UNITED PERFORMANCE METALS
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PRODEC® TYPE 316/316L

AMS 5507 / 5524

PRODEC® Type 316/316L is an improved machinability version of standard Type 316/316L molybdenum-containing austenitic stainless steel intended to provide improved corrosion resistance relative to Type 304/304L in moderately corrosive process environments, particularly those containing chlorides or other halides. With advanced ladle metallurgy techniques during melting, the steel is processed for improved machinability and outstanding uniformity offering the end user with Production Economy (PRODEC). PRODEC 316/316L offers faster machining speeds, longer tool life, improved part surface quality, and lower total cost of machined parts. Type 316/316L also maintains higher creep, stress rupture, and tensile strength at elevated temperature compared to Type 304/304L. PRODEC 316/316L is non-magnetic in the annealed condition but may become slightly magnetic as a result of welding.

Nominal Composition Prodec 316

C	Carbon - 0.08 max (316) Carbon - 0.03 max (316L)
Mn	Manganese - 2.00 max
P	Phosphorous - 0.045 max
S	Sulfur - 0.030 max
Si	Silicon - 0.75 max
Cr	Chromium - 16.0 - 18.0
Ni	Nickel - 10.0 - 14.0
Mo	Molybdenum - 2.0 - 3.0
N*	Nitrogen - 0.10 max

Percent by weight, maximum unless a range is listed.
*Flat rolled product only

Dual Certification

It is common for PRODEC 316L to be dual certified as Type 316 and Type 316L when the material meets both the lower carbon limit of Type 316L and the slightly higher strengths of Type 316. The producer of the steel must certify the material as Type 316 if it is to be used as Type 316 instead of Type 316L.

Standard Inventory Specifications

- UNS: S31600, S31603
- AMS: 5507, 5524
- ASTM: A 240

PRODEC 316/316L can be supplied to meet AMS, ASTM, ASME, QQS, and MIL-S specifications.

Forms & Thicknesses Stocked

- Plate - 0.1875” - 3.500”

Applications

- General purpose applications and environments
- Corrosion resistant machined parts
- Water Treatment

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Or click here to view our product page and request a quote on Prodec 316/316L

Features

- Improved corrosion resistance compared to 304/304L
- Enhanced high temperature strength relative to 304/304L
- High ductility and formability
- Excellent impact toughness even at cryogenic temperatures
- Good workability and weldability
- Excellent machinability

Resistance to Corrosion: The addition of molybdenum provides improved resistance to pitting and crevice corrosion in environments containing chlorides and other halides. PRODEC 316/316L is more resistant to atmospheric and similar mild types of corrosion than Type 316/316L.

Although improvements in machinability in the past have been associated with reduced corrosion resistance, PRODEC 316/316L has been shown to have corrosion resistance within the range typically expected of Type 316L stainless steel. Because of its low carbon content, PRODEC 316/316L retains good corrosion resistance in the as-welded condition.

Machinability

PRODEC 316/316L is melted to a closely controlled chemistry and ladle-treated to achieve control of the composition, amount, size, shape, and distribution of the nonmetallic inclusions (sulfides and oxides) normally occurring within a standard stainless steel. These inclusions provide for chip breaking and for reduced wear of carbide tooling at high machining speeds. PRODEC 316/316L permits higher machining speeds, longer tool life, and superior part quality with reduced total cost for finished parts.

The following tables give some speeds and feeds obtained in tests for PRODEC 316/316L, providing guidelines for possible adaptation to particular machining programs. The data provided are based on achieving tool lives of 15 minutes for cemented carbides and 60 minutes for high speed tool steels.

Turning (Table 1)

		Cutting speed, sfm			
Feed (in/rev)	Cutting depth (in)	C7	C6	C5	High speed Steel
<0.012	0.08	780	620	–	95
0.012-0.020	0.08-0.20	–	560	460	80
0.020-0.040	0.20-0.40	–	295	260	50

Threading (Table 2)

Tool	Speed (sfm)
Cemented Carbide (C6-C5)	295-425
High Speed Steel	50-65

Reaming (Table 3)

Ream diameter (in)	Cutting Speed (sfm)		
	Cemented Carbide	High Speed Steel	Feed (in/rev)

< 0.40	165	33-50	0.004-0.008
0.40 - 0.80	165	33-50	0.012
> 0.80	165	33-50	0.012-0.016

Cut Off (Table 4)

Tool	Speed (sfm)	Feed (in/rev)
Cemented Carbide (C5)	295-460	0.003-0.008
High Speed Steel	100	0.002

Drilling - High Speed Steel Twist Drills (Table 5)

Drill diameter (in)	Speed		Feed (in/rev)
	Rpm	fm	
0.04	3200-3800	33-38	0.002
0.12	1600-1800	50-57	0.004
0.20	1080-1270	57-66	0.008
0.40	540-640	57-66	0.012
0.60	360-430	57-66	0.014
0.80	370-320	57-66	0.016
1.20	180-220	57-66	0.018

Notes:

1. Cutting Fluid: Ample flow of 10% emulsion coolant.
2. With short NC drills, feed can be increased about 40%
3. When hole depths exceeds 4x diameter, clear chips from hole.
4. With TiN-Coated HSS drills, speed can be increased 10%
5. For rotating drill and fixed workpiece, as in drilling a hole in a plate, the maximum speed should not exceed 50 sfm.

Drilling - Indexable insert drills, cemented carbides (Table 6)

Drill diameter (in)	Speed sfm	Feed (in/rev)	Type of Carbide	
			Center	Periphery
0.80	655-820	0.004	C6	C7
1.20	655-820	0.005	C6	C7
1.60	655-820	0.006	C6	C7
2.00	655-820	0.008	C6	C7

Notes:
Cutting Fluid - Pressure: > 44 psi; Amount: > 6.5 gal/min
Cutting data for indexable insert drills are highly dependent on the make of drill; the manufacturer's recommendations should be considered.

Mechanical Properties at Room Temperature (Table 7)

Property	Typical	ASTM	
		316	316L
Ultimate Tensile Strength	85 ksi	75 min	70 min
0.2% Offset Yield Strength	44 ksi	30 min	25 min
Elongation in 2 inches	56%	40 min	40 min
Reduction in Area	69%	–	--
Hardness, Rockwell *0.375 inch plate	81B	95 max	95 max

Physical Properties (Table 8)

Properties	Value
Density	0.285 lb/in^3
Modulus of Elasticity	29 x 10^6
Coefficient of Thermal Expansion	8.9 x 10^{-6} 68-212°F, /°F
Thermal Conductivity	8.7 Btu/ft hr °F
Heat Capacity	0.12 Btu/lb °F
Electrical Resistivity	27.6 x 10^{-6} Ω-inch

Milling (Table 10)

Operation	Cemented Carbide			High Speed steel	
	Speed (sfm)	Feed (in/tooth)	Type of carbide	Speed (sfm)	Feed (in/tooth)
Face Milling	490-820	0.006-0.012	C7-C6	80-100	0.005-0.008
Side Milling	590-790	0.010-0.012	C7-C6	80-100	0.005-0.008
End Milling	490-720	0.004-0.008	C7-C6	80-100	0.001-0.006
End Milling (Solid cemented carbide)	165-330	0.002-0.008	C5	–	–

Heat treatment

Annealing: PRODEC 316/316L should be heated to 1900°F minimum and water quenched or rapidly cooled by other means. PRODEC 316/316L cannot be hardened by heat treatment.

Workability

Cold Working: PRODEC 316/316L is readily formed and fabricated through a full range of cold working operations. It can be used in heading, drawing, bending, and upsetting. Any cold working operations will increase the strength and hardness of the material.

Hot working: PRODEC 316/316L can be forged in the 1700-2200°F range. For maximum corrosion resistance, forgings should be annealed at 1900°F minimum and water quenched or rapidly cooled by other means after hot working operations.

Welding

PRODEC 316/316L is readily welded by a full range of conventional welding procedures (except oxyacetylene). AWS E316L/ER316L and other austenitic filler metals with molybdenum content higher than that of the base metal should be used with PRODEC 316/316L stainless steel.

Lowest Temperature (F) at Which the Corrosion Rate Exceeds 5 mpy (Table 11)

Corrosion Environment	654 SMO	254 SMO	904L	Type 316L (2.7 Mo)	Type 304	Outokumpu 2507	2205 Code Plus Two	Outokumpu 2304
0.2% Hydrochloric Acid	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling
1% Hydrochloric Acid	203	158	122	86	86p	>Boiling	185	131
10% Sulfuric Acid	158	140	140	122	–	167	140	149
60% Sulfuric Acid	104	104	185	<54	–	<57	<59	<<55
96% Sulfuric Acid	86	68	95	113	–	86	77	59
85% Phosphoric Acid	194	230	248	203	176	203	194	203
10% Nitric Acid	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling
65% Nitric Acid	221	212	212	212	212	230	221	203
80% Acetic Acid	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling
50% Formic Acid	158	212	212p	104	≤50	194	194	59
50% Sodium Hydroxide	275	239	Boiling	194	185	230	194	203
83% Phosphoric Acid + 2% Hydroflouric Acid	185	194	248	149	113	140	122	95
60% Nitric Acid + 2% Hydrochloric Acid	>140	140	>140	>140	>140	>140	>140	>140
50% Acetic Acid + 50% Acetic Anhydride	>Boiling	>Boiling	>Boiling	248	>Boiling	230	212	194
1% Hydrochloric Acid + 0.3% Ferric Chloride	>Boiling, p	203ps	140ps	77p	68p	203ps	113ps	68p
10% Sulfuric Acid + 2000ppm Cl^-+N2	149	104	131	77	--	122	95	<55
10% Sulfuric Acid + 2000ppm Cl^- + S02	167	140	122	<<59p	–	104	<59	<<50
WPA1, High Cl^- Content	203	176	122	≤50	<<50	203	113	86
WPA2, High F^- Content	176	140	95	≤50	<<50	167	140	95

ps = pitting can occur
ps = pitting/crevice corrosion can occur

WPA	P_2O_5	CL^-	F^-	H_2SO_4	Fe_2O_3	Al_2O_3	SiO_2	CaO	MgO
1	54	0.20	0.50	4.0	0.30	0.20	0.10	0.20	0.70
2	54	0.02	2.0	4.0	0.30	0.20	0.10	0.20	0.70