Machining Operations	Metallurgical Condition	Depth of cut or width (inches)	HSS Tooling			Coated Carbide Tools		
			Cutting Speed SFPM	Feed (ipr)	Type of Tool	Cutting Speed SFPM	Feed (ipr)	Type of Tool
Cut-off or Part-Off	Cold Drawn	0.04 0.08 0.12	115 - 130 105 - 125 80 - 100	0.002 - 0.003 0.002 - 0.003 0.002 - 0.003	M41 (T15)	220 - 430 205 - 395 190 - 365	0.002 - 0.003 0.002 - 0.003 0.002 - 0.003	C6 C6 C6
	Annealed	0.04 0.12 0.25	110 - 135 95 - 115 80 - 100	0.002 - 0.003 0.002 - 0.003 0.002 - 0.004		234 - 485 220 - 450 205 - 415	0.002 - 0.003 0.002 - 0.003 0.003 - 0.004	C6 C6 C6
Drilling	All	0.063 0.125 0.250 0.500 0.750	55 - 80	0.0005 - 0.002 0.002 - 0.004 0.003 - 0.006 0.005 - 0.009 0.008 - 0.012	M2	145 - 300	0.0005 - 0.002 0.002 - 0.004 0.002 - 0.005 0.004 - 0.006 0.006 - 0.009	C5 - C6 or C1 - C2 TiN coated
Insert Drilling	All	0.50 - 0.75 0.75 - 1.00 1.00 - 2.50				130 - 500 180 - 500 200 - 520	0.0015 - 0.004 0.002 - 0.005 0.002 - 0.006	C7 C6 C5
Reaming	All	0.063 0.125 0.250 0.500 0.750	55 - 80	0.002 - 0.005 0.004 - 0.008 0.007 - 0.016 0.015 - 0.025 0.015 - 0.030 0.020 - 0.030	M2 (M42)	145 - 300	0.002 - 0.004 0.004 - 0.008 0.007 - 0.016 0.015 - 0.025 0.015 - 0.030 0.020 - 0.030	C5 - C6 or C3 TiN coated
Tapping	All	All	35 - 55		M2 - M7 TiN Coated			

The machining data presented within all tables and graphs represent typical working ranges based on field and laboratory research. Results will vary based on parts to be produced, equipment and tooling utilized, personnel operating the equipment and customer part specifications.

For additional information, contact Technical Support at the Corporate Office: (800) 323-1233.

1. The table values are initial suggestions and can vary depending on machine and cutting conditions.
2. The use of coated tools increases the tool life by 20 - 50 % using the same cutting parameters, or it increases the cutting conditions (speed) by 10 % to 15 % using the same tool wear.
3. Tooling grades in parenthesis denotes alternate tool material choice.
4. Drill speeds were developed using 118° included angle drills. Increase speeds 10 - 20 % with the use of 140° angle drills.
5. Drill cutting conditions are valid for hole depths up to 4 times diameter.
6. Machining speeds and feeds apply to highly rigid equipment. Reductions may be necessary on cross slide operations or less rigid equipment.
7. When using C1, C2 or C3 carbides, reduce speeds by 25 - 40 %.
8. Use aggressive tool chip breaking geometries.

SCHMOLZ + BICKENBACH USA, INC.
Phone 800.323.1233
www.schmolz-bickenbach.us
Heat Treatment
Phone 800.265.0862

SCHMOLZ + BICKENBACH CANADA, INC.
Phone 800.268.4988
www.schmolz-bickenbach.ca

Technical Data Sheet
316/316L UGIMA®

Comparable Standard:

Typical Analysis %	C	Si	Mn	P	S	Cr	Ni	Mo	N
Min.						16.50	10.50	2.00	
Max.	0.03	0.75	2.00	0.040	0.030	18.00	13.00	2.50	0.10

Description

» **316/316L UGIMA®** is Ugitech's improved machining grade produced only by Ugitech. It is identical in every way to regular 316L, except with respect to machinability.

» **316/316L UGIMA®** represents the latest generation of Ugitech's popular UGIMA® family of high machinability grades. Through the use of new and beneficial modifications to the steel-making process, **316/316L UGIMA®** builds upon the proprietary UGIMA® manufacturing process to allow for excellent machinability across a wider range of operations and cutting conditions. When compared with older Ugima® versions, **316/316L UGIMA®** is a technologically advanced product that will allow for superior machinability at both low and high speeds, in cam-driven and CNC machines, and with high-speed steel or carbide tooling. Machine shops using **316/316L UGIMA®** have experienced consistent success regardless of machine, operation, tooling, or cutting conditions. From lot to lot, **316/316L UGIMA®** is engineered to give the same high performance every time without surprises.

» Shops have reported productivity increases of up to 30 % over leading competitive machining grades, and increases of up to 20 % over the original version of **316/316L UGIMA®**. Additional benefits include improved chip break ability, superior surface finish, increased tool life, and better interchange ability with stadard type 316/316L, regardless of the producer.

Classification

General purpose corrosion resistant austenitic stainless steel (300 series). Essentially a modified type 304 with molybdenum addition for added corrosion resistance. Oxidation resistance to continuous service to 1600 °F (870 °C), and intermittent service to 1450 °F (790 °C).

Characteristics

» AISI Types 316/316L
» UNS S31600/S31603
» SAE J405 Nos. 30316/30316L
» EN 10088-3 1.4401/1.4404 X2CrNiMo17-12-2/ X4CrNiMo17-12-2
» ASTM A182

Characteristics (cont.)

» ASTM A193 Class 1
» ASTM A276
» ASTM A314
» ASTM A320 Class 1
» ASTM A479
» ASTM A484
» ASTM F899
» ASME SA182
» ASME SA193 Class 1
» ASME SA276
» ASME SA479
» AMS 5648
» AMS 5653
» AMS-QQ-S-763
» MIL-S-862 - Chemistry
» NACE Standard MR0175

Mechanical Properties (Typical)

Bars ≤ 0.500"	
Tensile Strength	90 - 115 ksi (620 - 795 MPa)
Yield Strength (0.2 %)	45 ksi (310 MPa) minimum
Elongation	30 % minimum
Reduction of Area	50 % minimum
Hardness	140 - 241 HB
Bars 0.500" ≤ 0.750"	
Tensile Strength	90 - 115 ksi (620 - 795 MPa)
Yield Strength (0.2 %)	30 ksi (206 MPa) minimum
Elongation	30 % minimum
Reduction of Area	50 % minimum
Hardness	140 - 241 HB
Bars 0.750" ≤ 1"	
Tensile Strength	90 - 115 ksi (620 - 795 MPa)
Yield Strength (0.2 %)	30 ksi (206 MPa) minimum
Elongation	30 % minimum
Reduction of Area	50 % minimum
Hardness	140 - 223 HB
Bars > 1"	
Tensile Strength	75 ksi (517 MPa)
Yield Strength (0.2 %)	30 ksi (206 MPa) minimum
Elongation	30 % minimum
Reduction of Area	50 % minimum
Hardness	223 HB maximum

Typical Physical Properties	
Density	0.290 lbs/in^3 (8.0 g/cm^3)
Round bar weight per ft (lbs)	2.73 X (1/2 bar diameter in inches)^2
Hexagonal bar weight per ft (lbs)	3.01 X (bar diameter in inches)^2
Square bar weight per ft (lbs)	3.48 X (bar diameter in inches)^2
Mean Coefficient of Linear Expansion	68-392 °F (20-200 °C) = 9.3 x 10^{-6} in/in/ °F (16.8 x 10^{-6} cm/cm/ °C)
Modulus of Elasticity in Tension	68 °F (20 °C) - 29.02 x 10^6 psi (200,000 MPa) 212 °F (100 °C) - 23.80 x 10^6 psi (164,000 MPa) 572 °F (300°C) - 25.97 x 10^6 psi (179,000 MPa)
Thermal Conductivity @68 °F (20 °C)	8.8 Btu/ft/hr/ °F (15.3 W/m/ °C) @68 °F (20 °C)

Applications

» Food Processing Equipment
» Medical Equipment
» Chemical Industry
» Pulp Handling Equip.
» Screw Machine Parts
» Photo Developing Equip.
» Valves & Accessories
» Architectural Applications

Available Forms

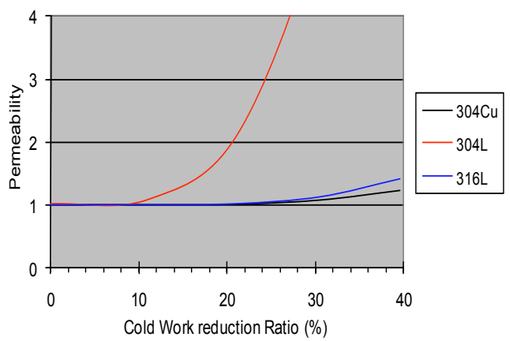
Cold drawn bars, Turned bars, Ground bars, SMQ™
Shapes: Round, Hexagonal, Octagonal, Square, Wire

Magnetic and Electrical Properties

Magnetic Permeability
Essentially non-magnetic in the annealed condition. Permeability increases upon cold work such as drawing or machining.

Typical Magnetic Permeability:
<1.03 at 23% cold work.

Magnetic Permeability Comparison



Electrical Resistivity 29.1 μΩ - in (740 μΩ - mm)

Heat Treatment

The heat treatment (annealing) that gives 316/316L UGIMA® its optimum properties includes heating in the range of 1850 - 2000 °F (1010 - 1095 °C), followed by rapid cooling with forced air or water quenching.

Hardenability (Cold Working)

Not hardenable by heat treatment. Strength and hardness increases upon cold work such as drawing and forming.

Forging (Hot Working)

» Heat in the range of 2100 - 2230 °F (1150 - 1220 °C).
» Avoid heating core beyond 2235 °F (1280 °C) during fast forging.
» Forge in the range of 1830 - 2190 °F (1000 - 1200 °C), minimum forge temperature 1740 °F (950 °C).
» After forging, cool small parts rapidly (quench) in water - anneal large parts.

Welding

316/316L UGIMA® can be readily welded, without preheating, with or without filler metal using all welding methods except oxyacetylene welding.
Oxyacetylene welding can result in carbon pickup in the weld, reducing corrosion resistance. The following are filler metal recommendations:
» E316L coated electrodes
» ER316L for TIG wire
» ER316LSi for MIG wire

Weld energies should be limited to the weld areas to avoid hot cracking. No annealing of the weld zone is required as the alloy is designed to avoid intergranular corrosion. Typically the grade can be used in the as-welded condition. However, for severe corrosion environments, the welded structure should be reannealed after welding.

Corrosion Resistance

316/316L UGIMA® has excellent corrosion resistance. It is highly corrosion resistant in rural and urban environments that contain moderate amounts of chloride or acids. This grade can be used in the food industry, including direct contact with food, and in the processing industry where ease of cleaning and sterilization are important.
316/316L UGIMA® maintains its corrosion resistance in media such as water, and many types of acidic media such as sulfuric, phoshoric, and organic acids depending on concentration and temperature. **316/316L UGIMA®** is also resistant to chlorinated media. This grade effectively resists intergranular corrosion and will pass the following standardized tests:
» ASTM A262 - Practices A & E
» DIN 50914
» AFNOR NFA05-159

The corrosion resistance of a stainless steel depends on many factors related to the composition of the corrosive environment, pH, temperature, velocity, agitation, crevices, deposits, dissimilar metal contact, metallurgical condition, as well as the preparation of the surface. The table here is for comparative purposes only and illustrates the performance in different environments. Consult your local Ugitech metallurgist to discuss your application.

Optimum corrosion resistance is achieved on smooth, clean surfaces, free from particulate matter such as machining oils, dirt and foreign particles. Under these conditions, parts will become passive in air. Should passivation be required, the following treatment should be followed:
» Solution: 25 % nitric acid at room temperature (68 °F - 20 °C) or at 120°F (50°C) for more rapid results.
» Treatment: Immerse for several hours at room temperature, or 25 - 40 minutes at 120°F (50°C) followed by a thorough rinsing to remove all residual solution.

Machinability

The UGIMA® family of grades is the next generation of Ugitech's high machinability alloys. UGIMA® builds on the UGIMA® manufacturing process originally developed by Ugitech. The proprietary manufacturing process transforms the hard abrasive oxides normally present in stainless steels into highly specific oxides that are malleable and soft at machine cutting temperatures. At this point, they melt and coat the tool, providing a lubricious layer that reduces cutting temperature and friction. Coupled with precise control of the manufacturing processes, the UGIMA® alloys provide consistency heat to heat, increased productivity, reduced cool wear, improved surface finishes and excellent chip control.

Shops quickly recognize that 316/316L UGIMA® does not machine like the standard type 316/316L. 316/316L UGIMA® has provided against other high machinability 316/316L alloys, exhibiting productivity gains of up to 20 % and decreases in tool wear up to 50 % have been reported.

Environment	Behavior
Nitric Acid	●●●○
Humidity	●●●●
Phosphoric Acid	●●○○
NaCl (Saline Mist)	●●●○
Sulfuric Acid	●●○○
Seawater	●●○○
Acetic Acid	●●●○
Petroleum	●●○○
Sodium Carbonate	●●○○

It is important to note, maintaining corrosion resistance at weld zones will require cleaning and passivation.

Machining Operations	Metallurgical Condition	Depth of cut or width (inches)	HSS Tooling			Coated Carbide Tools		
			Cutting Speed SFPM	Feed (ipr)	Type of Tool	Cutting Speed SFPM	Feed (ipr)	Type of Tool
Turning	Cold Drawn	0.04 0.08 0.12	90 - 120 80 - 110 75 - 95	0.005 - 0.008 0.006 - 0.010 0.006 - 0.012	M2 - M3 (T15)	295 - 855 260 - 690 245 - 595	0.005 - 0.008 0.006 - 0.010 0.006 - 0.012	C7 C6 C6
	Annealed	0.04 0.08 0.12	95 - 125 95 - 120 85 - 105	0.005 - 0.008 0.006 - 0.010 0.006 - 0.012		325 - 1020 295 - 755 260 - 660	0.005 - 0.008 0.006 - 0.010 0.006 - 0.012	C7 C6 C6
Forming & Grooving	Cold Drawn	0.08 0.25 0.50 1.00 2.00	105 - 125 105 - 125 100 - 120 100 - 120 100 - 120	0.002 - 0.003 0.003 - 0.004 0.003 - 0.004 0.002 - 0.003 0.002 - 0.003	M2 - M3 (T15)	255 - 415 235 - 380 235 - 290 220 - 275 220 - 240	0.002 - 0.003 0.003 - 0.004 0.003 - 0.004 0.002 - 0.003 0.002 - 0.003	C6 C6 C6 C6 C6
	Annealed	0.08 0.25 0.50 1.00 2.00	115 - 135 110 - 125 105 - 125 105 - 125 105 - 125	0.003 - 0.004 0.003 - 0.004 0.003 - 0.004 0.002 - 0.003 0.002 - 0.003		270 - 450 255 - 410 255 - 305 255 - 290 220 - 260	0.003 - 0.004 0.003 - 0.004 0.003 - 0.004 0.002 - 0.003 0.002 - 0.003	C6 C6 C6 C6 C6
Shaving & Skiving	Cold Drawn	0.08 0.25 0.50 1.00 2.00	100 - 120 95 - 115 95 - 115 95 - 115 95 - 115	0.002 - 0.003 0.002 - 0.003 0.002 - 0.003 0.002 - 0.003 0.002 - 0.003	M2 - M3 (T15)	245 - 295 230 - 280 230 - 280 210 - 265 195 - 230	0.002 - 0.003 0.002 - 0.003 0.002 - 0.003 0.002 - 0.003 0.002 - 0.003	C6 C6 C6 C6 C6
	Annealed	0.08 0.25 0.50 1.00 2.00	115 - 135 110 - 125 105 - 125 105 - 125 105 - 125	0.002 - 0.003 0.002 - 0.003 0.002 - 0.003 0.002 - 0.003 0.002 - 0.003		260 - 315 245 - 295 245 - 295 230 - 280 210 - 245	0.002 - 0.003 0.002 - 0.003 0.002 - 0.003 0.002 - 0.003 0.002 - 0.003	C6 C6 C6 C6 C6