high toughness quenched and tempered alloy. This alloy attains a typical 290 ksi (1999 MPa) UTS combined with a typical range of 60-65 ksi sqrt(in.) (66-71 MP sqrt(m)) fracture toughness.

Corrosion Resistance

Temper Tough alloy is not a stainless alloy and may require plating or coating with a rust preventative or oil to prevent corrosion. The KIscc (as measured in a Rising Step Load Test) of Temper Tough alloy is 11.0 ksi sqrt(in.) (12.1 MPa sqrt(m)) in a 3.5% NaCl solution.

Properties

Physical Properties

Mean CTE

75 to 100°F	6.15 x 10^{-6} in/in/°F
75 to 200°F	6.60 x 10^{-6} in/in/°F
75 to 300°F	6.72 x 10^{-6} in/in/°F
70 to 400°F	6.86 x 10^{-6} in/in/°F
75 to 500°F	6.97 x 10^{-6} in/in/°F
75 to 600°F	7.09 x 10^{-6} in/in/°F
75 to 700°F	7.21 x 10^{-6} in/in/°F
75 to 800°F	7.33 x 10^{-6} in/in/°F
75 to 900°F	7.50 x 10^{-6} in/in/°F
75 to 1000°F	7.64 x 10^{-6} in/in/°F

Mean Coefficient of Thermal Expansion

Temperature		Coefficient			
		Annealed		Heat Treated	
75°F to	24°C to	10^{-6}/°F	10^{-6}/°C	10^{-6}/°F	10^{-6}/°C
100	38	6.15	11.07	6.49	11.68
200	93	6.60	11.88	6.56	11.81
300	149	6.72	12.10	6.61	11.90
400	204	6.86	12.35	6.77	12.19
500	260	6.97	12.55	6.88	12.38
600	316	7.09	12.76	6.99	12.58
700	371	7.21	12.98	7.05	12.69
800	427	7.33	13.19	6.86	12.35
900	482	7.50	13.50	6.25	11.25
1000	538	7.64	13.75	6.42	11.56

Annealed = 1250°F/677°C (8 hr) Air Cool
Heat Treated: 1685°F/918°C (1.5 hr) + GQ + -100°F/-38°C (8hr) + AW + 500°F/260°C (2hrs) + AC

Poisson's Ratio	0.289	
Electrical Resistivity	108.3	ohm-cir-mil/ft

Phase Transition Temperatures*:
Pearlite = 1331°F (722°C)

Bainite = 758°F (403°C)
Ferrite = 1342°F (728°C)
Martensite:
Start = 495°F (257°C)
50% = 427°F (219°C)
Finish (90%) = 270°F (132°C)
*software calculated

Young's Modulus = 30.1 x 10^6 psi (207.5 x 10^3 MPa)

Shear Modulus = 11.7 x 10^6 psi (80.7 x 10^3 MPa)

Typical Mechanical Properties

Typical Annealed Mechanical Properties – TemperTough Alloy

Orient.	YS (ksi)	UTS (ksi)	Elong. (%)	R.A. (%)	Hardness HRC	Hardness BHN
L	133.0	176.0	13.3	35.5	34.5	302
T	137.0	180.0	12.6	33.6	----	----

Heat Treatment = 1250°F (8 h) A.C.

Typical Heat Treated Fracture Toughness and Stress Corrosion Cracking Resistance - Temper Tough Alloy

Orient.	Fracture Toughness (K_{Ic})		Stress Corrosion Cracking Resistance (K_{Iscc})	
	ksi√in	MPa√	ksi√	MPa√
L	63.8	70.1	11.0	12.1

Heat Treated: 1685°F/918°C (1.5 hr) + GQ + -100°F/-38°C (8hr) + AW + 500°F/260°C (2hrs) + AC
Data represents an average of production tests.

Typical Heat Treated Mechanical Properties – Temper Tough Alloy

Orient.	Yield Strength		Ultimate Tensile Strength		Elong. (%)	R.A. (%)	CVN Impact Energy at Room Temperature ft-lbs	Hardness HRC	Hardness BHN
	ksi	MPa	ksi	MPa					
L	237	1631	293	2023	12	45	14.2 (19.3 J)	54	555

Size: ¾" bar
Heat Treated: 1685°F/918°C (1.5 hr) + GQ + -100°F/-38°C (8hr) + AW + 500°F/260°C (2hrs) + AC
Data represents an average of production tests

Heat Treatment

Decarburization

Like other carbon bearing high strength alloys, Temper Tough alloy is subject to decarburization during hardening. Heat treatment should take place in a neutral atmosphere furnace, salt bath or vacuum. Decarburization should be determined by comparing the surface and internal hardness of a small test cube for proper response.

Normalizing

The normalizing treatment is 1700°F (927°C) for 1 hour followed by air cooling to room temperature. Suggested use of normalization is for grain conditioning of large forgings prior to annealing.

Annealing

Optimum softening for machining is obtained by following the normalizing treatment with annealing. Temper Tough alloy is annealed using a 1250°F (677°C) treatment for 8 hours. The optimum annealed hardness of 35 - 40 HRC maximum is obtained following this anneal.

Austenizing

The austenitizing treatment temperature range is 1685°F +/- 25°F (918°C +/- 14°C) for 1.5 hours. The austenitizing temperature must be monitored by a thermocouple attached to the load.

Quenching

Water quenching is not recommended. Temper Tough alloy should be air cooled or oil quenched to develop optimum properties.

Cold Treatment

Following cooling to room temperature, to obtain the full toughness capability, Temper Tough alloy should be cooled to -100°F (-73°C) and held at temperature for a minimum of 1 hour. The parts can then be air warmed to room temperature.

Tempering

The standard temper for Temper Tough alloy is 500°F (260°C) for 2 hours followed by air cooling to room temperature.

Workability

Forging

Primary breakdown forging of Temper Tough alloy should be done at a maximum starting temperature of 2100°F (1150°C). Finish forging should be done from 1800°F (982°C) with a finishing temperature below 1650°F (899°C) in order to optimize the final heat treated properties.

Following forging, the parts should be air cooled to room temperature and then normalized in order to restore properties to the dead zone. The normalized forgings should then be annealed/overtempered to obtain optimum softening for machining.

Machinability

Temper Tough alloy is somewhat more difficult to machine than 4340 at Rockwell C 40. The following data was obtained from internal and external studies.

*Mitsui Seiki® Horizontal Milling Machining Center HS6a			
Attribute	Units	Suggested Machining Parameters	
		Roughing	Finishing
Material Condition		Annealed (35 HRC)	Hardened (54 HRC)
Speed	ft/min (SFM)	311.67	250
	mm/min	95	76.2
Diameter	Inch	0.9842	1.2598
	mm	25	32
Revolutions	rpm	1209	758
Number	Number of flutes	4	6
Feed Per Tooth	inch (IPT)	0.00963	0.002
	mm	0.24	0.05
Feed	inch/min (IPM)	45.1181	9.4881
	mm/min	1146	241
	in^3/min	11.3234	1.7739
	cm^3/min	185.56	29.07
Depth of Cut	inch	1.0039	3.7401
	mm	25.5	95
Width of Cut	inch	0.25	-
	mm	6.35	-
Tool Number		30601492V1	3060549, 32 mm dia., 6 flute
Holder		NIKKENBH HSK 100A-C32-135	**System SCHUNK® 209569 32 mm dia., 32095009
Coolant		ON	OFF (dry cutting)

*Mitsui Seiki is a registered trademark of Mitsui Seiki Inc.
**SCHUNK is a registered trademark of Schunk Intec Incorporated

Suggested Machining Parameters for Drilling						
Condition (Hardness)	Tool	Inserts	Cutting Speed (C-Sp) (RPM's)	Feed Rate (in/rev)	Feed (in/min)	Depth (in.)
Annealed (35 HRC)	0.500" drill	Mitsubishi® Water Drill/Miracle	85/650	0.005	3.2	0.100 per peck cycle
		Solid Carbide Using Through Coolant	156/1150	0.007	6.2	0.100 per peck cycle

Coolant Used on All Tooling

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Suggested Machining Parameters for Slotting				
Condition (Hardness)	Tool	Inserts	Cutting Speed (C-Sp) (RPM's)	Feed Rate (in/rev)
Annealed (35 HRC)	5" Inserted Cutter	Iscar	275	0.020

Coolant Used on All Tooling

Suggested Machining Parameters for Milling					
Condition (Hardness)	Tool	Inserts	Cutting Speed (C-Sp) (RPM's)	Feed Rate (in/rev)	Depth (in.)
Annealed (35 HRC)	4" Shell Mill	Walter Tiger Tec WSP 45	280	0.020 Roughing	0.100 per cut
Hardened (Q & T) (54 HRC)	4" Shell Mill	Walter Tiger Tec WSP 45	300	0.025 Finishing	0.014
	2.5" Inserted End Mill Using for Side Cutting	*Iscar Sumo Tec® IC380	400	0.01	0.015

Coolant Used on All Tooling

Iscar Sumo Tec is a registered trademark of Iscar Ltd. Corporation

Suggested Machining Parameters for Turning						
Section	Operation	Condition	Inserts	Cutting Speed (C-Sp) (RPM's)	Feed Rate (in. per rev.)	Depth (in.)
O.D.	Roughing	Annealed (35 HRC)	Valentine DNMG 432 M6 8525	260	0.003	0.020
	Finishing	Hardened (Q & T) (54 HRC)	Valentine DNMG 432 M6 8525	275	0.005	0.015
Gage	Roughing	Annealed (35 HRC)	Valentine TNMG 431 M5 8535	180	0.005	0.010
	Finishing	Hardened (Q & T) (54 HRC)	Valentine TNMG 431 M5 8535	195	0.002	0.015
Groove	Roughing	Annealed (35 HRC)	Valentine VLG 3 125 L 5820	250	0.0025	0.200
Threading ½" – 13 Thread	Roughing	Annealed (35 HRC)	Scandinavian	245	-	0.010 Start

Coolant Used on All Tooling

Additional Machinability Notes

Figures used for all metal removal operations covered are starting points. 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 steps.

Other Information

Forms Manufactured

• Bar-Rounds

Edition Date: 10/13/14

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