CARPENTER TECHNOLOGY

DATASHEET

316/316L

Applicable designations: AMS 5648, AMS 5653, ASME SA479, ASTM A182, ASTM A276, ASTM A314, ASTM A479, MIL-S-862, QQ-S-763

Associated specifications: UNS S31600/S31603

Type analysis

Single figures are nominal except where noted.

Iron	Balance	**Chromium**	16.00–18.00 %	**Nickel**	10.00–14.00 %
Molybdenum	2.00–3.00 %	**Manganese**	Max 2.00 %	**Silicon**	Max 1.00 %
Phosphorus	Max 0.045 %	**Carbon**	Max 0.03 %	**Sulfur**	Max 0.03 %

Forms manufactured

Bar-Rounds

Description

316/316L is a low-carbon version of conventional 316. Controlling carbon of the austenitic alloy to a maximum of 0.03% minimizes carbide precipitation during welding. 316L is used in the as-welded condition in a variety of corrosive applications.

316/316L is suggested for applications requiring a moderate level of improvement in machinability for shorter runs of less complex parts, particularly at larger bar diameters. The safe scaling temperature for continuous service is 1600°F (871°C).

316/316L Project 70+® offers significantly improved machinability characteristics, including up to 50% higher machining speeds with improved finishes and longer tool life.

Key Properties:

- High-temperature performance
- Low-carbon, minimizes carbide precipitation

Markets:

- Aerospace
- Industrial
- Transportation
- Consumer
- Medical

Applications:

- Semiconductor systems
- High-temperature equipment applications
- Industrial process and handling equipment

> 316/316L

Corrosion resistance

316/316L has been used in sulfite pulp mills to resist corrosion by sulfurous acid compounds. Due to its superior corrosion resistance, its use has been extended to handling many of the chemicals used by chemical process industries.

The alloy is more resistant to pitting than conventional 18-8 alloys.

For optimum corrosion resistance, surfaces must be free of scale, lubricants, foreign particles, and coatings applied for drawing and heading. After fabrication of parts, cleaning and/or passivation should be considered.

IMPORTANT NOTE:
The following 4-level rating scale is intended for comparative purposes only. Corrosion testing is recommended; factors that affect corrosion resistance include temperature, concentration, pH, impurities, aeration, velocity, crevices, deposits, metallurgical condition, stress, surface finish, and dissimilar metal contact.

Nitric Acid	Good	**Sulfuric Acid**	Moderate
Phosphoric Acid	Moderate	**Acetic Acid**	Good
Sodium Hydroxide	Moderate	**Salt Spray (NaCl)**	Good
Sea Water	Moderate	**Sour Oil/Gas**	Moderate
Humidity	Excellent		

Physical properties

PROPERTY	At or From	English Units	Metric Units
SPECIFIC GRAVITY	—	7.95	7.95
DENSITY	—	0.2870 lb/in^3	—
MEAN SPECIFIC HEAT	32 to 212°F (0 to 100°C)	0.1200 Btu/lb/°F	—
MEAN COEFFICIENT OF THERMAL EXPANSION	32 to 1200°F (0 to 649°C)	10.3 x 10^{-6} in/in/°F	—
ELECTRICAL RESISTIVITY	73°F (23°C)	445.0 ohm-cir-mil/ft	—

> 316/316L

Heat treatment

Annealing	Heat to 1850/2050°F (1010/1121°C) and water quench. Brinell hardness approximately 150.
Hardening	316/316L cannot be hardened by heat treatment. The alloy hardens only by cold working.

Workability

Forging	316/316L can be readily forged, upset, and hot headed. To forge, heat uniformly to 2100/2300°F (1149/1260°C). Do not forge below 1700°F (927°C). Forgings can be air cooled. The best corrosion resistance is obtained if the forgings are given a final anneal.
Cold working	316/316L can be deep drawn, stamped, headed, and upset without difficulty. Since this alloy work hardens, severe cold forming operations should be followed by an anneal.
Machinability	316/316L machines with chip characteristics that are tough and stringy. The use of chip curlers and breakers is advised. Since the austenitic stainless steels work harden rapidly, heavy positive feeds should be considered.

> 316/316L

Additional machinability notes	When using carbide tools, surface speed feet/minute (SFPM) can be increased between 2 and 3 times over the high-speed suggestions. Feeds can be increased between 50 and 100%. 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	316/316L can be satisfactorily welded by the shielded fusion and resistance welding processes. Since austenitic welds do not harden on air cooling, the welds should have good toughness. Oxyacetylene welding is not recommended since carbon pickup in the weld may occur. The alloy can be welded without loss of corrosion resistance due to intergranular carbide precipitation. Usually the alloy can be used in the as-welded condition; however, for service in the most severe environments, the welded structure should be reannealed after welding. Where a filler metal is required, AWS E/ER316L welding consumables should be considered.

Typical feeds and speeds

The feeds and speeds in the following charts are conservative recommendations for initial setup.
Higher feeds and speeds may be attainable depending on machining environment.

TURNING — SINGLE-POINT AND BOX TOOLS

DEPTH OF CUT, IN	MICRO-MELT® POWDER HS TOOLS			CARBIDE TOOLS (INSERTS)			
	SPEED, FPM	FEED, IPR	TOOL MATERIAL	SPEED, FPM		FEED, IPR	TOOL MATERIAL
				UNCOATED	COATED		
.150	102	.015	M-48, T-15	350	450	.015	C-2
.025	120	.007	M-48, T-15	400	525	.007	C-3

TURNING — CUT-OFF AND FORM TOOLS

SPEED, FPM	FEED, IPR							TOOL MATERIAL	
	CUT-OFF TOOL WIDTH, IN				FORM TOOL WIDTH, IN			MICRO-MELT® POWDER HS	CARBIDE TOOLS
	1/16	*1/8*	*1/4*	*1/2*	*1*	*1-1/2*	*2*		
90	.001	.0015	.002	.0015	.001	.001	.001	M-48, T-15	—
330	.004	.0055	.007	.005	.004	.0035	.0035	—	C-2

> 316/316L

ROUGH REAMING

MICRO-MELT® POWDER HS		CARBIDE TOOLS		FEED, IPR, REAMER DIAMETER, IN`					
SPEED, FPM	TOOL MATERIAL	SPEED, FPM	TOOL MATERIAL	1/8	1/4	1/2	1	1-1/2	2
84	M-48, T-15	90	C-2	.003	.005	.008	.012	.015	.018

DRILLING — HIGH-SPEED TOOLS

SPEED, FPM	FEED, IPR NOMINAL HOLE DIAMETER, IN								TOOL MATERIAL
	1/16	1/8	1/4	1/2	3/4	1	1-1/2	2	
50–60	.001	.002	.004	.007	.010	.012	.015	.018	M-42
110	—	.002	.004	.006	.0085	.0096	.0113	.0113	C-2 Uncoated
140	.0005	.002	.004	.006	.0085	.0096	.0113	.0113	C-2 Coated

DIE THREADING — HIGH-SPEED TOOLS

SPEED, FPM				TOOL MATERIAL
7 OR LESS, TPI	8 TO 15, TPI	16 TO 24, TPI	25 AND UP, TPI	
8–15	10–20	15–25	25–30	M-7, M-10

MILLING — END PERIPHERAL

DEPTH OF CUT, IN	HIGH-SPEED TOOLS						CARBIDE TOOLS					
	SPEED, FPM	FEED, IN PER TOOTH CUTTER DIAMETER, IN				TOOL MATERIAL	SPEED, FPM	FEED, IPT CUTTER DIAMETER, IN				TOOL MATERIAL
		1/4	1/2	3/4	1-2			1/4	1/2	3/4	1-2	
.050	90	.001	.002	.003	.004	M-48, T-15	270	.001	.002	.003	.005	C-2

TAPPING — HIGH-SPEED TOOLS

SPEED, FPM	TOOL MATERIAL
12–25	M-7, M-10

BROACHING — HIGH-SPEED TOOLS

SPEED, FPM	CHIP LOAD, IPT	TOOL MATERIAL
18	.0040	M-48, T-15

For additional information, please contact your nearest sales office:

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