

Stainless Steels

DATA SHEET

B-32

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316L STAINLESS STEELS

Alloy type

316L Mo bearing austenitic stainless.

Materials to be welded

ASTM	BS EN & DIN
316L	1.4404/1.4401
316	1.4436
316LN	1.4406/1.4429
CF3M	1.4408
CF8M	1.4437

BS	UNS
316S11/13	S 31603
316S16/31/33	S 31600
316S61	S 31653
316C12/16/71	

Applications

These consumables are used for Mo bearing austenitic stainless steels with 1.5 – 3% Mo. They are also suitable for Ti or Nb stabilised and nitrogen-bearing or free machining versions of the above alloys. Type 316/316L steels are widely used for their good resistance to pitting, many acids and general corrosion.

The 316L consumables covered here are not suitable for 316/316H in elevated temperature structural applications, see data sheets C-12 and C-13. For cryogenic applications (–196°C) see data sheet B-38.

Microstructure

Austenite with a controlled level of ferrite, normally in the range 2-10FN depending on the application.

Welding guidelines

No preheat, maximum interpass temperature 250°C; no PWHT required.

Additional information

There are Technical Profiles available on Superroot 316L and sub-arc welding with 316S92. There is also additional information available covering the Supercore flux cored wires.

Related alloy groups

316L stainless steel consumables for LNG, and other cryogenic applications, are in data sheet B-38. Stainless steel consumables for high temperature applications on 316H can be found in data sheets C-12 or C-13.

Products available

Process	Product	Specification
MMA	Supermet 316L	AWS E316L-17
	Ultramet 316L	AWS E316L-16
	Ultramet B316L	AWS E316L-15
	Ultramet 316LP	AWS E316L-16
TIG	316S92	AWS ER316L
MIG	Supermig 316LSi	AWS ER316LSi
SAW	316S92	AWS ER316L
	SS300	BS EN SA AF2
	SSB	BS EN SA AF2
	LA491	BS EN SA FB255
FCW	L2N	BS EN SF CS 2
	Supercore 316L	AWS E316LT0-1/4
	Supercore 316LP	AWS E316LT1-1/4
	Superroot 316L	AWS R316LT1-5

General Data for all 316L MMA Electrodes

Storage	<p>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.</p> <p>For electrodes that have been exposed: Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total. Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.</p>																
Fume data	<p>Fume composition, wt % typical:</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>Fe</td> <td>Mn</td> <td>Cr</td> <td>Ni</td> <td>Mo</td> <td>Cu</td> <td>F *</td> <td>OES (mg/m³)</td> </tr> <tr> <td>8</td> <td>7</td> <td>5</td> <td>1</td> <td>0.5</td> <td>< 0.2</td> <td>16</td> <td>1</td> </tr> </table> <p>* F=28% for basic coated Ultramet B316L but this does not affect the OES.</p>	Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m ³)	8	7	5	1	0.5	< 0.2	16	1
Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m ³)										
8	7	5	1	0.5	< 0.2	16	1										


SUPERMET 316L

General purpose rutile 316L MMA electrode

Product description	<p>MMA electrode – rutile aluminosilicate flux on high purity 304L core wire giving very low typical carbon level. 'Low hydrogen' manufacturing technology ensures high resistance to weld metal porosity. 'Supermet Technology' gives acid rutile operability combined with controlled silicon content for maximum cracking/corrosion resistance. Designed for ease of use, exceptional weld bead appearance and high weld metal integrity, primarily in the downhand and HV positions; smaller sizes offer all-positional operability.</p> <p>Recovery is about 115% with respect to core wire, 65% with respect to whole electrode.</p>										
Specifications	AWS A5.4 E316L-17 BS EN 1600 E 19 12 3 LR 32 BS 2926 19.12.3.L.AR DIN 8556 E 19 12 3 LR 23										
ASME IX Qualification	QW432 F-No 5, QW442 A-No 8										
Composition (weld metal wt %)		C	Mn	Si	S	P	Cr	Ni	Mo*	Cu	FN
	min	--	0.5	--	--	--	17.0	11.0	2.0	--	3
	max	0.04	2.0	0.90	0.025	0.030	20.0	13.0	3.0	0.5	10
	typ	0.02	0.8	0.6	0.01	0.02	19	12	2.7	0.1	6
	* DIN & BS EN require Mo 2.5 – 3.0%.										
All-weld mechanical properties	As-welded				min		typical		1050°C + WQ		
	Tensile strength		MPa		520		600		550		
	0.2% Proof stress		MPa		320		480		320		
	Elongation on 4d		%		30		42		52		
	Elongation on 5d		%		25		39		49		
	Reduction of area		%		--		60		52		
	Impact energy *		+ 20°C		J		--		70		--
			-196°C		J		--		--		35
	* See data sheet B-38 for as-welded cryogenic applications at –196°C										
Operating parameters	DC +ve or AC (OCV: 50V min)										
	ø mm	1.6	2.0	2.5	3.2	4.0	5.0				
	min A	25	50	60	75	100	130				
	max A	45	70	90	120	155	210				
Packaging data	ø mm	1.6	2.0	2.5	3.2	4.0	5.0				
	length mm	250	300	300	350	450	450				
	kg/carton	8.7	10.5	11.4	12.6	17.4	16.8				
	pieces/carton	1344	846	603	339	249	159				

ULTRAMET 316L

All-positional rutile MMA electrode for 316L

Product description	MMA electrode – rutile flux coated 316L electrode on high purity 304L core wire. Ultramet has all the benefits of an advanced rutile flux design – this includes optimum versatility for downhand welding with high cosmetic finish and weld metal integrity; and all-positional welding with the 2.5/3.2mm electrodes including fixed pipework. Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.											
Specifications	AWS A5.4	E316L-16										
	BS EN 1600	E 19 12 3 L R 3 2										
	BS 2926	19.12.3.LR										
	DIN 8556	E 19 12 3 L R 2 3										
	Approvals	TÜV, Germanischer Lloyd, LRS										
ASME IX Qualification	QW432 F-No 5, QW442 A-No 8											
Composition (weld metal wt %)		C	Mn	Si	S	P	Cr	Ni	Mo*	Cu	FN	
	min	--	0.5	--	--	--	17.0	11.0	2.0	--	3	
	max	0.04	2.0	0.90	0.025	0.030	20.0	13.0	3.0	0.5	10	
	typ	<0.03	1	0.6	0.01	0.02	19	12	2.6	<0.1	6	
	* DIN & BS EN require Mo 2.5 – 3.0%.											
All-weld mechanical properties	As welded				min	typical	1050°C + WQ					
	Tensile strength				MPa	520	580	540				
	0.2% Proof stress				MPa	320	480	305				
	Elongation on 4d				%	30	43	52				
	Elongation on 5d				%	25	41	50				
	Reduction of area				%	--	65	58				
	Impact energy *	+ 20°C			J	--	70	--				
		-100°C			J	--	40	--				
		-196°C			J	--	--	40				
	Hardness				HV	--	230	185				
	* See data sheet B-38 for as-welded cryogenic applications at –196°C.											
Operating parameters	DC +ve or AC (OCV: 50V min)											
	∅ mm	2.5	3.2	4.0	5.0							
	min A	60	75	100	130							
	max A	90	120	155	210							
Packaging data	∅ mm	2.5	3.2	4.0	5.0							
	length mm	300	350	350	450							
	kg/carton	11.4	12.9	13.5	16.5							
	pieces/carton	618	393	261	159							

ULTRAMET B316L

Basic coated MMA pipe-welding electrode for 316L

Product description	MMA electrode – designed and manufactured to give high moisture resistance using a basic flux system and high purity 304L core wire. Ultramet B316L is particularly suited to the most demanding vertical and overhead welding applications including fixed pipework in the ASME 5G/6G position. Under site conditions it is tolerant to adverse wind and drafts. Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.										
Specifications	AWS A5.4	E316L-15									
	BS EN 1600	E 19 12 3 L B 4 2									
	BS 2926	19.12.3.LB									
	DIN 8556	E 19 12 3 L B 20+									
ASME IX Qualification	QW432 F-No 5, QW442 A-No 8										

ULTRAMET B316L (continued)

Composition (weld metal wt %)		C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
	min	--	0.5	--	--	--	17.0	11.0	2.0	--	3
	max	0.04	2.0	0.90	0.025	0.030	20.0	13.0	3.0	0.5	10
	typ	<0.03	1.2	0.3	0.01	0.02	19	12	2.6	<0.1	6

All-weld mechanical properties	As welded			min	typical
	Tensile strength		MPa	520	600
	0.2% Proof stress		MPa	320	470
	Elongation on 4d		%	30	37
	Elongation on 5d		%	25	33
	Reduction of area		%	--	50
	Impact energy *	-50°C	J	--	80
		-196°C	J	--	45
	Lateral expansion *	-196°C	mm	0.38	0.5
	* See data sheet B-38 for as-welded cryogenic applications at -196°C.				

Operating parameters	DC +ve only.									
	∅ mm		2.5	3.2	4.0	5.0				
	min A		60	75	100	130				
	max A		90	120	155	210				

Packaging data	∅ mm	2.5	3.2	4.0	5.0
	length mm	300	350	350	450
	kg/carton	12.0	13.5	13.5	16.5
	pieces/carton	681	396	261	159

ULTRAMET 316LP

All-positional pipe welding and root welding electrode

Product description	<p>MMA electrode – rutile flux on high purity 304L core wire giving very low typical carbon level. Ultramet 316LP is a fully all-positional electrode capable of the most demanding fixed pipework applications including ASME 5G/6G. The Ultramet 316LP electrode has also been designed to deposit single-side root runs without the need for a gas purge. The electrode is also suitable for vertical-down welding on thin sheet material.</p> <p>Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.</p>										
Specifications	AWS A5.4		E316L-16								
	BS EN 1600		E 19 12 3 L R 11								
ASME IX Qualification	QW432 F-No 5, QW442 A-No 8										
Composition (weld metal wt %)		C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
	min	--	0.5	--	--	--	17.0	11.0	2.0	--	3
	max	0.04	2.5	0.90	0.025	0.030	20.0	13.0	3.0	0.5	10
	typ	0.02	0.8	0.8	0.01	0.02	19	12	2.7	0.1	6
All-weld mechanical properties	As welded			min	typical						
	Tensile strength		MPa	520	600						
	0.2% Proof stress		MPa	320	485						
	Elongation on 4d		%	30	37						
	Elongation on 5d		%	25	35						
	Reduction of area		%	--	35						

Operating parameters	DC +ve or AC (OCV: 50V min)									
	∅ mm		2.0	2.5	3.2					
	min A		50	60	75					
	max A		70	90	120					

Packaging data	∅ mm	2.0	2.5	3.2
	length mm	300	300	350
	kg/carton	11.7	12.3	14.4
	pieces/carton	1089	747	459

316S92 and SUPERMIG 316LSi

Solid 316L wire

Product description	Solid wires for TIG, MIG and sub-arc welding.												
Specifications				316S92 (TIG & sub-arc)				Supermig 316LSi (MIG)					
	AWS A5.9 BS EN ISO 14343-A BS EN ISO 14343-B BS 2901: Pt2 DIN 8556 Approvals			ER316L 19 12 3 L SS316L 316S92 SG X2CrNiMo 19 12 (1.4430) TÜV, LRS				ER316L Si G 19 12 3 L Si SS316L Si 316S93 SG X2CrNiMo 19 12 (1.4430) TÜV, LRS				W=TIG, G=MIG, S=SAW	
ASME IX Qualification	QW432 F-No 6, QW442 A-No 8												
Composition (wire wt %)		C	Mn	Si *	S	P	Cr	Ni	Mo	Cu	FN		
	min	--	1.0	0.30	--	--	18.0	11.0	2.5	--	3		
	max	0.03	2.0	0.65	0.020	0.030	20.0	14.0	3.0	0.3	10		
	typ	0.01	1.4	0.5	0.01	0.015	18.5	12.8	2.6	0.15	6		
* Supermig 316LSi : Si range is 0.65 – 1.0%, typically 0.85%.													
All-weld mechanical properties							min				typical		
	As welded								TIG		MIG		SAW + SS300
	Tensile strength					MPa	510		605		570	570	
	0.2% Proof stress					MPa	320		465		435	450	
	Elongation on 4d					%	30		35		42	41	
	Elongation on 5d					%	30		33		40	37	
	Impact energy *				-130°C		J	--		> 100		> 70	> 45
					-196°C		J	--		> 60		30-60	30
Hardness cap/mid					HV	--		200/220		200/220	195/215		
* See data sheet B-38 for as-welded cryogenic applications at -196°C.													
Typical operating parameters				TIG			MIG			SAW			
	Shielding			Argon			Ar+2%O ₂ *			SS300**			
	Current			DC-			DC+			DC+			
	Diameter			2.4mm			1.2mm			2.4mm			
	Voltage			100A, 12V			260A, 26V			350A, 28V			
* Also proprietary Ar and Ar-He gas mixtures with < 3%CO ₂ .													
** SSB, L2N and LA491 also suitable.													
Packaging data			TIG			MIG			SAW				
	ø mm		316S92			Supermig 316LSi			316S92				
	0.8		To order			15kg reel			--				
	1.0		2.5kg tube			15kg reel			--				
	1.2		2.5kg tube			15kg reel			--				
	1.6		2.5kg tube			--			--				
	2.0		2.5kg tube			--			--				
	2.4		2.5kg tube			--			25kg coil				
3.2		2.5kg tube			--			25kg coil					
Fume data	MIG fume composition (wt %) (TIG and SAW fume negligible)												
			Fe	Mn	Cr ³	Ni	Mo	Cu	OES (mg/m ³)				
			30	12	15	11	1.5	< 0.5	3.3				

SUPERCORE 316L, 316LP

Rutile flux cored wires

Product description	<p>Flux cored wires – the wires are made with an austenitic stainless steel sheath and rutile flux system. Supercore 316L combines easy operability, high deposit quality and exceptional weld bead appearance for downhand and HV welding. Supercore 316LP is designed for all-positional welding including fixed pipework. Metal recovery is about 90% with respect to the wire.</p> <p>The Supercore 316L wire is not suitable for applications requiring PWHT or solution annealing – for these applications, it is recommended that Supercore 316LP is used.</p>																										
Specifications & Approvals	AWS A5.22 BS EN ISO 17633-A BS EN ISO 17633-B Approvals (1.2 & 1.6mm)			Supercore 316L E316LT0-1/4 T 19 12 3 L R C/M 3 TS316L-FB0 TÜV, Germanischer Lloyd				Supercore 316LP E316LT1-1/4 T 19 12 3 L P C/M 2 TS316L-FB1 TÜV, Germanischer Lloyd																			
ASME IX Qualification	QW432 F-No 6, QW442 A-No 8																										
Composition (weld metal wt %)		C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN																
	min	--	0.5	0.2	--	--	17.0	11.0	2.5	--	3																
	max	0.04	2.0	1.0	0.025	0.030	20.0	13.0	3.0	0.3	12																
	typ	0.03	1.3	0.5	0.02	0.02	19	12	2.7	0.1	8																
	* 0.9mm diameter Supercore 316L is typically 2.3%Mo and does not conform to BS EN ISO 17633-A.																										
All-weld mechanical properties	As welded				min		typical																				
	Tensile strength				MPa		510					580															
	0.2% Proof stress				MPa		320					440															
	Elongation on 4d				%		30					40															
	Elongation on 5d				%		25					38															
	Reduction of area				%		--					50															
	Impact energy				+ 20°C		J					--					70										
					-110°C		J					--					40										
	Hardness				cap/mid		HV					--					200/210										
Operating parameters	Shielding gas: Either 80%Ar-20%CO ₂ or 100% CO ₂ shielding gas at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.																										
	Current: DC+ve ranges as below for Ar-20%CO ₂ . Welding with 100%CO ₂ requires approx 3V higher:																										
	ø mm	amp-volt range					typical			stickout																	
	0.9 (Supercore 316L only)	75 – 170A, 20 – 30V					120A, 26V			15 – 20mm																	
	1.2	120 – 280A, 21 – 35V					180A, 28V			15 – 20mm																	
	1.2P	120 – 250A, 20 – 32V					160A, 26V			15 – 20mm																	
	1.6	200 – 350A, 26 – 36V					250A, 30V			15 – 25mm																	
Packaging data	Spools vacuum-sealed in barrier foil with cardboard carton: 15kg. The as-packed shelf life is virtually indefinite. Resistance to moisture absorption is high, but to maintain the high integrity of the wire surface and prevent any possibility of porosity, it is advised that part-used spools are returned to polythene wrappers. Where possible, preferred storage conditions are 60% RH max, 18°C min.																										
Fume data	Fume composition (wt %) <table border="1"> <thead> <tr> <th>Fe</th> <th>Mn</th> <th>Ni</th> <th>Cr³</th> <th>Cr⁶</th> <th>Cu</th> <th>F</th> <th>OES (mg/m³)</th> </tr> </thead> <tbody> <tr> <td>14</td> <td>12</td> <td>2.5</td> <td>4</td> <td>4</td> <td>< 1</td> <td>5</td> <td>1.2</td> </tr> </tbody> </table>											Fe	Mn	Ni	Cr ³	Cr ⁶	Cu	F	OES (mg/m ³)	14	12	2.5	4	4	< 1	5	1.2
Fe	Mn	Ni	Cr ³	Cr ⁶	Cu	F	OES (mg/m ³)																				
14	12	2.5	4	4	< 1	5	1.2																				

SUPEROOT 316L

Flux cored TIG wire for root welds without back purge

Product description	<p>Flux cored TIG wire Superoot 316L is made with a seamless austenitic stainless steel sheath, which results in a robust moisture resistant wire and rutile flux system. Superoot 316L is designed specifically for situations where it is impractical to apply back-purge for the TIG root run, or to gain the economic benefit of eliminating back-purge. For most applications, the use of a 316L root bead is considered compatible with subsequent filling with 308L, 347 or 316L as appropriate.</p> <p>Metal recovery is 90% with respect to the whole wire.</p>																									
Specifications	AWS A5.22 BS EN ISO 17633-B		R316LT1-5 TS316L-RI1																							
ASME IX Qualification	QW432 F-No 6, QW442 A-No 8																									
Composition (weld metal wt %)		C	Mn	Si	S	P	Cr	Ni	Mo	Cu																
	min	--	1.0	0.2	--	--	17.0	11.0	2.0	--																
	max	0.03	2.0	1.0	0.025	0.03	20.0	14.0	3.0	0.5																
	typ	0.01	1.6	0.8	0.005	0.020	19.2	12.5	2.2	0.05																
	Typically 5FN.																									
All-weld mechanical properties	As welded					typical																				
	Tensile strength					MPa	605																			
	0.2% Proof stress					MPa	450																			
	Elongation on 4d					%	38																			
	Note: In practice, mechanical properties of the root bead are assessed with the whole joint and subsequent filler.																									
Typical operating parameters	<table border="0" style="width: 100%;"> <tr> <td style="width: 50%;"></td> <td style="text-align: center;">TIG</td> </tr> <tr> <td>Shielding</td> <td style="text-align: center;">Argon*</td> </tr> <tr> <td>Current</td> <td style="text-align: center;">DC-</td> </tr> <tr> <td>Diameter</td> <td style="text-align: center;">2.2mm</td> </tr> <tr> <td>Voltage</td> <td style="text-align: center;">90A, 12V</td> </tr> </table> <p>* No back-purge is required.</p> <p>Satisfactory application of Superoot 316L requires the use of a keyhole welding technique. Further details are available on request.</p>											TIG	Shielding	Argon*	Current	DC-	Diameter	2.2mm	Voltage	90A, 12V						
	TIG																									
Shielding	Argon*																									
Current	DC-																									
Diameter	2.2mm																									
Voltage	90A, 12V																									
Packaging data	ø mm		TIG																							
	2.2		1kg tube																							
Fume data	<p>Fume composition (wt %)</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;"></th> <th style="width: 10%;">Fe</th> <th style="width: 10%;">Mn</th> <th style="width: 10%;">Ni</th> <th style="width: 10%;">Cr³</th> <th style="width: 10%;">Cu</th> <th style="width: 10%;">F</th> <th style="width: 10%;">OES (mg/m³)</th> </tr> </thead> <tbody> <tr> <td></td> <td style="text-align: center;">30</td> <td style="text-align: center;">12</td> <td style="text-align: center;">11</td> <td style="text-align: center;">15</td> <td style="text-align: center;">< 0.5</td> <td style="text-align: center;">--</td> <td style="text-align: center;">3.3</td> </tr> </tbody> </table>											Fe	Mn	Ni	Cr ³	Cu	F	OES (mg/m ³)		30	12	11	15	< 0.5	--	3.3
	Fe	Mn	Ni	Cr ³	Cu	F	OES (mg/m ³)																			
	30	12	11	15	< 0.5	--	3.3																			