Technical Datasheet

CarTech® BioDur® 316LS Stainless

Identification

UNS Number

- S31673

Type Analysis

Single figures are nominal except where noted.

Carbon (Maximum)	0.03 %	**Manganese (Maximum)**	2.00 %
Phosphorus (Maximum)	0.025 %	**Sulfur (Maximum)**	0.010 %
Silicon (Maximum)	0.75 %	**Chromium**	17.00 to 19.00 %
Nickel	13.00 to 15.00 %	**Molybdenum**	2.25 to 3.00 %
Copper (Maximum)	0.50 %	**Nitrogen (Maximum)**	0.10 %
Iron	Balance		

Pitting Resistance Equivalent* = 26.00 min.

NOTE: Pitting Resistance Equivalent (PRE) = 3.3 x Mo + Cr

General Information

Description

CarTech BioDur 316LS stainless steel is an electro-slag remelted (ESR) or vacuum arc remelted (VAR), low carbon, high nickel and molybdenum version of CarTech 316 stainless. The secondary premium melting step (ESR or VAR) imparts improved cleanliness. The chemistry modifications are designed to maximize the corrosion resistance of this alloy and provide a ferrite free microstructure. The alloy is nonmagnetic even after severe cold forming operations.

Applications

CarTech BioDur 316LS stainless has found application in fracture fixation devices such as bone plates, screws, and intramedullary nails. This alloy has been used as machining and forging stock for producing surgical implant devices. The alloy has also been used in surgical instruments where high hardness is not a requirement.

Corrosion Resistance

This alloy is balanced with higher chromium, nickel and molybdenum than standard Type 316L stainless, thus increasing its resistance to pitting corrosion. This increased resistance to pitting is illustrated by a Pitting Resistance Equivalent (PRE) of greater than 26 as opposed to a PRE of 23 for standard Type 316L stainless. This chemistry balance, combined with the exceptional cleanliness from the VAR remelt practice and absence of ferrite, makes BioDur 316LS stainless an excellent candidate for orthopedic applications.

Important Note: *The following 4-level rating scale is intended for comparative purposes only. Corrosion testing is recommended; factors which 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	Humidity	Excellent

Properties

Physical Properties

Specific Gravity	7.95	
Density	0.2870	lb/in³
Mean Specific Heat (32 to 212°F)	0.1200	Btu/lb/°F

Mean CTE (32 to 1200°F)	10.3	x 10^{-6} in/in/°F
Electrical Resistivity (70°F)	445.0	ohm-cir-mil/ft

Typical Mechanical Properties

BioDur 316LS stainless is supplied in the unannealed, annealed, or cold worked condition. Mechanical properties can be tailored to specific applications by changing the cold work percentage. In general, the acceptable property ranges are dependent on bar size due to varying penetration of cold work.

The following tables list the maximum specified tensile minimums for various size ranges and the typical mechanical properties for commonly produced tensile requirements.

Maximum Specified Tensile Minimums—BioDur® 316LS stainless

Diameter		Ultimate Tensile Strength	
In.	mm	ksi	MPa
Up to 0.250	Up to 6.3	175	1207
0.251 - 0.500	6.31 - 12.7	165	1138
0.501 - 1.000	12.71 - 25.4	155	1069
1.001 - 1.500	25.4 - 38.1	125	862
1.501 - 1.750	38.11 - 44.5	95	655
Over 1.750	Over 44.5	85	586

Typical Mechanical Properties—BioDur® 316LS stainless
Bar and Wire

Condition	% Cold Work	0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 4D	% Reduction of Area	HRC Hardness
		ksi	MPa	ksi	MPa			
Annealed	N/A	36	248	85	586	57	88	88HRB
Cold Worked	35	115	793	125	862	18	72	26
	48	120	827	145	1000	16	69	32
	52	123	848	150	1034	16	65	34
	60	128	883	160	1103	16	62	36
	70	130	896	170	1172	15	60	38
	80	137	945	180	1241	13	57	40

Typical Mechanical Properties—BioDur® 316LS stainless
Strip up to 0.120" thick

Condition	% Cold Work	0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 4D
		ksi	MPa	ksi	MPa	
Annealed	N/A	44	303	89	613	44
Cold Worked	15	82	565	112	772	27
	25	106	730	126	868	17
	35	130	896	140	965	7
	45	145	999	154	1061	5

Meets ASTM F139 and ISO 5832-1 Composition D specifications.

Heat Treatment

Annealing

Annealing is accomplished by heating in the range of 1800/2050°F (982/1121°C). Typically, the alloy is annealed at the lower end of this range to preserve the fine grain size that is required for medical applications.

Hardening

This alloy cannot be hardened by heat treatment. It must be hardened by cold working.

Workability

Hot Working

BioDur 316LS stainless can be readily forged, upset, and hot headed. To forge, heat uniformly to 2100/2300°F (1149/1260°C). Forgings may be air cooled. Best corrosion resistance is obtained if the forgings are given a subsequent anneal followed by a rapid quench.

Cold Working

BioDur 316LS stainless can be deep drawn, stamped, headed and upset without difficulty.

Machinability

The intentional reduction of sulfur in BioDur 316LS stainless, the cleanliness due to the VAR premium melting practice, and the typically highly cold worked structure make machining more difficult than standard Type 316L stainless.

Rigidly supported tools, as heavy a cut as possible, and positive feed should be used to prevent glazing. For more detailed machining recommendations for Type 316L stainless, consult the "Guide to Machining Carpenter Specialty Alloys."

Following are typical feeds and speeds for BioDur 316LS stainless.

Typical Machining Speeds and Feeds – BioDur® 316LS Stainless

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

Turning—Cut-Off and Form Tools

Tool Material		Speed (fpm)	Feed (ipr)						
			Cut-Off Tool Width (inches)				Form Tool Width (inches)		
High Speed Tools	Carbide Tools		1/16	1/8	1/4	1/2	1	1 ½	2
M2		56-85	.001	.0015	.002	.0015	.001	.001	-
	-	-	-	-	-	-	-	-	-

Rough Reaming

High Speed		Carbide Tools		Feed (ipr) Reamer Diameter (inches)					
Tool Material	Speed (fpm)	Tool Material	Speed (fpm)	1/8	1/4	1/2	1	1 ½	2
M7	70	-	-	.003-.008	.003-.008	.003-.008	.012-.018	012-.018	. 012-.018

Drilling

High Speed Tools									
Tool Material	Speed (fpm)	Feed (inches per revolution) Nominal Hole Diameter (inches)							
		1/16	1/8	1/4	1/2	3/4	1	1 ½	2
M1, M10	50-60	-	-	.004	-	.010	-	-	-

Die Threading

FPM for High Speed Tools				
Tool Material	7 or less, tpi	8 to 15, tpi	16 to 24, tpi	25 and up, tpi
M1, M2, M7, M10	8-15	10-20	15-25	15-25

Milling, End-Peripheral

Depth of Cut (in)	High Speed Tools						Carbide Tools					
	Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in)				Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in)			
			1/4	1/2	3/4	1-2			1/4	1/2	3/4	1-2
.050	M2, M7	75	.001-.004	.001-.004	.001-.004	.001-.004	-	-	-	-	-	-

Tapping

High Speed Tools	
Tool Material	Speed (fpm)
M1, M7, M10	20

Broaching

High Speed Tools		
Tool Material	Speed (fpm)	Chip Load (ipt)
M2, M7	15	.003

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

BioDur 316LS stainless can be satisfactorily welded by the conventional automatic and manual electric-arc techniques. The low carbon content reduces the susceptibility to carbide precipitation in the heat affected zone; however, when optimum corrosion resistance is required, a post weld anneal is always considered good practice. Filler metal should be the same alloy as the parent. Because this alloy is balanced to have zero ferrite potential, it is more susceptible to weld hot cracking than standard Type 316L stainless. This effect may be minimized by keeping heat inputs, base metal dilution, and joint restraint to a minimum.

Other Information

Applicable Specifications

- ASTM F138
- ASTM F139
- ISO 5832-1 Composition D

Forms Manufactured

- Bar-Flats
- Bar-Hexagons
- Bar-Rounds
- Bar-Squares
- Sheet
- Strip
- Wire

Technical Articles

- Effect of Cold Drawing and Heat Treating on Powder Metallurgy Processed ASTM F 1537 Alloy 1 & Alloy 2 Barstock
- Higher Performance Material Solutions for a Dynamic Spine Market
- Properties of an Essentially Nickel-Free Stainless Alloy for Medical Implants
- Selecting New Stainless Steels for Unique Applications
- Specialty Alloys And Titanium Shapes To Consider For Latest Medical Materials Requirements
- Unique Properties Required of Alloys for the Medical and Dental Products Industry

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