

Stainless Steels

DATA SHEET

B-38

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CRYOGENIC 316LCF CONSUMABLES

Alloy type

Controlled ferrite 316L austenitic stainless steels for joining 316L base materials used in cryogenic applications.

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	
316C16/71	

Applications

These consumables are used for Mo bearing austenitic stainless steels with 1.5 – 3% Mo. Type 316/316L steels are widely used for their good resistance to pitting, many acids and general corrosion. The controlled ferrite SMAW electrodes and flux cored wires are specifically designed for cryogenic service; they are not batch selected consumables.

Applications include **pipework** and **vessels** subject to **cryogenic service (-196°C)** eg **LNG**.

Standard 316L consumables for general purpose fabrication can be found in data sheet B-32. The 316L consumables covered here are not suitable for 316/316H in elevated temperature structural applications, see data sheets C-12 and C-13.

Microstructure

Austenite with a controlled level of ferrite, 2-5FN (3-8FN for solid wires).

Welding guidelines

No preheat, maximum interpass temperature 250°C (300°C may be acceptable on thicker section material); no PWHT required.

For optimum impact properties use heat inputs at the higher end of the allowable ranges.

Additional information

There is a Technical Profile covering the use of the controlled ferrite consumables for LNG applications.

G B Holloway et al 'Stainless steel arc welding consumables for cryogenic applications.' Stainless Steel World America 2004 Conference, Houston, 2004.

Related alloy groups

General purpose 316L stainless steel consumables are in data sheet B-32. 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	Ultramet 316LCF	AWS E316L-16
	Ultramet B316LCF	AWS E316L-15
TIG	ER316LCF	AWS ER316L
SAW	ER316LCF	AWS ER316L
	LA491	BS EN SA FB255
FCW	Supercore 316LCF	AWS E316LT1-1/4

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;"> <thead> <tr> <th>Fe</th> <th>Mn</th> <th>Cr</th> <th>Ni</th> <th>Mo</th> <th>Cu</th> <th>F *</th> <th>OES (mg/m³)</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">8</td> <td style="text-align: center;">7</td> <td style="text-align: center;">5</td> <td style="text-align: center;">1</td> <td style="text-align: center;">0.5</td> <td style="text-align: center;">< 0.2</td> <td style="text-align: center;">16</td> <td style="text-align: center;">1</td> </tr> </tbody> </table> <p>* F=28% for basic coated Ultramet B316LCF 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										

ULTRAMET 316LCF


Rutile MMA electrode for cryogenic 316L applications

Product description	<p>MMA electrode – special rutile flux coated 316L electrode on high purity 304L core wire. Versatile downhand and positional capability, Ultramet 316LCF has a controlled composition and ferrite content designed for cryogenic service requiring >0.38mm lateral expansion at minus 130-196°C. Also suitable for unusual occasions when 316L is specified for service up to 550°C and corrosion conditions preclude the use of 316H.</p> <p>Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.</p>											
Specifications	AWS A5.4 BS EN 1600 BS 2926 DIN 8556		E316L-16 (Nearest E 19 12 3 L R 3 2) 19.12.3.LR (Nearest 19 12 3 L R 2 3)									
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	--	2	
	max	0.04	2.0	0.90	0.025	0.030	20.0	13.0	3.0	0.5	5	
	typ	<0.03	1	0.6	0.01	0.02	18	12	2.2	<0.1	3	
	* Does not conform to DIN & BS EN which requires Mo 2.5 – 3.0%.											
All-weld mechanical properties	As welded							min	typical			
	Tensile strength				MPa	520		595				
	0.2% Proof stress				MPa	320		440				
	Elongation on 4d				%	30		43				
	Elongation on 5d				%	25		39				
	Reduction of area				%	--		48				
	Impact energy		+ 20°C		J	--		70				
			-100°C		J	--		50				
			-196°C		J	--		30				
	Lateral expansion *		-196°C		mm	0.38		0.45				
	Hardness				HV	--		230				
	* Batch tested for Charpy lateral expansion >0.38mm 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		13.5		13.5		16.5				
	pieces/carton	618		396		261		165				



ULTRAMET B316LCF

Basic coated MMA pipe-welding electrode for 316L

Product description	<p>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.</p> <p>Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.</p>											
Specifications	AWS A5.4	E316L-15										
	BS EN 1600	(Nearest E 19 12 3 L B 4 2)										
	BS 2926	19.12.3.LB										
	DIN 8556	(Nearest E 19 12 3 L B 20+)										
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	--	2	
	max	0.04	2.0	0.90	0.025	0.030	20.0	13.0	3.0	0.5	5	
	typ	<0.03	1.2	0.3	0.01	0.02	19	12	2.2	<0.1	3	
	* Does not conform to DIN & BS EN which requires Mo 2.5 – 3.0%.											
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	--	50			
	Lateral expansion *					-196°C	mm	0.38	0.60			
	* Batch tested for Charpy lateral expansion >0.38mm at -196°C.											
Operating parameters	DC +ve only.											
	ø mm	2.5	3.2	4.0								
	min A	60	75	100								
	max A	90	120	155								
Packaging data	ø mm	2.5	3.2	4.0								
	length mm	300	350	450								
	kg/carton	12.0	13.5	17.4								
	pieces/carton	681	396	255								

ER316LCF

Solid 316L wire for cryogenic applications

Product description	Solid wires for TIG and sub-arc welding.										
Specifications	AWS A5.9 ER316L BS EN ISO 14343-A 19 12 3 L BS EN ISO 14343-B SS316L BS 2901: Pt2 316S92 DIN 8556 SG X2CrNiMo 19 12 (1.4430)		W=TIG, 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	0.025	2.0	0.65	0.020	0.030	20.0	14.0	3.0	0.3	8
	typ	0.01	1.4	0.5	0.01	0.015	18.5	12.8	2.6	0.15	6
All-weld mechanical properties	As welded					min		typical			
								TIG		SAW + LA491	
	Tensile strength					MPa		510		605 570	
	0.2% Proof stress					MPa		320		465 450	
	Elongation on 4d					%		30		35 41	
	Elongation on 5d					%		25		33 37	
	Impact energy					-130°C		J		-- > 100 > 45	
						-196°C		J		-- > 60 30	
	Lateral expansion *					-196°C		mm		0.38 1.0 0.5	
* ER316LCF SAW wire batch tested, with LA491 flux for Charpy lateral expansion >0.38mm at -196°C.											
Typical operating parameters		TIG			SAW						
	Shielding	Argon			LA491						
	Current	DC-			DC+						
	Diameter	2.4mm			2.4mm						
	Voltage	100A, 12V			350A, 28V						
Packaging data	ø mm	TIG			SAW						
	1.6	2.5kg tube			--						
	2.0	2.5kg tube			--						
	2.4	2.5kg tube			25kg coil						
	3.2	2.5kg tube			--						
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 316LCF

Rutile all positional flux cored wire for cryogenic 316L applications

Product description	<p>Supercore 316LCF has a controlled composition and ferrite content designed for cryogenic service requiring >0.38mm lateral expansion at minus 130-196°C.</p> <p>Supercore 316LCF is designed for all-positional welding including fixed pipework. Metal recovery is about 90% with respect to the wire.</p>																																																			
Specifications	<p>AWS A5.22 E316LT1-1/4 BS EN ISO 17633-A (nearest T 19 12 3 L P C/M 2) BS EN ISO 17633-B TS316L-FB1</p>																																																			
ASME IX Qualification	<p>QW432 F-No 6, QW442 A-No 8</p>																																																			
Composition (weld metal wt %)		C	Mn	Si	S	P	Cr	Ni	Mo *	Cu	FN																																									
	min	--	0.5	0.2	--	--	17.0	11.0	2.0	--	2																																									
	max	0.04	2.0	1.0	0.025	0.030	20.0	13.0	3.0	0.5	5																																									
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Operating parameters	<p>Shielding gas: 80%Ar-20%CO₂ or 100% CO₂ at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.</p> <p>Current: DC+ve ranges as below for Ar-20%CO₂. Welding with 100%CO₂ requires approx 3V higher:</p> <table border="1"> <thead> <tr> <th>ø mm</th> <th>amp-volt range</th> <th>typical</th> <th>stickout</th> </tr> </thead> <tbody> <tr> <td>1.2</td> <td>120 – 280A, 22 – 34V</td> <td>180A, 29V (downhand) 150A, 25V (positional)</td> <td>15 – 20mm</td> </tr> </tbody> </table>											ø mm	amp-volt range	typical	stickout	1.2	120 – 280A, 22 – 34V	180A, 29V (downhand) 150A, 25V (positional)	15 – 20mm																																	
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Packaging data	<p>Spools vacuum-sealed in barrier foil with cardboard carton: 15kg (33 lbs)</p> <p>The as-packed shelf life is virtually indefinite.</p> <p>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.</p> <p>Where possible, preferred storage conditions are 60% RH max, 18°C min.</p>																																																			
Fume data	<p>Fume composition (wt %)</p> <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																									
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