Technical Datasheet CARPENTER TECHNOLOGY

CarTech® 19-9 DL Alloy

Identification

UNS Number

- K63198

AISI Number

- No. 651

Type Analysis

Single figures are nominal except where noted.

Carbon	0.28 to 0.35 %	**Manganese**	0.75 to 1.50 %
Silicon	0.30 to 0.80 %	**Chromium**	18.00 to 21.00 %
Nickel	9.00 to 11.00 %	**Molybdenum**	1.00 to 1.75 %
Titanium	0.10 to 0.35 %	**Columbium + Tantalum**	0.25 to 0.60 %
Tungsten	1.00 to 1.75 %	**Iron**	Balance

General Information

Description

CarTech 19-9 DL exhibits high strength and resistance to corrosion and oxidation at temperatures up to 1250°F (677°C).

Like all austenitic alloys of this type, CarTech 19-9 DL cannot be strengthened by thermal treatment and is frequently used in the annealed condition.

When higher properties are required they can be achieved by hot-cold working; that is, by starting the rolling or forging at 2000/2100°F (1093/1149°C) and finish working at 1200/1600°F (649/871°C).

Applications

CarTech 19-9 DL has been used in various high temperature applications such as:

Turbine wheels
Supercharger wheels
Buckets
Frames
Casings
Afterburner parts

Corrosion Resistance

19-9 DL possesses excellent resistance to corrosion against most atmospheres encountered in aircraft, automotive, diesel and jet engines up to approximately 1250°F (677°C).

Oxidation resistance is considered good under continuous operations up to 1750°F (954°C) and up to 1450°F (788°C) under intermittent operations.

Properties

Physical Properties

Specific Gravity	7.93	
Density	0.2860	lb/in³
Mean Specific Heat (32 to 212°F)	0.1000	Btu/lb/°F

Mean CTE		
70 to 200°F	8.50	x 10^{-6} in/in/°F
70 to 600°F	9.31	x 10^{-6} in/in/°F
70 to 800°F	9.59	x 10^{-6} in/in/°F
70 to 1000°F	9.78	x 10^{-6} in/in/°F
70 to 1200°F	9.97	x 10^{-6} in/in/°F
70 to 1500°F	10.0	x 10^{-6} in/in/°F

Mean coefficient of thermal expansion

Temperature		Expansion Coefficient	
70°F to	21.1°C to	10^{-6}/°F	10^{-6}/°C
200	93	8.50	15.3
600	316	9.31	16.8
800	427	9.59	17.3
1000	538	9.78	17.6
1200	649	9.97	17.9
1500	816	10.01	18.0

Thermal Conductivity		
70°F	94.00	BTU-in/hr/ft²/°F
800°F	128.0	BTU-in/hr/ft²/°F
1200°F	147.0	BTU-in/hr/ft²/°F

Thermal conductivity

Temperature		Thermal Conductivity	
°F	°C	Btu-in/ft²/hr/°F	W/m • K
70	21.1	94	13.6
800	427	128	18.5
1200	649	147	21.2

Modulus of Elasticity (E)		
70°F	29.5	x 10^{3} ksi
1000°F	23.3	x 10^{3} ksi
1501°F	20.0	x 10^{3} ksi

Modulus of elasticity

Temperature		Modulus of Elasticity	
°F	°C	psi x 10^{6}	MPa x 10^{3}
70	21.1	29.5	203
1000	538	23.3	161
1500	816	20.0	138

Electrical Resistivity (70°F)	466.0	ohm-cir-mil/ft
Melting Range	2500 to 2600	°F

Magnetic Properties

Magnetic Permeability (20.0 Oe)	1.0050 to 1.0900	Mu

Typical Mechanical Properties

Elevated Temperature Secondary Creep Rate—19-9 DL and 19-9 DX

Test Temperature		Stress for minimum creep rate of:			
		0.0001% hr.		0.00001% hr.	
°F	°C	ksi	MPa	ksi	MPa
1000	538	40	276	19	131
1200	649	19.5	135	9.8	68
1350	732	10	69	5.2	36
1500	816	5.5	38	—	—

Elevated Temperature Stress Rupture Properties—19-9 DL and 19-9 DX
Bar stock
For tests below 1300°F (704°C), specimens have been warm worked and stress relieved.
For tests above 1300°F (704°C), specimens have been solution treated and aged.

Test Temperature		Stress to Produce Rupture in:							
		10 Hours		100 Hours		1,000 Hours		10,000 Hours	
°F	°C	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
1000	538	73	503	64	441	56	386	48	331
1200	649	50	345	44	303	37	255	31	214
1350	732	30.5	210	22.5	155	17	117	12.5	86
1500	816	20	138	13	90	8.6	59	5.6	39

Elevated Temperature Tensile Properties—19-9 DL and 19-9 DX
Bar stock hot rolled and stress relieved to Brinell 217

Test Temperature		Yield Strength 0.2% Offset		Tensile Strength		% Elongation in 2" (50.8 mm)	% Reduction of Area
°F	°C	ksi	MPa	ksi	MPa		
70	21.1	67.5	465	109.6	756	38.5	48.0
1000	538	42	290	89	614	43.0	52.0
1200	649	37	255	75	517	33.5	33.5
1400	760	35.5	245	42.6	294	35.0	60.0

Impact Strength—19-9 DL and 19-9 DX
V-Notch Charpy

Condition	Hardness BHN	Impact at Test Temperature													
		-323°F -198°C		-104°F -76°C		76°F 24.4°C		500°F 260°C		1000°F 538°C		1200°F 649°C		1500°F 816°C	
		ft-lb	J	ft-lb	J	ft-lb	J	ft-lb	J	ft-lb	J	ft-lb	J	ft-lb	J
Hot Rolled and Stress Relieved at 1200°F (649°C)	228	—	—	—	—	46	62	53	72	52	71	56	76	60	81
Annealed 1800°F (982°C) Air Cooled	196	25	34	38	52	53	72	—	—	—	—	—	—	—	—
Warm Work and Stress Relieved	311	11	15	19	26	27	37	—	—	—	—	—	—	—	—
Cold Drawn and Stress Relieved	286	13	18	19	26	22	30	—	—	—	—	—	—	—	—

Room Temperature Tensile Properties—19-9 DL and 19-9 DX

Condition	Yield Strength 0.2% Offset		Tensile Strength		% Elongation	% Reduction of Area
	ksi	MPa	ksi	MPa		
Hot Rolled and Stress Relieved	67.5	465	109.6	756	38.5	48.0
Hot-Cold Rolled and Stress Relieved 1500°F (816°C)	84.1	580	117.25	808	31.0	47.3
Hot-Cold Rolled and Stress Relieved 1200°F (649°C)	102.9	710	136.3	940	24.0	43.0

Heat Treatment

19-9 DL is an austenitic alloy which cannot be strengthened by heat treatment. This alloy is normally used in the annealed condition or in the hot-cold worked condition.

Annealing

Solution treat bars and forgings to 1800/2150°F (982/1177°C), cool rapidly and follow by an aging or stress relieving operation at 1200/1400°F (649/760°C). Sheet and strip should be annealed in the range of 1650/1800°F (899/982°C).

Stress Relieving

Heat to 1200/1400°F (649/760°C), hold at heat for a minimum of 1 hour, then air cool.

Workability

Hot Working

Roll or forge from 2000/2100°F (1093/1149°C) and finish work at 1200/1600°F (649/871°C).

Forging

19-9 DL can be readily hot forged, headed, upset and riveted. These alloys should be forged from a temperature of 2000/2100°F (1093/1149°C), allowing sufficient time for a through soak.

Cold Working

19-9 DL may be cold formed in the annealed condition. This alloy stiffens and work hardens more rapidly than the 300 series stainless steels. Severe cold forming operations should be immediately followed by a stress relieving treatment.

Machinability

19-9 DL may be machined using the techniques employed on the standard austenitic stainless steels. Best machinability is realized when these materials are solution treated, cold worked 15/20% and stress relieved.

Following are typical feeds and speeds for 19-9 DL.

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	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 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	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 Material
		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 Tool								Carbide Tool	
	Speed, fpm	Feed, Inches per Rev — Reamer Diameter, Inches						Tool Material	Speed, fpm	Tool Material
		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		80	

Tapping

Condition	Speed, fpm	Tool Material
Solution Treated	15	M-1;M-7;M-10
Aged	10	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 Diameter, Inches				Tool Material	Speed, fpm	Feed—Inches per tooth — Cutter Diameter, Inches				Tool Material
			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 Material
Solution Treated	12	.002	M-42
Aged	10	.002	

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 or feeds should be increased or decreased in small steps.

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 or feeds should be increased or decreased in small steps.

Weldability

19-9 DL may be welded using the various electric arc methods. Although not always necessary, welding could be followed by a stress relieving operation at 1650/1800°F (899/982°C) to minimize sensitivity to intergranular corrosion.

Other Information

Applicable Specifications

- AMS 5526 (Strip)
- AMS 5527 (Strip)
- AMS 5720 (Bars and Forgings)
- AMS 5721 (Bars and Forgings)
- AMS 5722 (Bars and Forgings)

Forms Manufactured

- Bar-Rounds
- Strip

Edition Date: 02/01/1989

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