



A-10

# Low Alloy Steels

## 0.5% Mo CREEP RESISTING STEEL

#### Alloy type

Ferritic creep resisting 0.5%Mo steels for elevated temperature service.

#### Materials to be welded

#### pipe/tube:

ASTM	A335 grade P1 A209 & A 250 grade T1
BS	3059 grade 243 3606 grades 243, 245, 261
forged:	
ASTM	A336 grade F1 A204 grades A, B, C
BS EN DIN	10028-2 grade 16Mo3 (1.5415) 15Mo3 (1.5415) 16Mo5 (1.5423) 10MnMo 4 5 (1.5424) 11MnMo 4 5 (1.5425)
cast:	
ASTM	A217 grade WC1 A352 grade LC1
BS	1504 grade 245 3100 grade B1
DIN	GS-22Mo 4 (1.5419)

#### Applications

Nominal 0.5% Mo alloying results in improved elevated temperature performance over that of CMn steels. Used for the **fabrication of vessels** and associated **pipework** demanding creep rupture strength and ductility at temperatures up to about 450°C.

The Mo content also enhances resistance to hydrogen attack in chemical process plant operation.

Favourable mechanical properties of both as-welded and stress-relieved weld metal are also useful in welding structural and general engineering steels for ambient or sub-zero temperature service. In this respect these consumables are related to the higher strength manganese-molybdenum alloyed steel consumables.

**DATA SHEET** 

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#### Microstructure

In the stress-relieved condition the microstructure consists of acicular ferrite with some tempered bainite.

#### Welding guidelines

Preheat and interpass temperatures are normally in the range 100-250°C depending upon thickness being welded and restraint.

#### **Related alloy groups**

For high strength structural welding applications the MnMo alloys (A-50) are related.

#### **PWHT**

PWHT to temper the weldment varies according to the code; the extremes range from 550°C up to 720°C but the most common range is 630-670°C. For material up to 20mm thick some codes allow the PWHT to be omitted.

Process	Product	Specification
MMA	Mo.B	AWS E7018-A1
TIG/MIG	СМо	AWS ER70S-A1



Mo.B	М	olybdenu	m alloy	ed MN	/A eleo	ctrode	for ele	vated te	emperature servi				
Product description	Basic flux, metal po low weld metal hyd			high pur	ity mild s	teel core	wire. M	oisture res	istant coating giving ve				
	Recovery is about 1	20% with re	spect to	core wire	e, 65% wi	th respec	et to who	le electroc	le.				
Specifications	AWS A5.5 BS EN 1599 BS 2493 DIN 8575 BS and AWS Mn ra	E Mo MoB E Mo	o B 26	uired spo	ecification	n should	be stated	l on order.					
ASME IX Qualification	QW432 F-No 4,	BS and AWS Mn ranges overlap, but required specification should be stated on order. <b>QW432</b> F-No 4, <b>QW442</b> A-No 2											
Composition		n* Si	S	Р	Cr	Ni	Мо	Cu					
weld metal wt %)		75 20 0.60	0.025	0.030			0.40 0.65						
		.8 0.3	0.01	0.015	0.05	0.05	0.55	0.05					
All-weld mechanical	PWHT 600-650°C/h	*			min	typic	al	As	s-welded typical				
properties	Tensile strength			IPa	510	550-6			590				
	0.2% Proof stress		N	fPa	400	460-5			480				
	Elongation on 4d Elongation on 5d			%	22 22	27-32 23-29		27 23					
	Reduction of area			%		65-72		68					
	Impact energy	- 20°C	2	J		130			100				
	1	- 30°C		J		11:	-						
	Hardness		]	HV		200	0		200				
	* BS and DIN: 60 Satisfactory pro				e as-weld	ed condi	tion.						
Operating parameters	DC +ve or AC (OC	^					П						
	ø mm	2.5		3.2		4.0		5.0					
	min A	70		80		100		140					
	max A	110		140		180		240					
Packaging data	ø mm	2.5		3.2		4.0		5.0					
	length mm	350		380		450		450					
	kg/carton	12.0		15.0		16.5		16.5					
	pieces/carton	552		390		237		153					
Storage	hydrogen <5ml/100 For electrodes that <b>Redry</b> 250 – 300°C 3 cycles, 10h total.	g weld meta have been ex /1-2h to ensu electrodes at	Il during posed: re $H_2 < 1$ t 100 - 2	8h work 0ml/100	ing shift. g, 300-35	0°C/1-2h	to ensur	$e H_2 < 5ml$	ect use from tin will g /100g. Maximum 420 <sup>r</sup> ed quivers: no limit, 1				
Fume data	Fume composition,	wt % typical	l:										
	Fe	Mn	Ni	Cr	Cu	Pb	)	=   O	ES (mg/m <sup>3</sup> )				
	16	7	<0.1	<0.1	< 0.2	<0.		7	5				



СМо				(	D.5%N	/lo soli	d TIG a	nd MIG	wire fo	r creep i	resisti	ng steel		
Product description	Coppe	er coated s	olid wir	e for TIG a	and MI	G.								
Specifications	BS EI BS 29	AWS A5.28         ER70S-A1         (Previous classification was ER70S-G)           BS EN 12070         Mo Si           BS 2901: Pt1         A30           DIN 8575         SG Mo												
ASME IX Qualification	QW43	<b>QW432</b> F-No 6, <b>QW442</b> A-No 2												
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	V			
(wire wt %)	min	0.08	0.90	0.50					0.45					
(	max	0.12	1.30	0.70	0.020	0.02	0 0.2	0.20	0.60	0.3	0.03			
	typ	0.1	1.2	0.6	0.01	0.01	0.03	0.02	0.5	0.05	0.01			
All-weld mechanical properties	Proper	Properties as-welded (AW) or after PWHT: r			min. *	typical: TIG AW 620°C/1h			MAG: Ar + 5%					
	Tensile	e strength		MP		515	662		640	650		620		
	0.2% F	Proof stres	s	Ν	мРа	400	540		520	530		505		
	•	ation on 4c			%	19	29		25	29		25		
		ation on 5c			%	22	26		24	25		24		
	Impact	t energy	-	30°C	J		52		170	42		96		
	* M		alues are	e after PW				5°C/0.5h (		215/23 as-welded lower strer	l for BS			
Typical operating				TIG			MIG	6						
parameters	Shieldi	ina		Argon			1 - 2 - 2							
		0				Argon	+ 1.5% O <sub>2</sub>		tary					
	Curren			DC-			DC-							
	Diame			2.4mm	7		1.2m							
	Param	eters		100A, 12V	V		260A, 2	20 V						
Packaging data	ø mm			TIG			MIG							
	1.2						15kg sj	bool						
	1.6			5kg tube										
	2.4			5kg tube										
Fume data	MIG f	ume comp	osition	(wt %) (T	IG fume	e negligit	ole)							
			Fe	Mn	Cr <sup>3</sup>	Ni	Мо	Cu	OE	S (mg/m <sup>3</sup> )				
			55	5	< 0.1	< 0.1	< 0.5	1.2		5	_			



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# Low Alloy Steels

## 1<sup>1</sup>/<sub>4</sub>Cr-<sup>1</sup>/<sub>2</sub>Mo CREEP RESISTING STEEL

#### Alloy type

1<sup>1</sup>/<sub>4</sub>Cr-<sup>1</sup>/<sub>2</sub>Mo alloyed steel consumables for elevated temperature service.

#### Materials to be welded

#### ASTM

BS EN & DIN

A387 Gr 11 & 12 A182 F11 & F12 A217 WC6 & WC11 A234 WP11 & WP12 A199 T11 A200 T11 A213 T11 & T12 A335 P11 & P12 13CrMo 4-5 (1.7355) 13CrMo 4-4 (1.7335) 16CrMo 4-4 (1.7337) 11CrMo 5-5 (1.7339) GS-25CrMo 4 (1.7128) GS-17CrMo 5-5 (1.7357)

#### BS

1501 Gr 620 & 621 1502 Gr 620 1503 Gr 620 & 621 1504 Gr 621 3100 Gr B2 3604 Gr 620/440 & 621 3059 Gr 620/460

#### Applications

These consumables are designed for prolonged elevated temperature service up to 550°C. Main areas of application are associated with steam generating power plant, eg piping, turbine castings, steam chests, valve bodies and boiler superheaters. Some of the consumables will also find service in refineries where they are used for corrosion resistance to sulphur bearing crude oil at 250-450°C. Some of the consumables will also find applications in the chemical and petro-chemical industries where they are used for resistance to hydrogen attack in the fabrication of hydrocrackers, coal liquefaction plant and NH<sub>3</sub> pressure vessels operating at up to 450°C. In the aswelded condition the consumables also provide a useful source of 300HV hardness weld deposit for build-up or

hardsurfacing to resist metal-to-metal wear and heavy impact.

DATA SHEET

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#### Microstructure

After PWHT, the microstructure consists of tempered bainite.

#### Welding guidelines

Preheat and interpass temperature 200°C minimum, up to 300°C for thick sections. Maintain throughout welding cycle and some time after completion of welding.

#### **PWHT**

Apart from some special applications, PWHT will always be required. PWHT temperature is typically 690°C with time being dependent on section thickness.

#### Additional information

There are Technical Profiles available which cover some of the consumables on this data sheet. Additional information is available on Chromet 1X and Cormet 1.

Products available

Process	Product	Specification
MMA	Chromet 1	AWS E8018-B2
	Chromet 1L	AWS E7015-B2L
	Chromet 1X *	AWS E8018-B2
TIG/MIG	1CrMo	BS EN CrMo1Si
	ER80S-B2	AWS ER80S-B2
SAW	SA 1CrMo	AWS EB2
	LA121	BS EN SA FB 1
FCW	Cormet 1	AWS E81T1-B2

\* Chromet 1X is the temper embrittlement resistant (TER) version of Chromet 1.

## Cr-½Mo CREEP R



## General Data for all 1<sup>1</sup>/<sub>4</sub>Cr-<sup>1</sup>/<sub>2</sub>Mo Electrodes

Description		o the co	re wire and					e. Recovery is appr sture resistant coatin	
Storage	hydrogen < 50 For electrodes <b>Redry</b> 250 – 420°C, 3 cycl <b>Storage</b> of re	ml/100g s that ha 300°C/ es, 10h dried el	for longer we been exp 1-2h to ensi total. ectrodes at	than a worposed: ure $H_2 < 1$ $50 - 200^{\circ}$	rking shift .0ml/100g, C in holdin	of 8h. 300 – 350° ng oven or he	C/1-2h to eated qui	If life. Direct use from $H_2 < 5ml/1$ o ensure $H_2 < 5ml/1$ ver: no limit, but ma using plastic lid): < 0	00g. Maximum aximum 6 weeks
Operating parameters	DC +ve or AC	C (OCV	: 70V min)						ĴÊ Î
	ø mm		2.5		3.2	4.0	1	5.0	6.0
	min A		70		80	100	)	140	200
	max A		110		140	180	)	240	300
Fume data	Fume compos	sition, w	rt % typical	:					
		Fe	Mn	Cr	Ni	Cu	F	OES (mg/m <sup>3</sup> )	
		15	5	< 0.5	< 0.1	< 0.2	18	5	

CHROMET 1										1¼Cr-½Mo M	IMA electrode
Product description	MMA	electro	de meet	ing AW	'S and B	S EN nati	onal stan	dards su	itable for	most power genera	ation applications.
Specifications	AWS BS EI BS 24 DIN 8	N 1599 193		E 10	8018-B2 CrMo 1 CrMo B CrMo 1	B 3 2 H					
ASME IX Qualification	QW43	32 F-N	o 4, <b>Q</b>	W442	A-No 3						
Composition		C	Mn*	Si	S	Р	Cr	Мо	Cu		
(weld metal wt %)	min	0.05	0.50				1.00	0.45			
	max	0.10	0.90	0.50	0.025	0.025	1.40	0.65	0.15		
	typ	0.07	0.8	0.35	0.012	0.015	1.25	0.55	< 0.10		
	* Mn	may ex	ceed A	WS 0.90	)% max.						
All-weld mechanical											
properties	PWHT	690°C/	1h				min	ty	/pical		
	Tensile	e streng	th			MPa	550		650		
		Proof str				MPa	460		570		
	-	ation on				%	19		25		
	0	ation on tion of a				%	17		21		
		t energy		+ 2	ഘ	% J	 47		70 160		
	impac	cenergy		-10		J			100		
	Hardn	ess		(AV	-	HV			250		
					VHT)	HV			210		
	Prehea	at 150 –	250°C	(BS EN	), 200 – 1	300°C (B	S), 160 –	190°C	(AWS), 2	200 – 350°C (DIN).	
Packaging data	ø mm			2.5		3.2		4	.0	5.0	6.0
	length	mm		350	)	380	)	4.	50	450	450
	kg/car			12.6		15.0		16		17.4	17.4
	pieces	/carton		627		372	2	24	43	159	111



CHROMET 1L								Lo	w carbo	on 1¼C	r-½Mo	MMA el	ectrode
Product description	resistar	nce to sulp	hide stro		on cracki	ng wl	hen op	erating	g in wet 's				tresses for ole for thin
Specifications	AWS A BS EN BS 24 DIN 85	1599 93		E7015-B ECrMo 1 1CrMo L ECrMo 1	L B 3 2 B H								
ASME IX Qualification	QW43	<b>2</b> F-No 4	, <b>QW</b> 4	42 A-No	3								
Composition		С	Mn*	Si	S	Р	)	Cr	Мо	Cu			
(weld metal wt %)	min	0.03	0.50			-	-	1.00	0.45				
. ,	max	0.05	0.90	0.50	0.025	0.0	25	1.40	0.65	0.15			
	typ * Mn i	0.04 may excee	0.8 ed AWS	0.35 0.90% ma	0.012 ax.	0.0	15	1.25	0.55	<0.10			
All-weld mechanical	PWHT	690°C/1h					min		typical				
properties	Tensile	strength			М	Pa	520		600				
	0.2% P	roof stres	s		Μ	Pa	390		500				
	-	tion on 4d				%	19		26				
		tion on 5d				%	17		23				
		ion of are	-	••••		%			68				
	Impact	energy		· 20°C 10°C		J J			180 120				
	Hardne			AW)	Ц	IV			220				
	Tharana	.55		PWHT)		IV			200				
Packaging data	ø mm			2.5		3.2			4.0		5.0		
	length			350		380			450		450		
	kg/carte			12.0		15.0			17.7		18.0		
	pieces/	carton		612		399			252		168		

CHROMET 1X			1¼Cr-1	∕₂Mo a	lloyed	MMA e	lectroc	le for t	emper	embrit	tlemen	t resistance	
Product description	resistar	MMA electrode $-1\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo deposit which meets specific requirements for improved temper embrittle resistance with prolonged service at 400-600°C. Relevant trace elements (P, Sn, As, Sb) are controlled to e low Bruscato (X) and Watanabe (J) factors.											
Specifications	AWS BS EN BS 24 DIN 8	N 1599 93		E8018- ECrMo 1CrMo ECrMo	1 B								
ASME IX Qualification	QW43	<b>2</b> F-No	4, <b>QW</b>	442 A-N	lo 3								
Composition		С	Mn*	Si*	S	Р	Cr	Мо	Cu	Sn	As	Sb	
(weld metal wt %)	min	0.05	0.50	0.15			1.00	0.45					
	max	0.10	0.90	0.30	0.015	0.012	1.40	0.65	0.15	0.005	0.010	0.005	
	typ	0.06	0.7	0.25	0.012	0.009	1.25	0.55	< 0.05	0.002	0.003	< 0.002	
	* Mn+	-Si < 1.1	0%										
	Brusca	to factor	(X) :	<u>10P</u>	+ 5Sb + 2 100	4Sn + As	(ppm)	=	15 max	i			
	Watan	abe facto	r (J) :	(Mn-	+Si)x(P +	- Sn) x 10	4	=	180 ma	X			



## CHROMET 1X (continued)

All-weld mechanical	(1)					690°C/5h	690°C/5h + SC
properties	PWHT 690°C/1h <sup>(1)</sup> (\$	SC = step cooled	l)	min	typical	typical	typical
	Tensile strength		MPa	550	660	610	595
	0.2% Proof stress		MPa	460	570	515	490
	Elongation on 4d		%	19	25	29	29
	Elongation on 5d		%	20	21	25	25
	Reduction of area		%		70	70	70
	Impact energy	+ 20°C	J	47 (2)	160	200	200
		- 30°C	J		100	160	140
	Hardness	(AW)	HV		300-320		
		(PWHT)	HV		220-250	220	190
	<ul> <li><sup>(1)</sup> BS &amp; AWS PW</li> <li><sup>(2)</sup> DIN &amp; BS EN r</li> </ul>	,		>30min, BS	EN 720°C/11	1.	
Packaging data	ø mm	2.5	3.2		4.0	5.0	
	length mm	350	380		450	450	
	kg/carton	12.6	15.0		16.8	17.4	
	pieces/carton	627	372		243	159	

Solid welding wire for TIG & MIG.

Product description	Coppe	r coated	wire for	TIG and	MIG we	lding of	1¼Cr-½	Mo stee	ls, confor	ming to European	specifications.
Specifications		N 12070 01: Pt1		ER80S CrMo1 A32 SG CrM	Si	(W = TI	G, G = N	AIG)			
ASME IX Qualification	QW43	<b>32</b> F-No	6, <b>QW</b>	<b>1442</b> A-N	No 3						
Composition (wire wt %)	min max typ	C 0.06 0.12 0.1	Mn 0.80 1.20 1	Si 0.40 0.80 0.6	S  0.020 0.010	P  0.020 0.015	Cr 1.10 1.50 1.2	Ni  <0.1	Mo 0.45 0.65 0.5	Cu  0.4 0.1	
All-weld mechanical properties	Tensile 0.2% F Elonga	690°C/4 e strength Proof streation on 4 e energy ess	ss	=1h) -10°C	HV	MPa MPa % J (HB)	min 550 470 19 		ty <u>TIG</u> 635 520 25 > 200 20(215)	rpical <u>MIG</u> 590 480 26 > 115 195(190)	
Typical operating parameters	Shieldi Curren Diame Param	it ter		TIG Argor DC- 2.4mn 100A, 1	n	1	MIG -5%CO <sub>2</sub> DC+ 1.2mm 0A, 26V				
Packaging data	ø mm 0.8 1.2 1.6 2.4 3.2			TIG  5kg tub 5kg tub 5kg tub	be		MIG 5kg reel 5kg reel  				
Fume data	MIG f	ume com	position Fe 55	n (wt %) ( Mn 5	TIG fum Cr <sup>3</sup>	ne negligi Ni < 0	i N	10 0.5	Cu 1.2	OES (mg/m <sup>3</sup> )	



ER80S-B2								S	Solid we	elding wire for T	TIG & MIG.
Product description	Coppe specifi		wire for '	TIG and N	/IG weld	ling 1¼C	r-½Mo cro	eep resi	isting stee	els, conforming to the	e AWS/ASME
Specifications	_	N 12070 01: Pt1		ER80S-  A32 	·B2						
ASME IX Qualification	QW43	82 F-No	6, <b>QW</b>	442 A-N	lo 3						
Composition (wire wt %)	min max typ	C 0.07 0.12 0.1	Mn 0.40 0.70 0.5	Si 0.40 0.70 0.5	S  0.020 0.010	P  0.020 0.015	Cr 1.20 1.50 1.3	Ni  0.20 <0.1	Mo 0.40 0.65 0.5	Cu 0.35 0.1	
All-weld mechanical properties	Tensile 0.2% F Elonga Hardne	690°C/4 e strength Proof stre ttion on 4 ess energy	SS	=1h) - 10°C		Pa Pa % B) J	min 550 470 19 		TIG 635 520 25 220(215) > 200	typical MIG 590 480 26 195(190) > 115	
Typical operating parameters	Shieldi Curren Diame Param	it ter		TIG Argon DC - 2.4mm 100A, 12	l	Ar - I 1.	MIG 5% CO <sub>2</sub> DC+ 2mm A, 26V				
Packaging data	ø mm 1.2 1.6 2.4 3.2			TIG  5kg tub 5kg tub 5kg tub	e		MIG kg reel  				
Fume data	MIG fi	ume com	Fe	(wt %) (* Mn	Cr <sup>3</sup>	Ni	Мо		Cu	OES (mg/m <sup>3</sup> )	
			55	5	0.4	<0.1	<0	5	1.2	5	

LA121 FLUX									Sub	-arc flux
Product description	Agglomerated basis size is 0.2 – 2.0mr 40%(CaO +	n. Nom	inal com	position o	f the flu	ıx is:			d Mn pick-up/burn-or F2)	ut. Particle
Specifications	AWS A5.23 DIN 32522 BS EN 760	E		82 B2 AC 10 M 55 AC H5	,					
ASME IX Qualification	QW432 F-No,	QW44	2 A-No							
Composition (typical)	SA 1CrMo wire Deposit	C 0.10 0.07	Mn 0.8 0.8	Si 0.25 0.25	S 0.010 0.010	P 0.012 0.015	Cr 1.3 1.2	Mo 0.55 0.55		
All-weld mechanical properties with SA 1CrMo wire	PWHT 700°C/10h Tensile strength 0.2% Proof stress Elongation on 4d Impact energy Hardness cap/mid	+	-20°C	MPa MPa % J HV		/pical 480 360 40 80 50/180				



## LA121 FLUX (continued)

Typical operating	Current: DC +ve			
parameters	ø mm	amps	volts	travel speed, mm/min
	2.4	350	28	500
	3.2	450	28	500
	4.0	600	30	600
Packaging data		RH, > 18°C.	If the flux	oisture resistant 25kg metal drums. Preferred storage conditions for x has become damp or has been stored for a long period, it should be

CORMET 1							All-p	positional flux cored	wire			
Product description	<b>Cormet 1</b> is an all-position sheath with a metal reco						ed pipewor	k. Made using a high purit	y stee			
Specifications	AWS A5.29 BS EN ISO 17634-B		1-B2M 1-1M-10	CM								
ASME IX Qualification	QW432 F-No 6, QW	<b>442</b> A-N	lo 3									
Composition (weld metal wt %)	C         Mn           min         0.05            max         0.12         1.25           typ         0.06         1.0	Si  0.80 0.3	S  0.030 0.01	P  0.030 0.01	Cr 1.00 1.50 1.3	Mo 0.40 0.65 0.55	Cu  0.30 0.05					
All-weld mechanical properties	PWHT 690°C/1-2h Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 4d Impact energy Hardness	+ 20°C	М	Pa : Pa 4	min 550 470 19 17 	typical 650 550 24 22 > 40 220						
Operating parameters		le for use s as belov amp-vo 160 – 2	with 10 v:	0%CO <sub>2</sub> .	(Note: f		CO <sub>2</sub> shield	out argon should not exceed ing gas, voltage should be stickout 15 – 25mm 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 preven 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	%)										
		Mn 8	Ni < 0.5	Cr <sup>5</sup> 1			Cu F < 1 8	( 3 )				



## 2¼Cr-1Mo CREEP RESISTING STEEL

#### Alloy type

2<sup>1</sup>/<sub>4</sub>Cr-1Mo alloyed steel consumables for elevated temperature service.

#### Materials to be welded

ASTM

#### BS EN & DIN

A387 Gr 21 & 22 A182 F22 A217 WC9 A234 WP22 A199 T21, T22 A200 T21, T22 A213 T22 A335 P22 A234 WP22 11CrMo9-10 (1.7383) 10CrMo 9-10 (1.7380) GS-18CrMo 9 10 (1.7379) GS-12CrMo 9 10 (1.7380) 6CrMo 9 10 (1.7385) 12CrMo 9 10 (1.7375)

#### BS

#### Also Cr-Mo-V steels

BS 1503 Gr 660 BS 1504 Gr 660 BS 3100 Gr B7 BS 3604 Gr 660 1501 Gr 622 1503 Gr 622 1504 Gr 622 3100 Gr B3 3604 Gr 622 3059 Gr 622/640 & 622/490

#### Applications

These consumables are designed for prolonged elevated temperature service up to 600°C. Main areas of application are associated with steam generating power plant, eg piping, turbine castings, steam chests, valve bodies and boiler superheaters. Some of the consumables will also find service in refineries where they are used for corrosion resistance to sulphur bearing crude oil at 250-450°C. Some of the consumables will also find applications in the chemical and petro-chemical industries where they are used for resistance to hydrogen attack in the fabrication of hydrocrackers, coal liquefaction plant and NH<sub>3</sub> pressure vessels operating at up to 450°C. In the aswelded condition the consumables also provide a useful source of 300HV hardness weld deposit for build-up or hardsurfacing to resist metal-to-metal wear and heavy impact.

### DATA SHEET A-13

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#### Microstructure

After PWHT, the microstructure consists of tempered bainite.

#### Welding guidelines

Preheat and interpass temperature 250°C minimum, up to 300°C for thick sections. Maintain throughout welding cycle and some time after completion of welding.

#### **PWHT**

Apart from some special applications, PWHT will always be required. PWHT temperature is typically 690°C with time being dependent on section thickness.

#### Additional information

There are Technical Profiles available which cover some of the consumables on this data sheet. Additional information is available on Chromet 2X and Cormet 2.

**Products available** 

#### Process Product Specification MMA **Chromet 2** AWS E9018-B3 Chromet 2L AWS E8015-B3L Chromet 2X \* AWS E9018-B3 TIG/MIG 2CrMo BS EN CrMo2Si ER90S-B3 AWS ER90S-B3 SAW SA 2CrMo AWS EB3 LA121 BS EN SA FB 1 FCW Cormet 2 AWS E91T1-B3 AWS E91T1-B3L Cormet 2L

\* Chromet 2X is the temper embrittlement resistant (TER) version of Chromet 2.

#### Rev 05 09/06



	Genera	l Da	ta for a	<b>all 2</b> ½	∕₄Cr-1	Mo El	ectro	odes					
Description	with respect	Basic flux, metal powder type coatings on low carbon high purity core wire. Recovery is approximately 115% with respect to the core wire and 65% with respect to whole electrode. Moisture resistant coating gives very low weld metal hydrogen levels.											
Storage	hydrogen < For electrod Redry 250 - 420°C, 3 cyc Storage of r	<b>3 hermetically sealed ring-pull metal tins</b> per carton, with unlimited shelf life. Direct use from tin will give hydrogen $< 5ml/100g$ for longer than a working shift of 8h. For electrodes that have been exposed: <b>Redry</b> 250 - 300°C/1-2h to ensure H <sub>2</sub> $< 10ml/100g$ , 300 - 350°C/1-2h to ensure H <sub>2</sub> $< 5ml/100g$ . Maximum 420°C, 3 cycles, 10h total. <b>Storage</b> 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, $> 18°C$ .											
Operating parameters	DC +ve or A	AC (OC	V: 70V min)						Ê Î				
	ø mm		2.5		3.2	4.0	)	5.0	6.0				
	min A		70		80	100	)	140	200				
	max A		110		140	180	)	240	300				
Fume data	Fume comp	osition,	wt % typical:										
	Fe Mn Cr Ni Cu F OES (mg/m <sup>3</sup> )												
		15	5	1	< 0.1	< 0.2	18	5					

CHROMET 2										2¼Cr-1	Mo MMA	A electrode		
Product description	MMA	electro	de mee	ting AW	'S and B	S EN nati	onal stan	dards su	itable for	most power	generation	applications.		
Specifications	BS 24 DIN 8	N 1599 193		E 20 E	9018-B3 CrMo 2 CrMo B CrMo 2 onforms	B 3 2 H B 2 6	ication re	quireme	nts.					
ASME IX Qualification	QW43	QW432 F-No 4, QW442 A-No 4												
Composition		С	Mn*	Si	S	Р	Cr	Мо	Cu	Sn	As			
(weld metal wt %)	min	0.05	0.50				2.00	0.90						
	max	0.10	0.90	0.50	0.015	0.020	2.50	1.20	0.15	0.010	0.035			
	typ * Mn	0.07 0.07 0.07	0.8 ceed A	0.35 WS 0.90	0.012 )% max.	0.015	2.25	1.05	< 0.10	<0.006	<0.010			
All-weld mechanical	PWHT	PWHT 690°C/1h min typica							typical					
properties	Tensile	e streng	th			MPa	630		700					
		Proof str				MPa	540		620					
		ation on				%	17		22					
	-	ation on				%	15		19					
		tion of a				%			65					
	Impact	t energy			0°C	J	47		140					
	Linuda			-10	-	J			80					
	Hardne	ess		(AV	· ·	HV HV			300-320					
					VHT)	. 1			220-250					
	Prehea	nt 200 –	300°C	(BS & I	BS EN),	160 – 190	0°C (AWS	5), 200 -	– 350°C (I	DIN).				
Packaging data	ø mm			2.5		3.2		-	.0	5.0		6.0		
	length	mm		350		380	)	4	50	450		450		
	kg/cart			12.0		15.0			5.2	17.1		16.2		
	pieces	/carton		621		396	5	22	28	156		105		



CHROMET 2L								Low carb	on 2¼	Cr-1Mo	MMA e	lectrode
Product description	for res	istance to	sulphid	e stress co	rrosion cr	acking	, when c	ich produces operating in v that cannot b	vet 'sour'	environme	nts. The	
Specifications	AWS BS EN BS 24 DIN 8	N 1599 93		E8015-B ECrMo 2 2CrMo I ECrMo 2	2 L B 3 2 L B H							
ASME IX Qualification	QW43	<b>32</b> F-No 4	, <b>QW</b>	442 A-No	04							
Composition (weld metal wt %)	min max typ * Mn	C 0.03 0.05 0.04 may exceed	Mn* 0.50 0.90 0.8 d AWS	Si  0.50 0.35 5 0.90% m	S 0.015 0.012 ax.	P  0.02 0.01	0 2.	00 0.90 50 1.20	Cu  0.15 <0.10			
All-weld mechanical properties	Tensile 0.2% F Elonga Elonga Reduct	690°C/1h e strength Proof stress titon on 4d titon on 5d tion of area e energy	1 - (	+ 20°C -10°C (AW) (PWHT)	H		min 550 460 17 15    	typical 630 540 24 20 70 160 90 250-260 210-220				
Packaging data	ø mm length kg/cart pieces	on		2.5 350 12.0 621		3.2 380 15.0 396		4.0 450 17.4 228		5.0 450 17.1 156		

CHROMET 2X			2¼Cr-	1Mo a	lloyed l	MMA e	lectrod	e for t	emper	embrit	lemen	t resistanc	e		
Product description	resista		prolonge	d service	at 400-6	00°C. Re	1				1	r embrittleme rolled to ensu			
Specifications	BS EN BS 24	WS A5.5       E9018-B3         S EN 1599       ECrMo 2 B         S 2493       2CrMo B H         IN 8575       ECrMo 2 B 2 6													
ASME IX Qualification	QW43	QW432 F-No 4, QW442 A-No 4													
Composition (weld metal wt %)	Brusca	C 0.05 0.10 0.06 -Si < 1.10 tto factor abe factor	(X) :		100	P  0.012 0.010 4 <u>Sn + As</u> + Sn) x 10		Mo 0.90 1.20 1.05 = =	Cu  0.15 <0.05 15 max 180 ma		As 	Sb  0.005 <0.002			



## **CHROMET 2X (continued)**

All-weld mechanical properties	PWHT 690°C/1h <sup>(1)</sup> (\$	SC = step cooled	I)	min	typical	690°C/5h typical	690°C/5h + SC typical
	Tensile strength		MPa	630	700	660	650
	0.2% Proof stress		MPa	540	620	560	550
	Elongation on 4d		%	17	22	27	25
	Elongation on 5d		%	18	19	24	20
	Reduction of area		%		65	70	65
	Impact energy	+ 20°C	J	47 <sup>(2)</sup>	140	170	170
		- 30°C	J		80	140	110
	Hardness	(AW)	HV		300-320		
		(PWHT)	HV		220-250	195	205
	(1) BS & AWS PW (2) DIN & BS EN r			>30min, BS	EN 720°C/11	1.	
Packaging data	ø mm	2.5	3.2		4.0	5.0	
	length mm	350	380		450	450	
	kg/carton	13.5	15.0		18.0	17.1	
	pieces/carton	681	396		270	156	

2CrMo						Solid we	elding wir	e for TIG 8	ξ MIG.			
Product description	Coppe	r coated w	vire for	TIG and	MIG we	elding of	2¼Cr-1N	lo steels	, conform	ing to Euro	pean specifica	tions.
Specifications		N 12070 01: Pt1		ER90S CrMo2 A33 SG CrM	Si	(W = TI	G, G = N	fIG)				
ASME IX Qualification	QW43	<b>32</b> F-No 6	, <b>QW</b>	<b>442</b> A-N	lo 4							
Composition (wire wt %)	min max typ	C 0.06 0.12 0.1	Mn 0.80 1.20 1	Si 0.40 0.80 0.6	S  0.020 0.010	P  0.020 0.015	Cr 2.30 2.70 2.4	Ni  <0.1	Mo 0.90 1.10 1	Cu  0.4 0.15		
All-weld mechanical properties	Tensile 0.2% F Elonga	690°C/4h e strength Proof stres ttion on 4d energy ess	s	-10°C	HV	MPa MPa % J /(HB)	min 620 540 17 	>	typ TIG 660 550 22 5150 5(220)	bical MIG 655 540 23 > 95 220(215	i)	
Typical operating parameters	Shielding Current Diameter			TIG Argon DC- 2.4mm			MIG Ar-5%CO <sub>2</sub> DC+ 1.2mm					

		55	5	1.3	< 0.1	< 0.5	1.2	5
Fume data	MIG fume comp	position ( Fe	wt %) (Tl Mn	IG fume Cr <sup>3</sup>	negligible) Ni	Мо	Cu	OES (mg/m <sup>3</sup> )
			-					
	3.2		5kg tube					
	2.4		5kg tube					
	2.0		To order					
	1.6		5kg tube					
	1.2				15kg 1			
	0.8				15kg 1	reel		
Packaging data	ø mm		TIG		MIG	3		
	Parameters	1	00A, 12V	V	280A,			
	Diametei		2.4IIIIII		1.2111	111		



ER90S-B3								So	lid we	lding wire fo	or TIG & MIG.
Product description	Copper coa specificatio		e for T	IG and M	1IG weld	ing 2¼C	r-1Mo cree	ep resisti	ng steel	s, conforming to	o the AWS/ASME
Specifications	AWS A5.2 BS EN 12 BS 2901: DIN 8575	070		ER90S-  A33 	B3						
ASME IX Qualification	<b>QW432</b> F	-No 6,	QW4	<b>42</b> A-N	o 4						
Composition (wire wt %)	min 0.	07 ( 12 (	Mn 0.40 0.70 0.5	Si 0.40 0.70 0.5	S  0.020 0.010	P  0.020 0.015	Cr 2.30 2.70 2.4	Ni  0.20 <0.1	Mo 0.90 1.20 1	Cu  0.35 0.1	
All-weld mechanical properties	PWHT 690 Tensile stre 0.2% Proof Elongation Hardness Impact ene	ength stress on 4d	AWS=1	1h) - 10°C	MP MP 9 HV(HE	Pa %	min 620 540 17 	225	TIG 660 550 22 5 (220) 5 (220) 5 150	typical MIG 655 540 23 220(215 > 95	)
Typical operating parameters	Shielding Current Diameter Parameters	;		TIG Argon DC - 2.4mm 100A, 12		Ar - I 1.	MIG $5\% \text{ CO}_2$ OC+ 2mm A, 26V				
Packaging data	ø mm 1.2 1.6 2.4			TIG  5kg tube 5kg tube			MIG cg reel  				
Fume data	MIG fume	-						~	I	<b>050</b> (m. ( <sup>3</sup> )	
		Fe 55		Mn 5	Cr <sup>3</sup>	Ni <0.1	Mo <0.5	C		OES (mg/m <sup>3</sup> ) 5	

LA121 FLUX									Sub-arc flu	лх
Product description	Agglomerated bas size is 0.2 – 2.0mr 40%(CaO + MgO	n. Nom	inal com	position o	of the flu	x is:			d Mn pick-up/burn-out. Partic	ele
Specifications	AWS A5.23 DIN 32522 BS EN 760	E		3 B3 AC 10 M 55 AC H5						
ASME IX Qualification	QW432 F-No 6,	QW44	<b>2</b> A-No	4						
Composition		С	Mn	Si	S	Р	Cr	Мо		
(typical)	SA 2CrMo wire Deposit	0.10 0.07	0.8 0.8	0.25 0.25	0.010 0.010	0.012 0.015	2.5 2.2	1.0 1.0		
All-weld mechanical	PWHT 690°C/1h				typic	al				
properties with	Tensile strength			MPa	59	0				
SA 2CrMo wire	0.2% Proof stress			MPa						
	Elongation on 4d		2000	%	22					
	Impact energy Hardness	+	20°C	J HV	14					
	riarane35			11 V	20	0				



## LA121 FLUX (continued)

Typical operating	Current: DC +ve			
parameters	ø mm	amps	volts	travel speed, mm/min
	2.4	350	28	500
	3.2	450	28	500
	4.0	600	30	600
Packaging data		2H, ≥ 18°C.	If the flux	bisture resistant 25kg metal drums. Preferred storage conditions for thas become damp or has been stored for a long period, it should be

Product description	<b>Cormet 2</b> is an all-positional flux cored wire suitable for welding fixed pipework. Made using a high purity stee sheath with a metal recovery of about 90% with respect to the wire.												
	<b>Cormet 2L</b> , which is the low carbon version, is available to order; this wirepairs in power generation plant and the lower hardness may provide some applications.												
Specifications	AWS A BS EN		′634-B		net 2 1-B3M 1-1M-20	C1M		et 2L -B3LM -1M-2C	1ML				
ASME IX Qualification	QW432 F-No 6, QW442 A-No 4												
Composition (weld metal wt %)	min max typ * Corme	C* 0.05 0.12 0.06 et 2L C	Mn  1.25 1.0 ≤ 0.05%	Si  0.80 0.3 %, typical	S 0.030 0.01 0.04%	P  0.030 0.01	Cr 2.00 2.50 2.3	Mo 0.90 1.20 1.0	Cu  0.30 0.05				
All-weld mechanical properties	PWHT 6 Tensile s 0.2% Pro Elongatio Elongatio Impact e Hardnes	strength pof stres on on 4 on on 4 nergy	ss d	+ 20°C		Pa Pa % % J IV	min 620 540 17 15  	typ 72 62 2 2 2 2	met 2 ical 25 25 22 25 22 00 70 35	typ	Cormet 2L ical (as-welded)    50 280		
Operating parameters	The wire higher.)	e is also	o suitabl	e for use s as below amp-vol 160 - 2	with 100 v:	0%CO <sub>2</sub> .	(Note: fo				argon should not exceed 80 gas, voltage should be 1- stickout 15 – 25mm 15 – 25mm		
Packaging data	The as-p Resistan possibili	acked s ce to m ty of po	shelf life oisture a prosity, i	e is virtual absorption it is advis	lly indefi 1 is high, ed that p	nite. but to n art-used		ne high in e returne	d to poly		wire surface and prevent a wrappers.		
	Fume co	mposit	ion (wt	%)									
Fume data	i unic co	•											



## **CrMoV CREEP RESISTING STEEL**

#### Alloy type

1<sup>1</sup>/<sub>4</sub>Cr-1Mo-<sup>1</sup>/<sub>4</sub>V creep resisting alloy for elevated temperature service.

#### Materials to be welded

ASTM	A389 grade C24 (cast).
	A356 grade 9 (cast).
DIN	21CrMoV 5 11 (1.8070).
	15CrMoV 5 10 (1.7745).
	GS-17CrMoV 5 11 (1.7706) (cast).
EN	G17CrMoV5-10 (1.7706)
GE	B50A224

#### **Applications**

CrMoV base materials provide good creep rupture properties up to about 580°C, with a reasonable degree of corrosion resistance in superheated steam.

### DATA SHEET A-14

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Typical applications for the cast materials include valve casings and steam turbines, general use for boilers, pressure vessels in the power generation and petrochemical industries.

#### Microstructure

After PWHT the microstructure consists of tempered bainite.

#### **Products available**

Process	Product	Specification
MMA	Chromet 1V	BS EN ECrMoV1B
	13CMV	
FCW	Cormet 1V	

General Data For MMA Electrodes										
Operating parameters	DC +ve or AC (OCV: 70V min)									
	ø mm		2.5		3.2	4	.0	5.0	)	
	min A		70		80	1	00	140	)	
	max A		110		140	1	80	240	)	
	For electrodes <b>Redry</b> 250 – 420°C, 3 cycle <b>Storage</b> of red	hydrogen < 5ml/100g for longer than a working shift of 8h. For electrodes that have been exposed: <b>Redry</b> 250 – 300°C/1-2h to ensure H <sub>2</sub> < 10ml/100g, 300 – 350°C/1-2h to ensure H <sub>2</sub> < 5ml/100g. Maximum 420°C, 3 cycles, 10h total. <b>Storage</b> 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.								
	Fume composition, wt % typical:									
Fume data	Fume compos	ition, wt	% typical	:						
Fume data	Fume compos	ition, wt Fe	% typical Mn	: Ni	Cr	Cu	Pb	F	OES (mg/m <sup>3</sup> )	

#### Rev 03 09/04



CHROMET 1V	,			Bas	sic coa	ited M	MA ele	ctrode	for C	rMoV cre	eep resist	ing steels
Product description	resista	MMA electrode with a basic, metal powder type, coating on low carbon high purity mild steel core wire. Moisture resistant coating provides very low weld metal hydrogen levels. Recovery is about 115% with respect to core wire, 65% with respect to whole electrode.										
Specifications	DIN 8 BS EI	575 N 1599			íoV1 B íoV1 B							
ASME IX Qualification	QW43	32 F-No	, QW	<b>/442</b> A-1	No							
Composition		С	Mn	Si	S	Р	Cr	Мо	V			
(weld metal wt %)	min	0.05	0.70				1.00	0.90	0.10			
· · · · ·	max	0.15	1.50	0.50	0.025	0.025	1.30	1.30	0.35			
	typ	0.08	0.85	0.3	0.012	0.012	1.2	1.10	0.20			
All-weld mechanical	Typica	I PWHT	700°C/1h	ı			Room Te	emperatu	re	Hi	igh Temperat	ure
properties							min	typic	cal	+350°C	+400°C	+450°C
	Tensile	e strength	ı		M	IPa	590	800	0	750	730	695
	0.2% F	Proof stre	SS		N	IPa	435	74	5	675	650	620
	J	ation on 4				%		20	)			
	Ű	ation on 5	d			%	15	16				
		t energy		+ 20°C		J	24	60				
	Hardne	ess			]	HV		27:	5			
Packaging data	ø mm			2.5		3.2		4.0		5.0		
	length	mm		350		380		450		450		
	kg/car	ton		13.8		15.0		16.8		17.4		
	pieces	/carton		690		372		243		159		

13CMV		Basic coated MMA electrode for CrMoV creep resisting steels											
Product description		MMA electrode with a basic, metal powder type, coating on low carbon high purity mild steel core wire. Moisture resistant coating provides very low weld metal hydrogen levels.											
	carbor	The <b>13CMV</b> electrode is manufactured to order and is of a similar composition to the Chromet 1V although the carbon (at ~0.13%) and vanadium (at ~0.25%) are typically higher. The <b>13CMV</b> can also be manufactured by prior agreement to the GE specification B50A273.											
	Recovery is about 115% with respect to core wire, 65% with respect to whole electrode								le electrode.				
Specifications		DIN 8575         (ECrMoV1 B 20)           BS EN 1599         (ECrMoV1 B 32)           GE         B50A273         By prior agreement only.											
ASME IX Qualification	QW43	QW432 F-No, QW442 A-No											
Composition		С	Mn	Si	S	Р	Cr	Мо	V *	Ni			
(weld metal wt %)	min	0.10	0.3				1.00	0.90	0.20				
. ,	max	0.15	1.0	0.50	0.020	0.030	1.50	1.30	0.30	0.4			
	typ	0.13	0.6	0.3	0.012	0.012	1.2	1.10	0.25	0.05			
	* In th	* In the GE specification $V = 0.40-0.55\%$ .											
Packaging data	ø mm			2.5		3.2		4.0		5.0			
	length	mm		350		380		450		450			
	kg/car	ton		13.5		15.0		18.0		16.5			
	pieces/carton 687 396 258 153												



CORMET 1V		All-positional rutile flux cored wire for CrMoV creep resisting steels										
Product description		Cormet 1V (available to order) is an all-positional flux cored wire suitable for welding fixed pipework. Made using high purity steel sheath with a metal recovery of about 90% with respect to the wire.										
Specifications	There are n	There are no relevant national standards.										
ASME IX Qualification	QW432 F	-No, QV	V442 A-	No								
Composition (weld metal wt %)	min         0.0           max         0.1           typ         0.0	05 0.50 5 1.50	Si 0.15 0.50 0.4	S  0.025 0.01	P  0.025 0.01	Cr 1.00 1.50 1.3	Mo 0.90 1.30 1.1	V 0.10 0.35 0.2				
All-weld mechanical properties	PWHT 720 <sup>o</sup> Tensile stre 0.2% Proof Impact ener Hardness	ngth stress	+ 20°C	M	IPa IPa J HV	ypical 650 550 50 230						
Operating parameters	The wire is										30%.	
Packaging data	The as-pack Resistance possibility	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.									t any	
Fume data	Fume comp	Fe 20	%) Mn 8	Ni <0.5	Cr <sup>2</sup>			Cu <1	F 8	OES (mg/m³)		



#### A-15 **DATA SHEET**

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## **5CrMo FOR ELEVATED TEMPERATURE**

## 5%Cr-1/2%Mo steel for elevated temperature service up Materials to be welded A387 grade 5 pipe/tube:

Alloy type

ASTM	A335 grades P5, P5b
	A234 grade WP5 (fittings)
	A199 grade T5
	A213 grades T5, T5b
BS	3604 grades HFS 625, CFS 625
DIN	12CrMo 19 5 (1.7362)
	X7CrMo 6 1 (1.7373)
	X11CrMo 6 1 (1.7374)

#### forgings:

to 600°C.

plates:

ASTM

ASTM	A182 grade F5, F5a
	A336 grade F5
BS	1503 grade 625
	1501 grade 625 (section & bar)

cast:

ASTM	A217 grade C5
BS	1504 grade 625
	3100 grade B5
DIN	GS-12CrMo 19 5 (1.7353, 1.7363)

#### **Applications**

For elevated temperature service up to 600°C, with corrosion resistance in superheated steam, hot hydrogen gas and high sulphur crude oils.

Used primarily for boiler superheaters, heat exchangers, piping and pressure vessels in oil refineries.

This weld metal has also been used successfully for subsequent nitriding, for example in the repair of 3Cr-1Mo-V and 2Cr-Mo-1A1 (BS En40C, En41) steels used for moulds for injection-moulding of plastics.

#### **Microstructure**

In the PWHT condition the microstructure consists of tempered bainite.

#### Welding guidelines

Owing to the as-deposited hardness (up to 400HV) and the relatively poor fracture resistance of the 5CrMo bainitic microstructure, a preheat and minimum interpass temperature of 200°C should be applied to ensure freedom from hydrogen induced cold cracking. Properly controlled and handled electrodes will provide weld metal with hydrogen <5ml/100g. For TIG root runs or all-TIG welds, a lower preheat of 150°C may be acceptable, though it should be recognised that faster cooling rates may lead to partially martensite and harder deposits.

Full transformation of 5CrMo during welding will be completed within a 200-350°C working range, so direct transfer (at >150°C) to PWHT is permissible, followed by NDE. If PWHT will be applied after complete cool out and NDE, the preheat temperature should be maintained for some time after welding, according to thickness, to promote hydrogen dispersal. The latter precaution is less significant for the TIG and solid wire MAG processes.

#### **PWHT**

PWHT to temper the weldment would normally be in the range 705-760°C (eg. BS2633 & PD5500 710-750°C, ASME B31.3 705-760°C). Minimum holding time recommended is two hours. For castings the minimum suggested PWHT temperature is lower, with temperatures as low as 670°C being specified.

Process	Product	Specification
MMA	Chromet 5	AWS E8015-B6
TIG/MIG	5CrMo	AWS ER80S-B6
FCW	Cormet 5	AWS E81T1-B6



CHROMET 5							5%(	Cr-0.5%N	No MMA electrode		
Product description	Basic metal powde weld metal hydrog		on high p	urity lov	v carbon	core wire	. Mois	ture resistar	t coating gives very low		
	Recovery is about	120% with re	espect to	core wire	e, 65% w	ith respec	t to wh	ole electrod	e.		
Specifications	AWS A5.5 AWS A5.4 BS EN 1599 BS 2493 DIN 8575	5CrMe	15 105 B 32		nis classif	fication h	as now	been withdi	rawn from A5.4		
ASME IX Qualification	QW432 F-No 4,	QW442 A-	No 4								
Composition		Mn Si	S	Р	Cr	Ni	Мо	Cu			
(weld metal wt %)	max 0.10 1 typ 0.06	0.50 .00 0.50 0.8 0.35 00( 0.50 E8015	0.025 0.01	0.025		0.40 0.2	0.45 0.65 0.55	0.50			
All-weld mechanical	* Carbon 0.05-0.10 Typical properties a		о-В6 (<0.	05% for		C/1h **	to orde	740°C/2h	745°C/3h		
properties				(D. 6	min.	typic 610		typical	typical		
	Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d		MPa MPa % %		550 *** 460 19 18		)	610 480 23 20	540 360 28 25		
	Reduction of area			%	69			20 71	74		
	Impact energy	+ 20' - 10'	-	J J		150 80		130 50	140 50		
	Hardness cap/mid       HV        210/205       210/200       205/160         *       AWS A5.4 requires a PWHT of 840-870°C/2h, (this PWHT is never applied in practice so if this is the AWS A5.5 PWHT (732-760°C/1h). BS is 725-745°C/2h, BS EN & DIN is 730         ***       BS EN and DIN minimum is 590MPa. There are no base material grades requiring such strength ASTM is 414-552MPa dependent on grade.										
Operating parameters	DC +ve or AC (OC	CV: 70V min)	V min)								
	ø mm	2.5		3.2		4.0		5.0			
	min A max A	70 110		80 140		100 180		140 240			
Packaging data	ø mm	2.5		3.2		4.0		5.0	)		
	length mm kg/carton	350 12.0		380 14.4		45( 17.		450 16.5			
	pieces/carton	636		366		246		150			
Storage	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use fit hydrogen &lt; 5ml/100g weld metal during 8h working shift. For electrodes that have been exposed:</li> <li>Redry 250 – 300°C/1-2h to ensure H<sub>2</sub> &lt; 10ml/100g, 300-350°C/1-2h to ensure H<sub>2</sub> &lt; 5ml/100g. N 3 cycles, 10h total.</li> <li>Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but ma recommended. Recommended ambient storage conditions for opened tins (using plastic lid): &lt; 6</li> </ul>										
Fume data	Fume composition	, wt % typica									
	Fe	e Mn	Ni	С	r (	Cu	Pb	F C	DES (mg/m <sup>3</sup> )		
	15	5	<0.1	1.	5 <	0.2 <	<0.1				



5CrMo				Solid	TIG ar	nd MIG	wire fo	or 5%(	Cr-0.5%	∕₀Mo cr	reep re	sisting stee			
Product description	Solid	copper c	oated wi	re for TI	G and M	lG, alloye	ed with 5	%Cr-0.5	5%Mo.						
Specifications	AWS BS E	N 12070 901: Pt2		ER80S ER502 CrMo5 A34 SG Cr	!	/373)	This classification has now been withdrawn from A								
ASME IX Qualification	QW4	QW432 F-No 6, QW442 A-No 4													
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	V				
(wire wt %)	min	0.03	0.40	0.20			5.5		0.50						
	max	0.10	0.70	0.50	0.020	0.020	6.0	0.3	0.65	0.3	0.03				
	typ	0.07	0.5	0.4	0.01	0.01	5.7	0.1	0.55	0.2	0.02				
All-weld mechanical	Typica	al values	after PW	HT:			mir	າ. *	TIG 7	45⁰C/1h	TIG	740°C/2h			
properties		e strengt				MPa	590		660			570			
	0.2% F	Proof stre	ess			MPa	470		560			440			
	Elonga	ation on 4	1d			%	1	7	28			25			
	Elonga	longation on 5d				%	1	7	25			20			
	Reduc	tion of a	ea			%		-		72		78			
	Impac	t energy		+ 20°C					240						
	Hardn	ess cap/i	nid	HV10			10			5/215					
		inimum 2070.	values af	ter PWH	Т 745°С (	(730-760°	°C) for 1	h accord	ing to AV	VS A5.28	8 for ER8	0S-B6 and BS			
Typical operating				TIG			МІС	3							
parameters	Shield	ing		Argon	*	Ar + 1	-3%O <sub>2</sub> o	r 5-20%	CO <sub>2</sub>						
	Currer	nt		DC-			DC								
	Diame	eter		2.4m	n		1.2m	ım							
	Param			140A, 1			260A,	26V							
	*	Also req	uired as	a purge f	or root ru	ıns.									
Packaging data	ø mm			TIG			MIG								
	1.2					151	kg spool								
	1.6			5kg tu	be										
	2.4			5kg tu											
		MIG fume composition (wt %) (TIG fume neglig													
Fume data	MIG f	fume con	nposition	n (wt %) (	(TIG fun	ne negligi	ble)								
Fume data	MIG f	fume con	nposition Fe	n (wt %) ( Mn	(TIG fum Cr <sup>3</sup>	ne negligi Ni		Лo	Cu	OES (n	ng/m³)				



Product description		et 5 is an a with a m								ork. N	lade using a high purity steel	
Specifications	AWS AWS BS EN		'634-В	E5	1T1-B6M 02T1-4 5T1-1M-:	Ĵ					)2T1-4 will be of AWS A5.22	
ASME IX Qualification	QW43	<b>32</b> F-No	6, <b>QW</b>	442 A-1	No 4							
Composition (weld metal wt %)	min max typ	C 0.05 0.10 0.06	Mn  1.20 0.8	Si  0.50 0.3	S  0.030 0.01	P  0.030 0.01	Cr 4.00 6.00 5	Mo 0.45 0.65 0.5	Cu  0.3 0.05	Ni  0.40 0.01		
All-weld mechanical properties	Tensile 0.2% F Elonga Elonga Reduc	745°C/21 e strength Proof streation on 4 ation on 5 tion of are	ss d d ea	l hour PV	М	Pa Pa % % % VS requi	min 550 470 19 17  res 2 hou	ır PWHT	typical 690 600 22 19 67			
Operating parameters	The w higher	ire is also	o suitab	le for use s as belov amp-vc	e with 10	0%CO <sub>2</sub> .	(Note: f		CO <sub>2</sub> shie	lding រ្	rgon should not exceed 80%. gas, voltage should be 1-2V stickout 15 – 25mm	
Packaging data	The as Resista possib	Spools vacuum-sealed in barrier foil with cardboard carton: 1.2mm diameter 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 prev 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	composit	ion (wt	%)								
			Fe 20	Mn 8	Ni < 0.5	Cr <sup>3</sup>			Cu < 1	F 8	OES (mg/m <sup>3</sup> ) 3.3	



### DATA SHEET A-16

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## 9CrMo FOR ELEVATED TEMPERATURE

#### Alloy type

9%Cr-1%Mo martensitic alloy for elevated temperature service.

#### Materials to be welded

plates: ASTM	A387 grade 9
pipe/tube:	
ASTM	A335 grade 9 A234 grade WP9 (fittings) A199 grade T9 A213 grades T9
BS	3604 grades CFS & HFS 629-470, CFS & HFS 629-590
DIN	X12CrMo 9 1 (1.7386) X7CrMo 9 1 (1.7388)
forgings:	
ASTM	A182 grade F9 A336 grade F9
cast:	
ASTM BS	A217 grade C12 1504 grade 629 3100 grade B6
DIN	GS-12CrMo 10 1 (1.7389)

#### Applications

For elevated temperature service up to 600°C, with reasonable degree of corrosion resistance in superheated steam, hot hydrogen gas and high sulphur crude oils, where higher performance than 5%Cr-0.5%Mo steels is required.

Used primarily for boiler superheater tubing, heat exchangers, piping and pressure vessels in oil refineries and power plants.

#### Microstructure

In the PWHT condition the microstructure consists of tempered martensitic bainite.

#### Welding guidelines

Owing to the as-deposited hardness (up to 450HV) and the relatively poor fracture resistance of the martensitic 9CrMo microstructure, a preheat and minimum interpass temperature of 200°C shall be applied to ensure freedom from hydrogen induced cracking. Properly controlled and handled electrodes will provide weld metal with hydrogen <5ml/100g. For TIG root runs or all-TIG welds, a lower preheat of 150°C may be acceptable.

During welding, full transformation may not be complete within a working range of 200-350°C, so partial cooling to around 150°C is advised before direct transfer to PWHT, followed by NDE. If PWHT will be applied after complete cool out and NDE, the preheat temperature should be maintained for some time, according to thickness, to promote hydrogen dispersal. The latter precaution is less significant for the TIG and solid wire MAG processes.

#### **PWHT**

PWHT to temper the weldment would normally be in the range 705-780°C (eg. BS2633 710-750°C, PD5500 740-780°C, ASME B31.3 705-760°C). Minimum holding time recommended is two hours. For castings the minimum suggested PWHT temperature is lower, with temperatures as low as 670°C being specified.

Process	Product	Specification
MMA	Chromet 9	AWS E8015-B8
TIG/MIG	9CrMo	AWS ER80S-B8
FCW	Cormet 9	AWS E81T1-B8



Product description		metal powe netal hydro			gh purity lo	w carbon c	core wire.	Moisture	e resistant c	oating giving very l					
	Recov	ery is abou	t 120% <sup>,</sup>	with respec	t to core w	re, 65% w	ith respec	t to whole	e electrode.						
Specifications	AWS AWS BS EN BS 24 DIN 8	A5.4 N 1599 193		E8015-B3 E505-15 E CrMo9 9CrMoBI ECrMo9	В 32 Н5 Н	This class	rawn from A5.4								
ASME IX Qualification	QW43	<b>32</b> F-No 4,	QW4	42 A-No 5											
Composition		C *	Mn	Si	S	Р	Cr	Ni	Мо	Cu					
(weld metal wt %)	min	0.05	0.50				8.0		0.90						
, , , , , , , , , , , , , , , , , , ,	max	0.10	1.00	0.80	0.025	0.025	10.0	0.40	1.20	0.50					
	typ	0.06	0.75	0.35	0.012	0.015	9	0.2	1	< 0.05					
	* Carb	* Carbon 0.05-0.10% for E8015-B8 (<0.05% for E8015-B8L, made to order).													
All-weld mechanical	Typica	I PWHT				min *		°C/2h	746°/3h						
properties		<u> </u>				-00		ical	typical						
		e strength <sup>&gt;</sup> roof stress			MPa	590		10	680						
		ation on 4d			MPa %	460 19		00 22	550 26						
	-	ation on 5d			%			20	20 25						
	-	tion of area			%			70	70						
	Impact energy			+ 20°C	J	34		0	130						
	1			0°C	J		-	50							
				-10°C	J		-	25	90						
	Hardne	ess			HV		2	35	220						
	AWS PWHT is 732-760°C /1 hour. BS EN PWHT is 740-780°C/2 hours. See front page under PWHT normal fabrication practice.         * ASTM base material minimum varies in the range 414-586MPa depending on grade.														
Operating parameters		$e \text{ or } \Delta C (C)$	CV: 70V	V min)											
Operating parameters	DC + v	e of <i>M</i> e (e													
Operating parameters	DC +v			2.5	3.2		4.0		5.0						
Operating parameters	ø mm min A			70	80		100		140						
Operating parameters	ø mm						-								
	ø mm min A max A ø mm			70 110 2.5	80 140 3.2		100 180 4.0		140 240 5.0						
	ø mm min A max A ø mm length	mm		70 110 2.5 350	80 140 3.2 380		100 180 4.0 450		140 240 5.0 450						
	ø mm min A max A ø mm length kg/cart	mm ton		70 110 2.5 350 11.7	80 140 3.2 380 15.0		100 180 4.0 450 17.4		140 240 5.0 450 16.5						
	ø mm min A max A ø mm length kg/cart	mm		70 110 2.5 350	80 140 3.2 380		100 180 4.0 450		140 240 5.0 450						
Packaging data	ø mm min A max A ø mm length kg/cart pieces. <b>3 hern</b> hydrog For ele <b>Redry</b> 3 cycle <b>Storag</b>	mm ton //carton metically so gen $< 5ml/1$ ectrodes that $7250 - 300^{\circ}$ es, 10h tota ge of redrie	ealed rin 00g wel tt have b °C/1-2h t 1. d electro	70 110 2.5 350 11.7 612 <b>ng-pull met</b> Id metal dur been expose to ensure H <sub>2</sub> odes at 50 –	80 140 3.2 380 15.0 399 tal tins per ring 8h wo d: 2 < 10ml/10 - 200°C in	carton, wi king shift. 0g, 300-35 holding ov	100 180 4.0 450 17.4 249 th unlimi	to ensure ted quive	$     \begin{array}{r}       140 \\       240 \\       5.0 \\       450 \\       16.5 \\       150 \\       life. Direc: \\       H_2 < 5ml/1 \\       r: no limit,     $	00g. Maximum 420° but maximum 6 wea					
Packaging data Storage	ø mm min A max A ø mm length kg/cart pieces. <b>3 hern</b> hydrog For ele <b>Redry</b> 3 cycle <b>Storag</b> recom	mm ton //carton metically so gen $< 5ml/1$ ectrodes that $7250 - 300^{\circ}$ es, 10h tota ge of redrie	ealed rin 100g wel 11 have b 2C/1-2h t 1. d electro ecomme	70 110 2.5 350 11.7 612 <b>ng-pull met</b> Id metal dur been expose to ensure H <sub>2</sub> odes at 50 – ended ambie	80 140 3.2 380 15.0 399 tal tins per ring 8h wo d: 2 < 10ml/10 - 200°C in	carton, wi king shift. 0g, 300-35 holding ov	100 180 4.0 450 17.4 249 th unlimi	to ensure ted quive	$     \begin{array}{r}       140 \\       240 \\       5.0 \\       450 \\       16.5 \\       150 \\       life. Direc: \\       H_2 < 5ml/1 \\       r: no limit,     $	t use from tin will g 00g. Maximum 420 but maximum 6 wea id): < 60% RH, > 18					
Operating parameters Packaging data Storage Fume data	ø mm min A max A ø mm length kg/cart pieces. <b>3 hern</b> hydrog For ele <b>Redry</b> 3 cycle <b>Storag</b> recom	mm ton /carton metically so gen $< 5ml/1$ ectrodes tha $7250 - 300^{\circ}$ es, 10h tota ge of redrie mended. R	ealed rin loog wel at have b PC/1-2h t l. d electro ecomme n, wt %	70 110 2.5 350 11.7 612 <b>ng-pull met</b> ld metal dur been expose to ensure H <sub>2</sub> odes at 50 – ended ambie	80 140 3.2 380 15.0 399 tal tins per ring 8h wo d: 2 < 10ml/10 - 200°C in ent storage	carton, wi king shift. 0g, 300-35 holding ov conditions	100 180 4.0 450 17.4 249 th unlimi	to ensure ted quive	140         240         5.0         450         16.5         150         life. Direct $H_2 < 5ml/1$ r: no limit, ng plastic li	00g. Maximum 420° but maximum 6 wea					



9CrMo						TIG	and M	IG cop	per co	pated wire for 9%Cr-1%Mo
Product description	Solid c	opper co	ated wi	re for TIC	and M	IG.				
Specifications		A5.9 I 12070 01: Pt1	E C A	R80S-B8 R505 rMo9Si 35 G CrMo9			classific	ation has	s now be	een withdrawn from A5.9
ASME IX Qualification	QW43	<b>2</b> F-No	6, <b>QW</b>	<b>/442</b> A-1	No 5					
Composition (wire wt %)	min max typ	C 0.03 0.10 0.07	Mn 0.40 0.60 0.5	Si  0.50 0.3	S  0.020 0.01	P  0.020 0.015	Cr 8.5 10.0 9	Ni  0.5 0.1	Mo 0.8 1.2 0.9	Cu  0.35 0.1
All-weld mechanical properties	Tensile 0.2% P Elonga Impact	strength roof stre tion on 4	n ss d	+ 20°C		1Pa 1Pa % J HV	min 550 470 17 	TIG 729 612 25 80 225/230		
Typical operating parameters	Shieldii Current Diamet Parame * A	t er eters	iired as a	TIG Argon DC- 2.4mn 140A, 1 a purge fo	n 4V		MIC -3%O <sub>2</sub> o DC 1.2m 260A,	r 5-20% + 1m	CO <sub>2</sub>	
Packaging data	ø mm 1.2 1.6 2.4 3.2			TIG  5kg tub 5kg tub To ord	be	Т	MIG o order  			
Fume data	MIG fume composition (wt %) (TIG fume n						ible):			
			Fe 50	Mn 4	Cr <sup>3</sup>	N <0.		Ло 0.5	Cu 1.2	OES (mg/m <sup>3</sup> ) 5



CORMET 9									All	-pos	itional flux cored wire
Product description							ole for we espect to		ed pipew	ork. N	Aade using a high purity steel
Specifications	AWS AWS BS EN		′634-B	E81T1-B8M Concurrent AWS speci E505T1-4 withdrawn at the next r -B T55T1-1M-9C1M							
ASME IX Qualification	QW43	<b>32</b> F-No	6, <b>QW</b>	442 A-1	No 5						
Composition (weld metal wt %)	min max typ	C 0.05 0.12 0.06	Mn  1.25 0.8	Si  1.00 0.3	S  0.030 0.01	P  0.040 0.01	Cr 8.0 10.5 9	Mo 0.85 1.20 1.0	Cu  0.5 0.05	Ni  0.4 0.3	
All-weld mechanical properties	Tensile 0.2% F Elonga Elonga Reduct	745°C/2l e strength Proof streation on 4 ation on 5 tion of are	ss d d ea	es 1 hour	М	Pa Pa % % %	min 550 470 19 17  quires 2 h	our PWI	typical 640 500 24 21 65 HT.		
Operating parameters	The w	ire is also .)	o suitab	le for use s as belor amp-vo	e with 10	0%CO <sub>2</sub> .	(Note: f		CO <sub>2</sub> shie	lding ;	rrgon should not exceed 80%. gas, voltage should be 1-2V stickout 15 – 25mm
Packaging data	Spools vacuum-sealed in barrier foil with cardboard carton: 1.2mm diameter 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 p 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.										wire surface and prevent any
Fume data	Fume	composit	ion (wt	%)							
			Fe	Mn	Ni	Cr			Cu	F	OES (mg/m <sup>3</sup> )
			20	8	< 0.5	3	3	3.	< 1	8	1.7



## P91 - MODIFIED 9CrMo

#### Alloy type

Modified 9CrMo for high temperature creep resistance.

#### Materials to be welded

#### ASTM

A 213 T91 (seamless tubes) A 335 P91 (seamless pipes) A 387 Gr 91 (plates) A 182 / A336 F91 (forgings) A 217 C12A (castings) A 234 WP91 A 369 FP91 **DIN / BS EN** 1.4903 (X10CrMoVNb 9 1) **BS** 1503 Gr91 3059-2 Gr91 **AFNOR** 

NF A-49213/A-49219 Gr TU Z 10 CDVNb 09-01

#### **Applications**

These consumables are designed to weld equivalent 'type 91' 9CrMo steels modified with small additions of niobium, vanadium and nitrogen to give improved long term creep properties.

These consumables are specifically intended for high integrity structural service at elevated temperature so the minor alloy additions responsible for its creep strength are kept above the minimum considered necessary to ensure satisfactory performance. In this case, weldments will be weakest in the softened (intercritical) HAZ region of parent material, as indicated by so-called 'type IV' failure in transverse weld creep tests.

Modified 9CrMo steels are now widely used for components such as **headers**, **main steam piping** and **turbine casings**, in fossil fuelled **power generating plants**. They may also find future use in **oil refineries** and **coal liquefaction** and **gasification plants**.

#### Microstructure

In the PWHT condition the microstructure consists of tempered martensite with alloy carbides.

#### DATA SHEET A-17

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#### **PWHT**

Minimum preheat temperature  $150^{\circ}$ C with maximum interpass temperature of  $300^{\circ}$ C; in practice a preheat-interpass range of  $200 - 300^{\circ}$ C is normal. To ensure full martensite transformation, welds should be cooled to ~ $100^{\circ}$ C prior to PWHT.

ASME base material codes and AWS consumable classifications allow PWHT down to 730°C, whilst BS EN consumable classifications specify 750°C. Optimum properties are obtained with a tempering parameter (P) of around 21 or above, where P = °C+273 (log t + 20) x 10<sup>-3</sup>. Maximum PWHT temperature varies, AWS consumable specifications are 760°C, BS EN 770°C; BS 1503 allows up to 790°C for base material forgings.

When compared with directly matching weld metal, the addition of some nickel and reduction of niobium provides a useful improvement in toughness after conveniently short PWHT at  $750 - 760^{\circ}$ C. PWHT above  $765^{\circ}$ C is not generally recommended for Ni-containing consumables, because some re-hardening could occur due to the proximity of Ac<sub>1</sub>. Some authorities specify weld metal Ni + Mn < 1.5% to keep Ac<sub>1</sub> high enough to allow higher PWHT temperature if required.

#### **Additional information**

More detailed information on the products and properties of P91 are available in the Technical Profile – "Welding Consumables for P91 Steels for the Power Generation Industry" – available from the Technical Department.

Process	Product	Specification
MMA	Chromet 9MV-N	AWS E9015-B9
	Chromet 9-B9	AWS E9015-B9
	Chromet 91VNR	AWS E9016-B9
	Chromet 91VNB	AWS E9015-B9
TIG	9CrMoV-N	AWS ER90S-B9
MIG	Cormet M91 (MCW)	AWS E90C-G
SAW	9CrMoV-N (wire)	AWS EB9
	LA491 (flux)	BS EN SA FB 255AC
	L2N (flux)	BS EN SF CS 2 DC
FCW	Supercore F91	AWS E91T1-B9



## General Data for all Modified 9CrMo (P91) Electrodes

Description	Basic metal pow	der types made	on high pu	rity steel o	core wire.										
	Recovery is appr	ox 120% with	respect to c	ore wire, (	65% with re	espect to w	hole electr	rode.							
	Moisture resistar	Moisture resistant coatings giving very low weld metal hydrogen levels.													
Operating parameters	DC +ve.	AC (OCV	70V min)												
	ø mm	2.5		3.2	4	.0	5.0								
	min A	70		80	10	00	140								
	max A	110		140	18	80	240								
Storage	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin will give hydrogen &lt;5ml/100g weld metal during 8h working shift.</li> <li>For electrodes that have been exposed:</li> <li>Redry 250 - 300°C/1-2h to ensure H<sub>2</sub> &lt; 10ml/100g, 300 - 350°C/1-2h to ensure H<sub>2</sub> &lt; 5ml/100g. Maximum 420°C, 3 cycles, 10h total.</li> <li>Storage of redried electrodes at 100 - 200°C in holding oven, or 50 - 150°C in heated quivers: no limit, but maximum 6 weeks recommended.</li> </ul>														
	For electrodes the Redry 250 – 300 420°C, 3 cycles, Storage of redri	at have been ex 0°C/1-2h to ens 10h total. ed electrodes at	kposed: sure $H_2 < 10^{\circ}$ t 100 – 200°	ml/100g,	300 – 350°		-	e							
Fume data	For electrodes the Redry 250 – 300 420°C, 3 cycles, Storage of redri	at have been ex 0°C/1-2h to ens 10h total. ed electrodes at ks recommende	kposed: sure $H_2 < 10^{\circ}$ t 100 – 200°	ml/100g,	300 – 350°		-	e							
Fume data	For electrodes th <b>Redry</b> 250 – 30 420°C, 3 cycles, <b>Storage</b> of redri maximum 6 wee Fume composition	at have been ex 0°C/1-2h to ens 10h total. ed electrodes at ks recommende	kposed: sure $H_2 < 10^{\circ}$ t 100 – 200°	ml/100g,	300 – 350°		-	e							

## **Chromet 9MV-N**

MMA electrode to AWS/BS EN with high Ni to maximise toughness

Product description	MM	A elect	rode –	with N	i additio	n and lo	wer Nb	for in	nprove	d tough	ness, co	onfor	ming to I	BS EN 159	99	
Specifications		S A5.5 EN 159	-	E9015- E CrMo	B9 591 B 3 2	2										
ASME IX Qualification	QW	QW422 P-No 5B group 2, QW432 F-No 4, QW442 A-No 5														
Composition		C	Mn	Si	S*	P*	Cr	Ni	Мо	Nb	V	Ν	Cu	Sn	Ni+Mn	
(weld metal wt %)	min max	0.08 0.12	0.50 1.20	 0.50	 0.01	 0.01	8.0 10.0	0.4 0.8	0.85 1.2	0.04 0.07	0.15 0.25	0.0 0.0	-	 <0.008	 1.5	
	typ * I	0.1 Low Ni	0.6 variant	0.25 t is ava	0.008 ilable, <b>C</b>	0.01 hromet	9 : <b>9-B9</b> .	0.7	1	0.05	0.2	0.0	5 0.05	0.003	1.3	
All-weld mechanical	PWF	HT 755	°C / 3h						min <sup>(1)</sup>		typical		550°C	600°C	650°C	
properties	Tens	sile strer	ngth				MPa		620		770		>450	>375	>285	
	0.2%	Proof	stress				MPa		530		640		>360	>255	>175	
	Elon	gation c	n 4d				%		17		22					
	Elon	gation c	n 5d				%		15		19		>15	>17	>21	
	Redu	uction o	f area				%				60		>68	>75	$>\!\!80$	
		act energ			+20		J		47		65					
		ral expa			+ 20	)°C	mm				1.00					
		lness af					HV				250					
		Iness as 1inimur		-	parent n	naterial	HV is lowe	r than	AWS 1	require	450 nent sh	own.				
Packaging data	ø mr	n			2.5		3.2			4.0			5.0			
	lengt	th mm			350		380			450			450			
	kg/ca	arton			12.9		15.0			17.4			16.5			
	piece	es/carto	n		651		405			234			150			



## Chromet 9-B9

#### MMA electrode meeting AWS/ASME

Product description	MMA	A electro	ode – ma	anufact	ured to the	e require	ments o	of AWS	A5.5 E	E9015-B9	9			
Specifications		AWS A5.5         E9015-B9           BS EN 1599         (E CrMo91 B 3 2)												
ASME IX Qualification	QW4	<b>22</b> P-N	lo 5Bg	group 2,	QW432	F-No	4, <b>QV</b>	<b>V442</b> A	-No 5					
Composition		С	Mn*	Si	S	Р	Cr	Ni*	Мо	Nb	V	Ν	Cu	Al
(weld metal wt %)	min	0.08	0.40				8.0	0.2	0.85	0.03	0.15	0.03		
	max	0.12	0.75	0.30	0.01	0.01	10.0	0.4	1.2	0.07	0.25	0.07	0.25	0.04
	typ	0.1	0.55	0.25	0.008	0.008	9	0.3	1	0.04	0.2	0.05	0.05	< 0.01
	* Ni	+ Mn <	< 1. 0%	. Nick	el is belov	v 0.4% (	as pare	ent mate	rial) al	though A	AWS a	llows uj	to 1.0%	%Ni. See
	Chro	met 9N	IV-N fo	r variar	nt with 0.4	- 1.0%	Ni conf	òrming	to BS I	EN speci	fication	n.		
All-weld mechanical	PWH.	T 760°C	/ 2h					min <sup>(1)</sup>		typical	55	0°C	600°C	650°C
properties	Tensile strength					Μ	Pa	620		710	>	>450		>285
	0.2%	Proof st	ress			Μ	Pa	530		590	>	360	>255	>175
	0	ation or					%	17		22.5				
		ation or					%	15		19		·15	>17	>21
		ction of					%			63	>	-68	>75	>80
	•	ct energ	•		+ 20°C		J			75				
		al expan		_	+ 20°C		m			1.10				
		ness afte		I			V			240				
		ness as-					V			450				
	<sup>(1)</sup> M	ınımum	strengt	h for pa	irent mate	rial is lo	wer tha	n AWS	require	ement sho	own.			
Packaging data	ø mm	1		2.	5	3.2	2		4.0*		5.	0		
	length	n mm		35	0	38	0	3	80/450		45	0		
	kg/ca	rton		13.	.5	15	;	1	5/17.1		16	.5		
	piece	s/carton		65	7	37	8	2	64/249	)	15	0		
	* 45	0mm is	standar	d lengtl	h for 4.0m	m, 380n	ım pro	duced to	order.					

### **Chromet 91VNR**

### MMA electrode for root welding

Product description	MMA ele	ctrode f	or root	welding	g applicat	ions.									
Specifications	AWS A5 BS EN 1														
ASME IX Qualification	QW422	QW422 P-No 5B group 2, QW432 F-No 4, QW442 A-No 5													
Composition		С	Mn*	Si	S	Р	Cr	Ni*	Мо	Nb	V	Ν	Cu		
(weld metal wt %)	min	0.08	0.4				8.0	0.4	0.85	0.03	0.15	0.03			
	max	0.12	1.0	0.3	0.01	0.01	9.5	0.8	1.2	0.07	0.25	0.07	0.25		
	typ	0.1	0.6	0.25	0.008	0.008	8.5	0.5	1	0.04	0.2	0.05	0.05		
	* Ni + N	Mn <1.5	0												
All-weld mechanical	PWHT 76	50°C / 2h	ı					min <sup>(1)</sup>	typ	oical					
properties	Tensile st	rength				MP	a	620	7	50					
	0.2% Proc	of stress				MP	a	530	6	00					
	Elongation	n on 4d				9	6	17	2	20					
	Elongation	n on 5d				9	6	16	1	18					
	Impact en				+ 20°C		J			55					
	Hardness					H	·		_	50					
	<sup>(1)</sup> Minim	um stre	ngth fo	r parent	material	is lower t	han A	WS requ	irement	shown.					
Packaging data	ø mm			2.5		3.2									
	length mn	า		350	)	380									
	kg/carton			14.	l	13.5	5								
	pieces/ca	rton		714	Ļ	408									



MMA electrode for root welding

Product description	appro	x 120% v	with res	pect to	e for root v core wire, en levels.									
Specifications	AWS BS E	A5.5 N 1599		015-B9 CrMo9	) 1 B 3 2									
ASME IX Qualification	QW422 P-No 5B group 2, QW432 F-No 4, QW442 A-No 5													
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	V	Ν	Cu	AI
(weld metal wt %)	min	0.08	0.4				8.0	0.4	0.85	0.03	0.15	0.03		
	max	0.12	1.2	0.3	0.01	0.01	9.5	0.8	1.2	0.07	0.25	0.07	0.25	0.04
	typ	0.1	0.8	0.25	0.008	0.008	8.5	0.5	1	0.04	0.2	0.05	0.05	0.01
All-weld mechanical	PWH1	Г 760°С	/ 2h					min <sup>(1)</sup>		typical				
properties	Tensil	e streng	h			l	MPa	620		750				
	0.2%	Proof str	ess			I	MPa	530		600				
	Elonga	ation on	4d				%	17		20				
	Elonga	ation on	5d				%	16		18				
		t energy			+ 20°0	0	J			55				
	<sup>(1)</sup> Mi	nimum s	strength	for pa	rent materi	al is low	er than	AWS ree	quirem	ent show	n.			
Operating parameters	DC +	ve, DC –	ve or A	.C (OC	V 70V mir	1)							Î	Î
	ø mm			2.5	5									
	min A			60										
	max A	١		110	)									
Fume data	Fume	compos	ition (w	t %)										
			Fe	M	n Ni		Cr	Cu	Pt	)	F	OES mg	g/m <sup>3</sup> )	
			15	5	< 0	.1 <	< 3	< 0.1	< 0	.1 1	8	1.7		

### **Chromet 91VNB**

## 9CrMoV-N

#### Solid wire for TIG and SAW

Product description	Solid	Solid wire, non-copper coated, for TIG and SAW													
Specifications	AWS	A5.23 A5.28 N 1207	0		TIG N/A ER903 WCrM		E N	AW B9 I/A SCrMo91	1)						
ASME IX Qualification	QW4	<b>22</b> P-N	o 5Bg	roup 2,	QW432	<b>2</b> F-No (	5, <b>Q</b>	<b>W442</b> A	A-No 5						
Composition		С	Mn	Si *	S	Р	Cr	Ni	Мо	Nb	V	Ν	Cu	Al	
(wire wt %)	min	0.08	0.40	0.15			8.0	0.40	0.85	0.03	0.15	0.03			
	max	0.13	0.80	0.30	0.010	0.010	9.5	0.80	1.10	0.08	0.25	0.07	0.10	0.04	
	typ	0.1	0.5	0.25	0.006	0.008	8.7	0.6	1	0.05	0.2	0.05	0.03	< 0.01	
	* A5.28 ER90S-B9 allows up to 0.50% Si and BS EN 12070 allows up to 0.60% Si.														
All-weld mechanical	PWHT	Г 750 — 7	/ 60°C	2 – 3h				min	TIC	G	SAW t	ypical	SAW	/ typical	
properties									typical		LA491 flux		L2N flux		
	Tensil	e streng	th			MP	a	620	80	0	75	0	,	750	
		Proof str				MP		415	70		63	0		630	
	0	ation on					6	16	22		25			25	
	-	ation on				,	6	17	19		23	-		23	
		ction of a				0	6			)	70			70	
		t energy		+2	0°C	III (m	J	*	220		45			35	
	Hardn					HV (mic			26	3	25	0		250	
	* Mir	nimum i	mpact r	required	by BS E	N is 47 J									



## 9CrMoV-N (continued)

Parameters	Shielding Current Typical parameters 2.4mm ø	TIGArgonDC-100A, 12V	SAW LA491 or L2N DC+ 450A, 30V, 45		MIG 9CrMoV-N not recommended for MIG, Cormet M91 or Supercore F91 should be used.
Packaging data	ø mm	TIG	SAW		MIG
	0.8/0.9	Spool to order			
	1.2				Not recommended - see
	1.6	5kg tube			Supercore F91 or Cormet
	2.4	5kg tube	25kg coil		M91.
	3.2	5kg tube	25kg coil		
Fume data	Fume composition (wt %);	TIG and SAW fun	e are negligible:		
	Fe M	ln Ni	Cr <sup>3</sup> Mo	Cu	OES (mg/m <sup>3</sup> )
	50	4 < 0.4	6 0.5	< 0.5	5

Cormet M91									Meta	l core	d wire	for M	IG we	lding
Product description	Metal	cored w	vire for	MIG w	elding. H	ligh purit	y steel	sheath w	vith 96%	metal	recovery	with re	spect to	wire.
Specifications	AWS . BS EN		17634-	в		G (B9) 5-0M-9C	1MV							
ASME IX Qualification	QW42	QW422 P-No 5B group 2, QW432 F-No 6, QW442 A-No 5												
Composition (weld metal wt %)	min max typ	C 0.08 0.13 0.1	Mn 0.60 1.20 1	Si  0.40 0.3	S  0.015 0.01	P  0.020 0.01	Cr 8.0 10.0 9	Ni  0.80 0.3	Mo 0.85 1.20 1	Nb 0.03 0.07 0.05	V 0.18 0.25 0.2	N 0.03 0.07 0.05	Cu  0.15 0.05	Al  0.04 0.03
All-weld mechanical properties	1 05				0°C 0°C	MPa 620 MPa 563 % 16 % 14 J mm HV			Ar	-2½%C0 780 650 17 16 30 0.30 260	-	rpical 80/20 780 650 17 16 25 0.28 260	75 6. 1 1 3 0.	e-CO <sub>2</sub> 80 50 7 6 55 45 60
Parameters	better a best co	arc chai	racterist	ics but onsidere rn, high <b>Ga</b> 15	lower CC		evels p om Ar-2 e used t <b>Op</b> DC	roduce b 2½%CO	althoug optimu	pact pro	operties. act prop	The erties istics. out		
Packaging data	possib	ility of	porosity	, it is a	dvised th	gh, but to at part-us ditions ar	ed spoo	ols are re	turned t	o polytl				
Fume data	Fume	compos 	ition (w Fe 60	/t %) Mr 5		Ni 0.5	Cr <sup>3</sup> 5	Mo <0.1	Ci <0		DES (mg 5	g/m <sup>3</sup> )		



#### **Product description** LA491 is an agglomerated fluoride-basic submerged arc welding flux. L2N is a fused calcium silicate flux for submerged arc welding. Specifications LA491 L2N BS EN 760 (flux) SA FB 255 AC SF CS 2 DC AWS A5.23 (flux wire combination) (F62PZ-EB9-B9) (F62PZ-EB9-B9) Composition L2N LA491 (flux wt %) SiO<sub>2</sub> + Ti O<sub>2</sub> 30% 15% CaO + Mg O 40% 35% $AlO_3 + MnO$ 20% 5% CaF<sub>2</sub> 25% 20% Basicity index (Boniszewski) ~2.7 ~1.3 Analysis deposit С Mn Si S Р Cr Ni Mo Nb V Ν (typical) 9CrMoV-N Wire 0.10 0.8 0.30 0.005 0.005 9.0 0.6 1 0.06 0.20 0.05 Deposit with LA491 8.6 0.08 0.8 0.35 0.005 0.010 0.6 1 0.05 0.17 0.05 Deposit with L2N 0.005 0.09 0.5 0.6 0.012 8.3 0.6 1 0.04 0.16 0.05 All-weld mechanical PWHT 750-760°C / 2-3h SAW typical SAW typical min properties LA491 flux L2N flux Tensile strength MPa 620 750 750 0.2% Proof stress MPa 630 630 415 Elongation on 4d % 25 25 16 Elongation on 5d % 17 23 23 Reduction of area % 70 70 \_\_\* + 20°C 40 35 Impact energy I Hardness 250 250 HV (mid) ---\* Minimum impact required by BS EN 12070: SCrMo91 is 47 J. **Parameters** LA491 L2N AC or DC+ 800A maximum AC or DC+ 900A maximum Packaging data LA491 L2N Packaging: 25kg sealed drums Packaging: 20kg sealed drums Preferred storage <60%RH, > 18°C. Preferred storage <60%RH, > 18°C. If flux becomes damp, rebake at 300–350°C/ 1–2hours If flux becomes damp, rebake at 150-250°C/1–2hours to restore to as-packed condition. For critical work, it to restore to as-packed condition.

is recommended to redry to ensure <5ml H<sub>2</sub>/100g.

### LA491 and L2N

#### Sub-arc fluxes for use with 9CrMoV-N solid wire



## Supercore F91

#### All-positional flux cored wire

Product description					vire desig ucing wel						Mo steel	ls (P91)	. Rutile	e flux s	ystem
Specifications		8 A5.29 En ISO		4-B	E91T1- T69T1-	B9M 1M-9C11	MV								
ASME IX Qualification	QW432 F-No -, QW442 A-No -														
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	V	Ν	Cu	Al	Ni+ Mn
(weld metal wt %)	min max typ	0.08 0.13 0.1	0.60 1.20 0.8	0.50 0.3	0.015 0.010	 0.020 0.016	8.0 10.0 9	0.80 0.5	0.85 1.2 1	0.02 0.07 0.04	0.15 0.25 0.2	0.02 0.07 0.05	0.15 0.05	0.04 0.01	 1.5 1.3
All-weld mechanical properties	PWHT 760°C / 2h							n	typic	al	+566°(	•	empera +600°C		50°C
	Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area					MPa MPa % %	56 10	620 565 16 14		)))	450 360 21 20 73		420 288 27 25		396 245 29 26 85
		ct energ		H	+ 20°C	J HV			55 25 26(				81  		 
Operating parameters	Ø 1.2m	ent: D0	C+ve ra	anges a welding Positio	0%CO <sub>2</sub> (o s below: g position nal age shoul	<u>an</u> 14	np-volt ra 0-170A,	ange * 24-26\	t	at 20-25 ypical 160A, 2			stickou 15-25r		
Packaging data	Spoo The a Resis possi	ls vacuu as-packo stance to bility o	um-sea ed shel o moist f poros	led in t f life is ure abs ity, it is	parrier fo virtually orption is s advised storage c	il with ca indefini high, bu that part	rdboard te. t to main -used sp	carton ntain th	e high i e returr	ntegrity red to p	of the volution			l preve	nt any
Fume data	Fume	e compo	osition	(wt %)	, shieldin	g gas 80°	%Ar-20	%CO <sub>2</sub> :							
		_	Fe		Mn	Ni	Cr <sup>3</sup>	С	r <sup>6</sup>	Cu	F	OE	S (mg/m	1 <sup>3</sup> )	
		-	18		8	< 0.5	3	1	3	< 1	8		1.7		



## CONSUMABLES FOR E911 CrMo STEEL

### DATA SHEET A-18

METRODE PRODUCTS LTD HANWORTH LANE, CHERTSEY SURREY, KT16 9LL Tel: +44(0)1932 566721 Fax: +44(0)1932 565168 Sales Fax: +44(0)1932 566149 Technical Fax: +44(0)1932 566199 Export Email: info@metrode.com Internet: http://www.metrode.com

#### Alloy type

Modified 9CrMo type generically called E911, with a nominal composition of 9%Cr-1%Mo-1%W+NbVN.

#### Materials to be welded

DIN X11CrMoWVNb 9 1 1 G-X12CrMoWVNbN 10 1 1 (cast)

#### Applications

Electrodes for the new European creep-resistant steel E911, which is essentially the ASTM P91 type with 1%W added to increase creep strength for service up to at least 600°C.

These consumables are mainly intended for castings, which have a slightly higher Cr level. Castings also have up to 1%Ni to suppress retained ferrite; in wrought products nickel is limited to 0.4%. For microstructural control and to optimise toughness after PWHT, the weld metal has about 0.5%Ni added.

Applications for E911 steels include components such as headers, main steam piping, boiler tubes, turbine casings and valves in fossil fuelled power generating plants. It may also find future use in oil refineries and coal liquefaction and gasification plants.

#### Microstructure

In the PWHT condition consists of tempered martensite.

#### Welding guidelines

Preheat-interpass range for E911 is 200-300°C. Before PWHT it is preferable to cool to 100°C or lower to ensure full martensite transformation.

#### **PWHT**

PWHT requirements are essentially the same as for P91, which requires PWHT in the range 730-780°C. Castings are often PWHT at temperatures towards the bottom of this range but the time is proportionally increased to ensure sufficient tempering. As a general rule the tempering parameter (P), should be 21, or higher, to achieve adequate tempering.

 $P = {}^{\circ}C + 273(20 + \log t) \times 10^{-3}$  (t = time in hours)

#### **Related alloy groups**

This alloy is closely related to the P91 alloy (data sheet A-17) and P92 alloy (data sheet A-20). The 9CrWV TIG wire (A-20) can be used in conjunction with Chromet 10MW. Also see alloy 921 (data sheet A-25).

Process	Product	Specification
MMA	Chromet 10MW	
FCW	Cormet 10MW	



CHROMET 10	MW						MMA	elect	rode f	for E9	911 cre	eep-re	sisting	steel
Product description	MMA electrode with a basic low hydrogen flux system made on high purity steel core wire. Electrode is all positional with a moisture resistant coating giving very low weld metal hydrogen levels.													
	Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.													
Specifications	AWS	A5.5	E90	)15-G (E	9015-B9	modified	)							
ASME IX Qualification	QW432 F-No, QW442 A-No													
Composition	C N			Si	S	Р	Cr	Ni	Ni Mo		Nb	V	Ν	Al
(weld metal wt %)	min	0.08	0.50	0.15			9.0	0.40	0.9	0.9	0.04	0.18	0.04	
	max typ	0.13	1.20 0.8	0.50	0.01 0.008	0.02	10.0 9.5	0.80	1.1	1.1	0.07	0.25	0.07	0.02
All-weld mechanical properties	Typica	al after P	WHT: 7	30°C/12	h		typica	1						
properties	Tensil	e streng	th			MPa	760	·						
		Proof str				MPa	620							
	-	ation on				%	19							
		ction of a t energy		+20	°C	% J	62 60							
	Hardn			. 20	C	HV	250							
Operating parameters	DC +v	ve or AC	C (OCV	: 70V m	in)					Ų			Ê	Û
	ø mm			3.2		4.0		5.	0					
	min A			80		100		140						
	max A	1		140		180		240						
Packaging data	ø mm			3.2		4.0		5.						
	length			380		450		45						
	kg/car pieces			14.4 393		16.5 225		16 15						
Storage	pieces/carton393225159 <b>3 hermetically sealed ring-pull metal tins</b> per carton, with unlimited shelf life. Direct use from tin with hydrogen < 5ml/100g for longer than a working shift of 8h. For electrodes that have been exposed:  <b>Redry</b> 250 - 300°C/1-2h to ensure H2 < 10ml/100g, 300 - 350°C/1-2h to ensure H2 < 5ml/100g. Max 420°C, 3 cycles, 10h total.											ximum 5 weeks		
Fume data	Fume	compos	ition, w	t % typi	cal:									
			Fe	Mn N		li C	r	Cu			F	OES (mg/m <sup>3</sup> )		
			15	5	<0	.2 <	3	<0.1	<0.1		18	1.7	,	



#### Metal cored wire for E911 creep-resisting steel **Product description** Metal cored wire designed to weld equivalent E911 steels. Metal powder core with an alloyed strip producing weld metal recovery of about 96%. Specifications **AWS A5.29** No current national standards. **ASME IX Qualification** QW432 F-No -, QW442 A-No -С Ρ Cr W Nb V В Composition Mn Si S Ni Mo Ν AI Cu (wire wt %) 0.08 0.50 ---9.0 0.40 0.9 0.9 0.04 0.18 0.04 min \_\_\_ \_\_\_ -------0.04 0.13 0.40 0.0015 max 1.20 0.015 0.020 10.0 0.85 1.1 1.1 0.07 0.25 0.07 0.1 0.05 Тур 0.11 0.8 0.30 0.01 0.017 9.5 0.6 1.0 1.0 0.05 0.2 0.05 0.0005 0.01 All-weld mechanical PWHT 755°C / 3h typical properties Tensile strength 770 0.2% Proof stress 650 Elongation on 4d 11 Elongation on 5d 9 Reduction of area 20 Impact energy $+20^{\circ}C$ 14 Hardness 260 **Operating parameters** Shielding gas: Ar + 2.5-20%CO, at 20-251/min (operability is improved at higher CO, contents but impact properties are better with lower CO<sub>2</sub> contents). Current: DC+ve ranges as below: ø amp-volt range stickout 1.2mm 260A, 28V 15-25mm (0.045in) Packaging data Spools vacuum-sealed in barrier foil with cardboard carton: 15kg (33 lbs) 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 %), shielding gas 80%Ar-20%CO<sub>2</sub>: Fe Cr<sup>3</sup> Pb Mn Ni Cu OES (mg/m<sup>3</sup>) 5 5 < 0.5 < 0.1 5.0 60 < 0.1

**Cormet 10MW** 



## Low Alloy Steels

## **12CrMoV CREEP RESISTING STEEL**

#### Alloy type

12% Cr creep resisting steel also with nominally 1% Mo-0.5%W-0.3%V. The matching base material is generically called X20.

#### Materials to be welded

AISI	Туре 422.
DIN	X20CrMoV 12 1 (1.4935)
	G-X22CrMoV 12 1 (1.4931) cast
BS	3604 grade 762.

#### **Applications**

Chromet 12MV deposits high strength martensitic weld metal of nominally 0.2%C-12%Cr-1%Mo modified with vanadium and tungsten. The alloying is balanced with a small addition of nickel to ensure a fully martensitic microstructure.

12%CrMoV steels are used for critical heat and creep resisting service up to at least 550°C. The high chromium level confers superior steam and fireside corrosion performance compared with 2-9%CrMo creep-resisting steels.

Used in cast and wrought form for high pressure steam piping and headers, heat exchangers and turbine components, particularly in the power generation industry and sometimes in petrochemical applications.

#### **Microstructure**

In the PWHT condition the microstructure consists of tempered martensite.

#### Welding guidelines

The room temperature hardness of as-deposited weld metal exceeds 500HV over a wide range of cooling conditions. Preheat of 400°C with maximum interpass temperature of 500°C is specified by DIN 8575. These temperatures are above the austenite-martensite transformation range (Ms-Mf about 350-150°C) and more recent procedures have benefited from welding in the 200-350°C preheat range to reduce grain-coarsening and promote some tempering of partially transformed multipass weld metal.

DATA SHEET

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After welding, the joint must be cooled slowly to 120C (100-150°C) and held for 1-2 hours, to allow transformation before post-weld heat treatment. If immediate heat treatment is not possible, the transformation step must be followed by a post-heat of about 350°C for 1-4 hours for hydrogen release, before cooling below 60°C is allowed. In this condition, the hard weld zone is potentially sensitive to stress corrosion cracking (SCC) and must be kept dry, with minimum delay before PWHT.

#### **PWHT**

For production welds typical PWHT is in the temperature range 730-770°C. Normally this would be required for a minimum of three hours but will vary according to thickness, see appropriate application code for details.

#### **Related alloy groups**

The newer P91 materials have replaced many of the original applications for this alloy (data sheet A-17).

Process	Product	Specification
MMA	Chromet 12MV	BS EN E CrMoWV 12 B
TIG	12CrMoV	BS EN W CrMoWV 12 Si



Product description	weld n	netal hyd	rogen le	vels.		-	h purity co 65% with				_	ggiving v	ery lov
Specifications	BS EI DIN 8	N 1599 575			MoWV12 MoWV 1								
ASME IX Qualification	QW43	QW432 F-No, QW442 A-No											
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	W	V		
(weld metal wt %)	min	0.15	0.40				10.0		0.80	0.40	0.20		
	max	0.25	1.30	0.80	0.025	0.025	12.0	0.8	1.20	0.70	0.40		
	typ	0.20	0.8	0.25	0.010	0.017	11	0.5	1	0.5	0.3		
All-weld mechanical	PWHT	760ºC / 3	3 hrs			Room					emperatu		
properties						temp	erature	38	50°C	40	0°C	45	0°C
						min *	typical	min	typ	min	typ	min	typ
		e strength			MPa	690	750		590		560		52
		Proof stree			MPa	550	550	370	450	355	420	325	41
		ation on 4			%		24		18		20		17
	-	ation on 5			%	15	21		16		16		14
		tion of are		+ 20°C	% J	34	55 40		50		48		48
	Impaci	energy		+ 20°C	J		33						
	Hardne	299		00	HV		235						
			equirem	ents afte		1	233 60°C/2 hou	1		I		I	
Operating parameters	DC +v	e or AC (	OCV: 7	OV min)					Ū			Ê	Î
	ø mm			2.5		3.2		4.0		5.0			
	min A			70		80		100		140			
	max A			110		140		180		240			
Packaging data	ø mm		· ·	2.5		3.2		4.0		5.0			
	length	mm		350		380		450		450			
	kg/cart			12.6		13.8		16.8		16.8			
		/carton		600		339		234		150			
Storage	hydrog For ele <b>Redry</b> 3 cycle <b>Storag</b>	gen $<5$ ml ectrodes t 250 - 30 es, 10h to ge of redr	/100g fo hat have 0°C/1-2 tal. ied elec	or longer e been ex th to ensu trodes at	than a wo posed: are $H_2 < 10$ 50 - 200	orking shi ml/100g, °C in hol	rton, with ft of 8h. 300 - 350 ding over ditions for	°C/1-2h 1 or heat	to ensure ed quive	e H <sub>2</sub> <5ml r: no limi	/100g. M it, but ma	aximum ximum 6	420° 5 weel
Fume data	Fume	composit	ion, wt 9	% typical	:								
		Fe	Mr	Mn Ni			Cu	Мо		v	F	OES (r	ng/m <sup>:</sup>
	-	20	4		0.1	<b>Cr</b> 3	<0.2	0.1		.1	16	1.	



## 12CrMoV

### Solid TIG wire for 12%Cr creep resisting steel

Product description	Solid v	wire for 7	ΓIG.									
Specifications	BS EI DIN 8	N 12070 575			foWV 12 MoWV12							
ASME IX Qualification	QW43	<b>32</b> F-No	, QV	<b>/442</b> A-1	No							
Composition (wire wt %)	min max typ	C 0.17 0.24 0.2	Mn 0.40 1.00 0.6	Si 0.20 0.60 0.4	S  0.020 0.005	P  0.025 0.01	Cr 10.5 12.0 11	Ni  0.80 0.6	Mo 0.80 1.20 1	V 0.20 0.40 0.3	W 0.35 0.80 0.5	
All-weld mechanical properties	Tensile 0.2% F Elonga	l values a e strength Proof stre ation on 5 energy	n SS	HT 760°C + 20°C	M M	IPa IPa % J	min 690 550 15 34	typ 75 60 2 5	50 00 0			
Operating parameters	Shieldi Curren Diame Voltage	t ter		TIG Argon DC- 2.4 100A, 1								
Packaging data	ø mm 2.4			TIG 5kg tub	De							
Fume data	Fume	composit	tion (wt	%) (TIG :	-	gligible)						
			Fe 55	Mn 4	Cr <sup>3</sup>	N <0.		Ио 0.5	Cu <0.5	OES (m 5	g/m³)	



## Low Alloy Steels

### **P92 CONSUMABLES**

#### Alloy type

9%Cr steel alloyed with W, Mo, V, Nb, and N for high temperature creep resistance.

#### Materials to be welded

#### ASTM

A 213 T92 (seamless tubes) A 335 P92 (seamless pipes) A 387 Gr 92 (plates) A 182 F92 (forgings) A 369 FP92 (forged & bored pipe)

#### ΕN

X10CrWMoVNb 9-2

#### Applications

These consumables are designed to weld equivalent 'type 92' 9% Cr steels modified with tungsten, vanadium, niobium, nitrogen and a small addition boron to give improved long term creep properties.

They are specifically intended for high integrity structural service at elevated temperature so the minor alloy additions responsible for its creep strength are kept above the minimum considered necessary to ensure satisfactory performance. In practice, weldments will be weakest in the softened (intercritical) HAZ region of parent material, as indicated by so-called 'type IV' failure in transverse weld creep tests.

The rupture strength of P92 is up to 30% greater than P91, and interest in its use is growing as a candidate for components such as **headers**, **main steam piping** and **turbine casings**, in fossil fuelled **power generating plants**.

#### Microstructure

In the PWHT condition the microstructure consists of tempered martensite.

#### DATA SHEET A-20

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#### **PWHT**

Minimum preheat temperature  $200^{\circ}$ C with maximum interpass temperature of  $350^{\circ}$ C; in practice a preheat-interpass range of  $200 - 300^{\circ}$ C is normal. To ensure full martensite transformation welds should be cooled to ~ $100^{\circ}$ C prior to PWHT; up to 50mm wall thickness can be cooled to room temperature whilst thick wall forgings or castings should not be cooled below ~ $80^{\circ}$ C prior to PWHT.

ASME base material codes allow PWHT down to 730°C but for weld metals PWHT is normally carried out in the range 750-770°C. Optimum properties are obtained with PWHT at 760°C for 4 hours.

When compared with directly matching weld metal, the addition of some nickel and reduction of niobium provides a useful improvement in toughness after PWHT.

#### Additional information

D Richardot, J C Vaillant, A Arbab, W Bendick: "The T92/P92 Book" Vallourec & Mannesmann Tubes, 2000.

Process	Product	Specification
MMA	Chromet 92	
TIG	9CrWV	
SAW	9CrWV (wire)	
	LA491 (flux)	BS EN SA FB 255AC
FCW	Supercore F92	



Chromet 92				ſ	MMA	all-po	sitior	nal el	ectro	de fo	or join	ing P	92 cr	eep re	sisting	g stee
Product description		c coate metal				nade on	pure	low ca	bon co	ore wir	e. Mois	sture re	sistant	coatings	giving	very low
	Reco	very is	appro	ox 120	% with	respect	to co	re wire	, 65%	with re	espect t	o who	le electi	rode.		
Specifications	None	e appl	icable	e.												
ASME IX Qualification	QW4	QW422 P-No 5B group 2, QW432 F-No, QW442 A-No														
Composition		С	Mn	Si	Si S P (			Ni	Мо	W	Nb	V	Ν	В	AI	Cu
(weld metal wt %)	min	0.08	0.40				8.0		0.30	1.5	0.04	0.15	0.03	0.001		
	max	0.13	1.00	0.40	0.015	0.020	9.5	0.80	0.60	2.0	0.07	0.25	0.07	0.005	0.03	0.15
	typ	0.11	0.6	0.25	0.01	0.01	9	0.6	0.45	1.7	0.05	0.2	0.05	0.003	< 0.01	< 0.05
All-weld mechanical	PWH	T 760	°C / 2-	4h				mi	n	typical			Hi	gh Temp	erature	
properties												50°C	+600		+650°C	
		ile stre	•	MPa			620			40		511	422		340	
		Proof		MPa				44			30		419	320		229
	-	gation o			( )			17		22			15	19.5		19.5
	-	gation o					%	16		19		14		18 73		18
		iction o			2000		%				50		64			80
	Impa Hardı	ct ener ness	gy	-	+ 20°C		J HV				50 1-260					
Packaging data	ø mm				2.5			3.2		4.0*			5.0			
	length mm			350				380		380/450			450			
	kg/ca	irton			13.5			15.0		15.0	/17.1		16.5	i		
	piece	s/carto	n		657			378		264	/249		150			
	* 450	)mm is	the st	andar	d lengtl	n for 4.0	)mm, 1	380mn	n produ	ced to	order.					
Operating parameters	DC +	-ve.		A	AC (OCV 70V min)					Ų		<	$\mathbb{Z}$		Ê	Î
	ø mm	า		1	2.5			3.2		4	.0		5.0			
	min A				70			80			00		140			
	max				110			140			80		240			
Storage	hydr For e Redr 420° Stora	electroc y 250 C, 3 cy age of	5ml/1 les tha – 300 cles, 1 redrie	00g w at have °C/1-2 10h to d elec	veld me e been e 2h to er tal.	tal durin exposed nsure H <sub>2</sub> at 100 –	ng 8h : < 10i	workir ml/100	ıg shift g, 300	– 350°	°C/1-2ł	n to ens	sure H <sub>2</sub>	ect use fr < 5ml/1 red quive	00g. M	aximur
Fume data	Fume	e comp	ositio	n (wt 9	%)											
			F	е	Mn	Ν	li	Cr		Cu	Pb		F	OES (	mg/m³)	
						< (								(-	J/	_



9CrWV												Sol	id wir	e for T	IG and	SAW
Product description	Solid	l wire, 1	non-co	pper c	oated, f	or TIG	and S	AW	velding	g.						
Specifications	None	e applic	able.													
ASME IX Qualification	QW4	<b>422</b> P-1	No 5E	8 grou	p2, <b>Q</b>	W432	F-No	,	QW44	<b>2</b> A-	No					
Composition		С	Mn	Si	S	Ρ	Cr	Ni	Мо	W	Nb	V	Ν	В	AI	Cu
(wire wt %)	min max	0.08 0.13	0.40 1.00	 0.40	0.015	0.015	8.0 9.5	 0.80	0.30 0.60	1.5 2.0	$\begin{array}{c} 0.04 \\ 0.07 \end{array}$	0.15 0.25	0.03 0.07	$0.001 \\ 0.005$	0.03	0.15
	Тур	0.11	0.7	0.30	0.01	0.01	9	0.5	0.45	1.7	0.06	0.2	0.05	0.003	< 0.01	< 0.05
All-weld mechanical properties	PWH	IT 760°(	C/2-	4h				n	nin	TIG typical			High Temperature TIG +550°C +600°C +6			IG +650°C
	Tensile strength 0.2% Proof stress				MPa MPa				20 40	800			455 374	38 282	7 2	312 200
	Elongation on 4d				%			1	6	22 19			24.5 22.5	20. 19		28 25.5
	Elongation on 5d Reduction of area				%0 %0					70			22.5 82	85		25.5 89
		ct energ		+ 20°C			J			220				,		
	Hard	ness				HV (r	nid)				265					
Parameters					TI	G			S	AW				М	IG	
	Shiel	ding			Arg				LA49		х			VV is not		
		eter, m	m		2.					2.4				for MIG		<i></i>
	Curre Typic	ent cal para	meters		D0 100A	-		450A	-	0C+ , 450r	nm/mir	ı	Supero	core F92	should	be used.
Packaging data	ø mm	า			TI	G			S	AW						
	2.4				5kg	tube			25k	g coil						
Fume data	Fume	e compo	osition	(wt %	rt %); TIG and SAW fur				me is negligible:							
			Fe		Mn Ni			Cr		Mo Cu		u	OES	(mg/m³)		
			50		4	< 0.	4	6		0.5	< 0	.5		5	-	

## LA491 Flux

Sub-arc flux for use with 9CrWV solid wire

Product description	Agglomerated	Agglomerated fluoride-basic submerged arc welding flux												
Specifications	Flux:	BS EN 760         SA FB 255												
Composition (weld metal wt %)	15% SiO <sub>2</sub> + T 40% CaO + M 20% AlO <sub>3</sub> + M 25% CaF <sub>2</sub> Basicity index	Ig O AnO	Bonisze	ewski)										
Analysis deposit (typical)	9CrWV Wire Deposit	C 0.11 0.09	Mn 0.7 0.7	Si 0.3 0.3	S 0.01 0.01	P 0.01 0.01	Cr 9.0 8.5	Ni 0.5 0.5	Mo 0.4 0.4	W 1.7 1.7	Nb 0.06 0.04	V 0.19 0.16	N 0.05 0.04	B 0.003 0.001



## LA491 Flux (continued)

#### Sub-arc flux for use with 9CrWV solid wire

All-weld mechanical properties	PWHT 760°C / 2 – 4h		min	SAW & LA491					
properties		MD-		typical					
	Tensile strength	MPa	620	740					
	0.2% Proof stress	MPa	440	630					
	Elongation on 4d	%	16	20					
	Reduction of area	%		60					
	Impact energy + 20°C	J		35					
	Hardness	HV (mid)		250					
Parameters	AC or DC+ 800A maximum								
Packaging data	25kg sealed drums Preferred storage $<60\%$ RH, $> 18$ °C. If flux becomes damp, rebake at $300 - 350$ °C / 1 – 2hours to restore to as-packed condition. For critical work, it is recommended to redry to ensure $<5$ ml H <sub>2</sub> /100g.								

Supercore F9	2											All-p	ositic	onal flu	x core	ed wire
Product description					wire de covery o				valent	P92 s	steels.	Rutile f	flux sys	stem with	ı an allo	yed strip
Specifications	AWS	S A5.2	9	N	lo curre	nt natio	onal st	andard	s.							
ASME IX Qualification	QW	<b>432</b> F-No -, <b>QW442</b> A-No -														
Composition (wire wt %)	min max Typ	C 0.08 0.13 0.11	Mn 0.40 1.20 0.8	Si  0.40 0.30	S  0.015 0.01	P  0.020 0.017	Cr 8.5 9.5 9	Ni 0.30 0.80 0.5	Mo 0.30 0.60 0.45	W 1.5 2.0 1.7	Nb 0.03 0.07 0.04	V 0.15 0.25 0.2	N 0.03 0.07 0.04	B 0.001 0.005 0.003	AI  0.03 <0.01	Cu  0.15 <0.05
All-weld mechanical properties		IT 760°		h			typical			+550°C		High Ter +600°C		+650°		+700°C
	0.2% Elony Elony Redu Impa	ile strei Proof s gation c gation c uction o ict energiness	stress on 4d on 5d f area	+	20°C		775 650 21 18 50 25 260			47 38 18 1' 6!	35 .5 7 8	40 29 25 22 77 	4 5 .5 7	308 194 26.5 24.5 81 		215 125 25.5 23.5 86 
Operating parameters	Shielding gas:       80% Ar-20% CO <sub>2</sub> (or 15 – 25% CO <sub>2</sub> ) or 100% CO <sub>2</sub> at 20-251/min.         Current:       DC+ve ranges as below:         Ø       welding position         amp-volt range *       typical         stickou										out					
	1.2m (0.04 * Us	5in)		Position the vol	nal Itage sh	ould be		-170A, ased by		/	160A,	25V		15-2	5mm	
Packaging data	The Resignment of the Resignme	as-pack stance t ibility c	ed shel to mois of poros	lf life i ture al sity, it	barrier s virtua osorptio is advis d storag	lly inde on is hig sed that	efinite gh, but part-u	to mai ised sp	intain t ools ar	he hig e retu	gh integ rned to	rity of polyth		e surface appers.	and pre	event any
Fume data	Fum	e comp	osition	(wt %	), shiel	ding ga	s 80%		%CO <sub>2</sub> :							
			Fe 18		Mn 8	Ni < 0.		Cr <sup>3</sup>	-	cr <sup>6</sup> 3	Cu < 1	F 8		OES (mg 1.7	/m³)	



## Low Alloy Steels

## **T23 CONSUMABLES**

#### Alloy type

 $2\frac{1}{4}$  Cr steel alloyed with W, Mo, V, Nb, and B for high temperature creep resistance.

#### Materials to be welded

ASTM A 213 T23 (seamless tubes)

#### Applications

These consumables are designed to weld equivalent 'type 23' 2<sup>1</sup>/<sub>4</sub>%Cr steels modified with tungsten, vanadium, niobium, and a small boron addition to give improved long term creep properties. The Chromet 23L electrode is specifically designed for as-welded applications but can also be subject to PWHT; the flux cored wire will typically be used on thicker wall pipe where it is envisaged that PWHT will be applied.

The consumables are intended for high integrity service at elevated temperature so the minor alloy additions responsible for creep strength are kept within the parent material range.

The rupture strength of T23 can be up to twice that of T22 and interest in its use is growing as a candidate for components such as **waterwalls in ultra-super-critical boilers**, in fossil fuelled **power generating plants**.

#### Microstructure

In the as-welded condition the microstructure consists of bainite.

#### DATA SHEET A-21

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#### Welding guidelines

In many situations it is claimed that thin wall tube can be welded without preheat; if preferred, and for thicker wall sections, a preheat of 150-200°C can be applied. Maximum interpass temperature should be kept to 350°C.

For many current applications T23 tube is put into service in the as-welded condition. During production of the tube the typical tempering cycle applied is  $760^{\circ}C/30$  minutes; the ASME code case specifies a minimum tempering temperature of  $730^{\circ}C$  for base material. When it has been applied PWHT in the range  $715-740^{\circ}C$  has been applied.

#### Additional information

J Arndt, G Knottmann, J C Vaillant, W Bendick, F Deshayes: "The T23/T24 Book" Vallourec & Mannesmann Tubes, 1998.

Process	Product	Specification
MMA	Chromet 23L	
TIG	2CrWV	
SAW	2CrWV (wire)	
	LA491 (flux)	
FCW	Cormet 23	



<b>Chromet</b> 2	23L
------------------	-----

MMA all-positional electrode for joining T23 creep resisting steel

Product description		c coate metal				nade on	pure	low car	bon co	ore wir	e. Mois	ture re	sistant	coatings	giving v	ery low
	Reco	overy i	s appro	ox 120	% with	respect	t to co	ore wire	e, 65%	with r	espect	o who	le elec	trode.		
Specifications	Non	e appl	icable	e.												
ASME IX Qualification	QW	<b>422</b> P	-No 51	3 grou	p 2, <b>Q</b>	W432	F-Nc	), <b>Q</b>	W442	A-No	)					
Composition (weld metal wt %)	min max typ	C 0.04 0.10 0.05	Mn 0.10 1.00 0.5	Si  0.50 0.25	S  0.015 0.01	P  0.020 0.01	Cr 1.9 2.6 2.2	Ni  0.80 0.6	Mo 0.05 0.30 0.2	W 1.45 1.75 1.6	Nb 0.02 0.08 0.03	V 0.20 0.30 0.23	N  0.03 0.02	B 0.0005 0.0060 0.001	Al  0.03 <0.01	Cu  0.15 <0.05
All-weld mechanical properties		ile stre		0.20	0.01		MPa	typi as-we	cal elded	t	ypical 15°C/1 700		0.02	0.001		
	0.2% Elon Elon Redu	Proof gation gation uction o	stress on 4d on 5d of area				MPa % %	87 19 10 50	70 9 6 0		625 22 20 60					
		ict ene ness	rgy	-	- 20°C		J HV	22 290-350		22	70 20-260					
Operating parameters	DC -	⊦ve.		A	C (OCV	70V m	nin)				Ú	<			Î	Û
	ø mr	n			2.5			3.2		4	.0					
	min /				70			80			00					
	max	A		-	110			140			80					
Packaging data	ø mr				2.5 350			3.2			.0					
	kg/ca	h mm arton			350 12.0			380 15.0			50 5.2					
	•	es/carto	on		621			396			28					
Storage	<b>3 hermetically sealed ring-pull metal tins</b> per carton, with unlimited shelf life. Direct use from tin will give <b>hydrogen</b> $<5ml/100g$ weld metal during 8h working shift. For electrodes that have been exposed: <b>Redry</b> 250 – 300°C/1-2h to ensure H <sub>2</sub> $<10ml/100g$ , 300 – 350°C/1-2h to ensure H <sub>2</sub> $<5ml/100g$ . Maximum 420°C, 3 cycles, 10h total. <b>Storage</b> of redried electrodes at 100 – 200°C in holding oven, or 50 – 150°C in heated quivers: no limit, but maximum 6 weeks recommended.											aximum				
Fume data	Fum	e comp	oositio	n (wt	%)											
			F		Mn 5	N < (		Cr < 3	<	Cu < 0.1	Pb < 0.	1	F 18	OES (r 1.	<u> </u>	

2CrWV

#### Solid T23 wire for TIG welding

Product description	Solid	Solid wire, copper coated, for TIG welding.													
Specifications	None	None applicable.													
ASME IX Qualification	QW4	QW422 P-No 5B group 2, QW432 F-No, QW442 A-No													
Composition		C	Mn	Si	S	Р	Cr	Ni	Мо	W	Nb	V	В	Al	Cu
(wire wt %)	min	0.04					1.9		0.05	1.45	0.02	0.20	0.0005		
max 0.10 1.0 0.5 0.015 0.020 2.6 0.8 0.30 1.75 0.08 0.30 0.0060										0.03	0.25				
	Тур	0.06	0.6	0.3	0.01	0.01	2.4	0.5	0.2	1.6	0.05	0.25	0.003	< 0.01	0.15



## 2CrWV (continued)

All-weld mechanical properties				typica as-weld		typical 715°C/30min	typical 740°C/2h		
	Tensile strength		MPa	950		755	640		
	0.2% Proof stress		MPa	875		700	555		
	Elongation on 4d		%	21		23	28		
	Elongation on 5d		%	19		20	24		
	Reduction of area		%	55		70	80		
	Impact energy	+ 20°C	J	50		190	>250		
	Hardness		HV (mid)	325		255	220		
Parameters		TIG	i						
	Shielding	Argo	n						
	Diameter, mm	2.4							
	Current	DC	-						
	Typical parameters	100A,	12V						
Packaging data	ø mm	TIG	i						
	2.4	5kg tu	ıbe						
Fume data	Fume composition (wt %); TIG and SAW fume is negligible:								
	Fe	Mn	Ni	Cr	Мо	Cu	OES (mg/m <sup>3</sup> )	_	
	55	5	1.3	< 0.5	< 0.5	1.2	5		

## LA491 FLUX

Sub-arc flux

Product description	Agglomerate	d fluoric	de-basi	c non-a	lloying fl	ux for	submer	ged ar	c weldi	ing.				
Specifications	DIN 32522 BS EN 760		-	FB 6 5: A FB 25	5455 AC 55 AC	8								
ASME IX Qualification	QW432 F-N	QW432 F-No -, QW442 A-No -												
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	W	Nb	V	Cu	В
(typical wt%)	2CrWV wire Deposit	0.06 0.05	0.6 0.6	0.30 0.35	<0.01 <0.01	0.01 0.01	2.4 2.3	0.5 0.5	0.2 0.2	1.6 1.5	0.05 0.04	0.25 0.22	0.1 0.1	0.003 0.002
All-weld mechanical		740°C/2h												
properties with	Tensile streng	Tensile strength 0.2% Proof stress				MPa 645								
2CrWV wire	0.2% Proof st	ress			MI	Pa	570							
	Elongation on	4d				%	22							
	Elongation on	Elongation on 5d				%	18							
	Reduction of	area				%	55							
	Impact energy	/	+2	20°C		J	175							
	Hardness				HV (mi	d)	245							
Operating parameters	Current: DC	+ve ran	ges as	below:										
	ø mm		ar	np-volt i	ange			typical	I		stic	kout		
	2.4	· · · ·						350A, 29V         20-25mm						
Packaging data	Metrode LA491 Flux is supplied in sealed moisture resistant 20kg metal drums. Preferred storage conditions for opened drums: $< 60\%$ RH, $> 18$ °C. If the flux has become damp or has been stored for a long period, it should be redried in the range 3000-350°C/1-3h.													



# Low Alloy Steels

## **CONSUMABLES FOR WB36**

#### Alloy type

WB36 is a NiMo base material with Cu and Nb additions with good hot strength. Although consumables of matching composition are not used compatible alternatives have been found to provide the required properties.

#### Materials to be welded

The consumables listed on this data sheet can be used for a wide variety of applications (see also data sheets A-50, A-61 and A-64) but this data sheet concentrates on the welding of:

15NiCuMoNb5
1.6368
15NiCuMoNb5-6-4
1.6368
Grade 591
Code Case 2353
A335 P36
WB36 (V+M)

#### **Applications**

WB36 is a high temperature construction steel for service up to 450°C; typical applications are below 400°C designed on the basis of tensile rather than creep properties. It is mainly used for **feedwater piping systems** in place of standard carbon steels (eg.A106 grade C) in conventional and nuclear power stations. WB36 also finds applications for **headers, manifolds** and **fittings** in power stations.

#### **Microstructure**

In the stress relieved condition the microstructure consists of tempered ferrite/bainite.

#### DATA SHEET A-23

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#### Welding guidelines

The actual preheat and PWHT requirements will depend on the thickness of the base material being welded. Normally preheat/interpass temperatures will be in the range 100-250°C depending on wall thickness.

#### **PWHT**

WB36 is tempered during manufacture in the temperature range  $580-680^{\circ}$ C, depending on specifications and requirements and following welding PWHT is required for WB36. The PWHT requirements will depend on a number of factors but will normally be about  $590\pm30^{\circ}$ C.

#### Additional information

For offshore oil well-head process pipework and fittings, after PWHT these low nickel consumables satisfy NACE MR0175 requirements (<1%Ni & <22HRC) intended to ensure resistance to sulphide-induced stress corrosion cracking in sour service, combined with good sub-zero toughness.

Also find applications for the repair of medium strength low alloy steel castings where a stress-relief only (rather than N+T) is to be applied.

Process	Product	Specification
MMA	1NiMo.B	AWS E9018-G
TIG/MIG	MnMo	AWS ER80S-D2
SAW	SA1NiMo (wire)	AWS EF3
	LA121 (flux)	BS EN SA FB 155



1NiMo.B				All-	positior	nal NiM	lo low	alloy st	eel MMA (	electrode			
Product description	MMA electrode w very low weld me			on high j	purity mil	d steel co	ore wire.	Moisture	resistant coat	ing provides			
	Recovery is abou	t 120% with r	espect to a	core wir	e, 65% wi	th respec	ct to wh	ole electro	de.				
Specifications	AWS A5.5	E90	18-G										
ASME IX Qualification	QW432 F-No 4,	QW432 F-No 4, QW442 A-No 10											
Composition (weld metal wt %)	C min 0.07	Mn Si 0.8	S 	P 	Cr 	Ni 0.8	Mo 0.20	Cu					
(weid metal wt 70)	max 0.12	1.5 0.5	0.020	0.025	0.30	1.0	0.45	0.10					
	typ 0.10	1.2 0.3	0.01	0.015	0.1	0.9	0.35	0.05					
All-weld mechanical properties	PWHT 590-620°C	c/1-2h:			min	typic	cal	Hi 250°C	gh Temperati 350°C	ure 450°C			
	Tensile strength			IPa	620	72		650	640	545			
	0.2% Proof stress		Ν	IPa	530	64		505	445	432			
	Elongation on 4d Elongation on 5d			% %	17	26 23		22	28	24			
	Reduction of area			%		65		57	69	73			
Operating parameters	DC +ve or AC (C	OCV: 70V min	)										
	ø mm	2.5		3.2		4.0		5.0					
	min A	70		80		100		140					
	max A	110		140		180		240					
Packaging data	ø mm	2.5		3.2		4.0		5.0					
	length mm	350		380		450		450					
	kg/carton	12.0		14.7		16.8		18.0					
	pieces/carton	621		390		240		168					
Storage	hydrogen < 5ml/1 For electrodes tha <b>Redry</b> 250 – 300 420°C, 3 cycles, <b>Storage</b> of redrie	3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin will give hydrogen $< 5ml/100g$ for longer than a working shift of 8h. For electrodes that have been exposed: Redry 250 - 300°C/1-2h to ensure H <sub>2</sub> $< 10ml/100g$ , 300 - 350°C/1-2h to ensure H <sub>2</sub> $< 5ml/100g$ . Maximum 420°C, 3 cycles, 10h total. Storage of redried electrodes at 50 - 150°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, $> 18°C$ .											
Fume data	Fume compositio	n, wt % typica	ıl:										
	F	e Mn	Ni	С	r (	Cu	F	OES (mg	g/m³)				
	1	4 5	0.5	<0	.1 <	0.2	18	5					



MnMo						S	Solid N	/InMo	low alloye	d wire fo	r TIG ai	nd MIG
Product description	Solid c	opper co	ated wi	re for TIG	and MI	G.						
Specifications	AWS A BS EN BS 29			ER80S-I (G4Mo) A31	· ·	90S-D2						
ASME IX Qualification	QW43	<b>2</b> F-No	6, <b>QW</b>	1442 A-No	o 11							
Composition (wire wt %)	C         N           min         0.07         1           max         0.12         2           typ         0.1         1				S  0.025 0.005	P  0.025 0.01	Ni  0.15 0.05	Mo 0.40 0.60 0.5	Cu  0.4 0.1			
All-weld mechanical properties		values F 0°C/1-2h			min *	TIG	Ar + 5		IIG Ar + 20%CO <sub>2</sub>		emperatur 350°C	re (TIG) 450°C
	0.2% P Elonga Impact Hardne * Minin (higher	ess cap/n mum as- $CO_2 + CO_2$	ss d - 30 nid welded v D <sub>2</sub> ) have	HV values are fo e lower stre	470 17 27  or AWS ength.			or ER80S-D2	is based on	100%CO2		
Typical operating parameters	T	er eters				Ar + 5- I 1. 280.	DC+ 2mm A, 26V	2	properties, see	above. Oth	ier proprie	tary gas
Packaging data	ø mm 1.2 1.6 2.4 3.2			TIG 15k 5kg tube 5kg tube To order								
Fume data	MIG fi	ime com	position Fe 55	n (wt %) (T Mn 10	TG fum Cr <sup>3</sup> <0.1	e negligib Ni <0.1	N	Ло 0.5	Cu OE 1.2	S (mg/m <sup>3</sup> )	_	



SA1NiMo									Solid I	NiMo alloyed wire for SAW				
Product description										ition of 1%Ni-0.5%Mo capable of 0%Ni maximum on request.				
Specifications	AWS A BS EN			EF3 S3Ni1	EF3 S3Ni1Mo									
ASME IX Qualification	QW432	QW432 F-No 6, QW442 A-No 10 (Nearest)												
Composition (wire wt %)	min max typ * Ni sup	C 0.08 0.15 0.10 oplied to	Mn 1.30 2.40 1.75 0 1.0% n	Si 0.05 0.25 0.2 maximum	S  0.020 0.005 n (NACE	P  0.020 0.01 MR0175	Ni * 0.8 1.2 0.9 ) on req	Mo 0.45 0.65 0.55 uest.	Cr  0.20 0.05	Cu  0.30 0.1				
All-weld mechanical properties	Typical v Tensile s 0.2% Pro Elongati Impact e	ss d	d & PWF	MP MP	a 70 a 60 6 2	W 00 00 00	600°C/1 680 580 22 120	h						
Typical operating parameters	Shieldin Current Diamete Paramet	er	4	LA 2	SAW 121 flux DC+ 2.4mm V, 450mr	n/min								
Packaging data	ø mm 2.4			SAW 25kg c										
Fume data	Fume co	omposit	ion (wt	%) (SAV	V fume no	egligible)								
			Fe	Mn	Cr <sup>3</sup>	Ni	l	Мо	Cu	OES (mg/m <sup>3</sup> )				
			50	10	< 0.5	<0.	5 <	1.5	1.2	5				

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#### **Product description**

MMA electrode (previously named Chromet WB2) depositing advanced 9CrMoV alloy with nominal composition 0.12%C-9.5%Cr-1.5%Mo-1%Co-0.25%V-0.05%Nb+B. Low hydrogen moisture-resistant flux covering on high purity steel core wire. Metal recovery is about 120% with respect to core wire, 65% with respect to the whole electrode.

#### **Specifications**

No national specifications.

#### Materials to be welded

For advanced creep resistant steel B2 developed in the European COST programme in forged (FB2) or cast (CB2) forms, such as GX-13CrMoCoVNbNB 9-2-1.

#### Applications

COST alloy B2 was originally developed as a turbine rotor material and its outstanding creep performance (above P91 and E911) has been confirmed with further optimisation. The weld metal deposited by Chromet 921 is designed to match the base material composition quite closely for fabricating thick wall components used in the construction of power plants operating with advanced steam parameters up to at least 600°C.

#### **Microstructure**

After PWHT: tempered martensite with finely dispersed precipitates.

#### Welding guidelines

Preheat-interpass range 200-300°C. Welding heat input should be kept below  $\sim$ 3kJ/mm. Cooling to  $\sim$ 100°C before PWHT is advisable to ensure full transformation to martensite. PWHT (for >27J): 730°C/16-24h or preferably



DATA SHEET A-25

### CHROMET 921

760°C/~4h.

#### **Related alloy groups**

Equivalent solid wire is not currently available; nearest for compatible properties is 9CrWV (P92), see data sheet A-20.

#### Parameters

DC+ve or AC (	OCV: 7(	)V)	Û <		Ê Î
ø mm	2.5	3.2	4.0	5.0	
min A	70	80	100	140	
max A	110	140	180	240	

#### **Packaging data**

ø mm	2.5	3.2	4.0	5.0
length mm	350	380	450	450
kg/carton	13.5	14.4	16.5	16.5
pieces/carton	657	396	240	156

#### Storage

**3 hermetically sealed ring-pull metal tins** per carton, with unlimited shelf life. Direct use from tin will give **hydrogen** <5ml/100g weld metal during 8h working shift.

For electrodes that have been exposed:

**Redry** 250 – 300°C/1-2h to ensure  $H_2 < 10ml/100g$ , 300 – 350°C/1-2h to ensure  $H_2 < 5ml/100g$ . Maximum 420°C, 3 cycles, 10h total.

**Storage** of redried electrodes at  $100 - 200^{\circ}$ C in holding oven, or  $50 - 150^{\circ}$ C in heated quivers: no limit, but maximum 6 weeks recommended.

#### Fume data

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Pb	F	OES (mg/m <sup>3</sup> )
15	5	< 0.1	<3	0.1	< 0.1	18	1.7

#### All-weld mechanical properties

PWHT 760°C 4h or eq	uivalent		min	typical
Tensile strength		MPa	650	735
0.2% Proof stress		MPa	530	602
Elongation on 4d		%	15	23
Elongation on 5d		%	17	21
Reduction of area		%		58
Impact energy	+ 20°C	J	27	40

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Cr	Ni	Мо	V	Nb	Ν	В	Со
min	0.10	0.40	0.15	-	-	9.0	0.40	1.4	0.20	0.04	0.010	0.005	0.80
max	0.15	1.00	0.50	0.015	0.020	10.5	0.80	1.7	0.30	0.07	0.035	0.015	1.20
typ	0.12	0.6	0.3	0.009	0.010	9.5	0.6	1.5	0.25	0.05	0.02	0.008	1.0



## Low Alloy Steels

## **1%Ni FOR IMPROVED TOUGHNESS**

#### Alloy type

Low alloy steel alloyed with nominally 1%Ni for improved toughness. Actual Ni content is kept below 1% to ensure conformance with NACE MR0175.

#### Materials to be welded

CMn steels with yield stress of 450MPa or where good toughness is required down to  $-50^{\circ}$ C, such as:

ASTM	A333 & A334 Grade 6.
	A350 Grades LF2 & LF5.
	A352 Grades LCB & LCC (cast).
API	5L X65.
BS	4360 Grades 43E, 50E, 55C, 55EE, 55F.

#### **Applications**

For welding higher strength steel structures where PWHT is impracticable so that welds must possess an appropriate degree of toughness and crack resistance.

The addition of about 1%Ni promotes microstructural refinement, with improved tolerance to procedural variations compared to plain CMn weld metal. Nickel also increases atmospheric weathering resistance and improves electrochemical balance between weld and base metal, thus minimising preferential weld area corrosion in marine environments. For offshore oilfield sour service, a maximum of 1.0%Ni is commonly required (NACE MR0175).

Also recommended where design requirements specify toughness testing of higher strength low alloy steel welds down to  $-50^{\circ}$ C eg. offshore construction, pipelines and pressure vessels.

**DATA SHEET** 

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#### **Microstructure**

In the as-welded condition the microstructure is ferritic with a component of acicular ferrite for optimum toughness.

#### Welding guidelines

Preheat will dependent on the grade and thickness of the base material.

#### **Related alloy groups**

The 2%Ni (data sheet A-41) and 3%Ni (data sheet A-42) are also designed for applications requiring low temperature toughness.

Process	Product	Specification
MMA	Tufmet 1Ni.B	AWS E8018-C3
TIG/MIG	1Ni	AWS ER80S-Ni1
FCW	Metcore DWA55E	AWS E71T-5



TUFMET 1Ni.	3		1%Ni I	MMA	electro	de for go	bod le	ow tem	peratur	e tougl	nness	
Product description	MMA electrode w coating giving ver Recovery is about	y low weld me	etal hydro	ogen l	evels.					Aoisture r	esistant	
Specifications		BS EN ISO 2560-A       E 46 6 1Ni B 42         BS EN ISO 2560-B       E5518-N2 A U         BS 2493       1Ni.BH         DIN 8529       EY 4675 1NiB										
ASME IX Qualification	QW432 F-No 4,	QW442 A-1	No 10									
Composition (weld metal wt %)	min (	Mn         Si           0.80         0.20           1.20         0.50           1         0.3           10%Ni max.	S  0.030 0.015	P  0.03 0.01		Ni 0.80 1.00* 0.9	Mo  0.2 0.1	V  0.05 0.01	Nb  0.05 <0.05	Cu  0.3 0.05		
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Impact energy	- 20°C - 40°C - 50°C - 60°C		Pa Pa % % J J J J J	min 550-680 470-550 24 17   47  47	typica 610 520 27 25 70 150 120 80 65	I					
Operating parameters	DC +ve or AC (O ø mm min A max A	CV: 70V min) 2.5 70 110		3.2 80 140		4.0 100 180		5.0 140 240	)	Ê	Û	
Packaging data	ø mm length mm kg/carton pieces/carton	2.5 350 12.0 627		3.2 380 13.5 390	5	4.0 450 16.8 243		5.0 45( 16.2 162	) 2			
Storage	hydrogen <5ml/10 For electrodes that Redry 250 – 300° 3 cycles, 10h total Storage of redriced	<b>3 hermetically sealed ring-pull metal tins</b> per carton, with unlimited shelf life. Direct use from tin will give <b>hydrogen</b> $<5ml/100g$ weld metal during working shift of 8h. For electrodes that have been exposed: <b>Redry</b> 250 – 300°C/1-2h to ensure H <sub>2</sub> $<10ml/100g$ , 300-350°C/1-2h to ensure H <sub>2</sub> $<5ml/100g$ . Maximum 420° C, 3 cycles, 10h total. <b>Storage</b> 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, $>18°C$ .										
Fume data	Fume composition	n, wt % typical	l:									
	Fe 14		Ni < 0.5	C < ()				F C	DES (mg/n 5	n <sup>3</sup> )		



1Ni								19	%Ni wi	ire for i	mproved tou	ighness	
Product description	Solid co	opper co	ated wi	re for TIC	and MI	G.							
Specifications	AWS A BS EN	\5.28   440 &	1668	ER80S (G3Ni1	-Ni1   – MIG;	W3Ni1	– TIG)						
ASME IX Qualification	QW43	QW432 F-No 6, QW442 A-No 10											
Composition (wire wt %)	min	C 0.06	Mn 0.80	Si 0.40	S 	P 	Cr 	Ni 0.80	Mo *	Cu 	V 		
	max typ	0.12	1.25 1	0.80	0.015	0.020	0.15	1.00 0.9	0.35	0.35	0.05		
	* Mo	st wire h	as a typ	oical Mo o	of 0.02%	but som	e batches	s will ha	ve typica	ally 0.3%	Mo.		
All-weld mechanical	Typical	values a	s welde	d			min *		TIG	М	AG Ar + 5%CO <sub>2</sub>	!	
properties	Tensile strength 0.2% Proof stress Yield strength				Μ	IPa IPa IPa	550 470 	550-650 460-510 472			571 475 498		
		tion on 4	b			%	24	32		35			
	Impact	energy		- 50°C		J	27		> 120		> 130		
	Hardne	ss cap/m	hid	- 75°C	I	J IV			> 110 95/240		> 50 190/205		
	min higi	nimum or her typic	slightl al stren	y lower, d	epending ted). Ho	on proce wever, no	ess, shield ote that y	ding gas	and Mo c	content (h	proof stress valu igher Mo wires p MPa above the (	roduce the	
Typical operating				TIG			MIG						
parameters	Shieldir Current Diamete			Argor DC- 2.4mn			-20%CC DC+ .2mm	<b>)</b> <sub>2</sub> *					
	Voltage			120A, 14		)A, 26V							
	* A	r + 1-5%	$6O_2$ and	proprieta	ıry mixtu	res also	suitable.						
Packaging data	ø mm			TIG			MIG						
	1.0						kg spool						
	1.2					151	kg spool						
	1.6 2.0			5kg tub									
	2.0			to orde 5kg tub									
		: 3.2)		5kg tub									
Fume data	MIGIU												
Fume data	MIG IU		Fe	Mn	Cr <sup>3</sup>	Ni	N	Ло	Cu	OES (n	ng/m³)		



Product description	positio	ons. The	wire is a	ulloyed w	ith abou	ıt 0.4%N	i and pro	y transfer at low currents and easy operation in all welds ad provides good as-welded ed toughness down to $-40^{\circ}$ C. L intent of typically $< 5$ ml/100g.						
	Metal recovery 90% with respect to wire.													
		-	7070 W	-										
Specifications	_	A5.20 N 758 )84			-5 (MJ ) PM1 H5 GPH									
		ets suffix oduced ir							nts. Not	e that the	new classification E71	T-9]		
ASME IX Qualification	QW4	32 F-No	6, <b>QV</b>	<b>V442</b> A-	-No 1									
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	V				
(weld metal wt %)	min							0.30						
	max	0.08	1.75	0.90	0.03	0.03	0.20	0.50	0.30	0.08				
	typ	0.05	1.1	0.5	0.01	0.02	< 0.1	0.35	< 0.1	0.02				
All-weld mechanical		As welded (PWHT with caution) min *								typica	al			
properties		•		caution)			min *		as-we	ded	600°C/4h **			
		e strengtl				MPa	480		580		575			
		0.2% Proof stress Elongation on 4d				MPa	400		500		485			
	-		d	1000	~	%	22		32		29			
		t energy		- 40°C	j.	J	27		11:		>27			
	Hardn					HV			190	)	180			
	* As	specifie	d by AV	VS A5.2	0 E71T-	-5MJ as-	welded.							
	** PV	VHT has	a detrin	nental eff	fect on i	mpact er	ergy but	all bate	hes are i	mpact tes	sted after PWHT of 600	)°C/		
Operating parameters	Shield	ling gas:	80%Aı	-20%CC	$D_2$ at 20-2	251/min.	Propriet	ary gase	es may be	used but	t argon should not excee	ed 80		
	Curre	nt: DC+	ve range	es as belo	ow.									
	ø mm		ve rung.	1	olt rang	۵		typica	al		stickout			
	1.2				00A, 16				A, 26V		15-25mm			
Packaging data	The as Resist possib		shelf lif noisture orosity,	è is virtu absorpti it is adv	ally ind on is hig ised tha	lefinite. gh, but to t part-us	ed spools	s are ret	urned to	polythen	e wire surface and preve e wrappers.	ent a		
Eumo data	-		•			inions al	C 0070 K	11 max,	10 € 111					
Fume data	rume	composi				_			_	_	· · · · · · · · · · · · · · · · ·			
				-e	Mn	Cr	Ν		Cu	F	OES (mg/m <sup>3</sup> )			
			-	33	12	< 0.5	< (	<b>\ 1</b>	< 0.5	2	5			



# Low Alloy Steels

## **2%Ni FOR IMPROVED TOUGHNESS**

#### Alloy type

Nominally 2.5%Ni low alloy steels.

#### Materials to be welded

CMn and low alloy steel plate, pipe, forgings and castings used extensively for service at low temperature eg. LT50.

ASTM	A203 Grade A & B plate.
	A333 Grade 6 pipe.
	A350 Grade LF1 & LF2 forgings.
	A352 Grade LC2 casting.
BS	1501-224 Grade 490B plate.

Also proprietary medium tensile steels eg. Hyplus 29 (Corus) and Corten weathering steel (Corus, US Steels).

#### **Applications**

Fabrication of **storage tanks**, **process plant** and associated **pipework** where good fracture toughness from as-welded joints is demanded down to temperatures in the region of -60°C.

The addition of about 2.5%Ni improves microstructural refinement and tolerance to procedural variations compared to plain CMn weld metal. It also promotes the formation of a stable patina as required for

matching the characteristics of weathering steels, and is an alternative to using matching consumables (data sheet A-70).

**DATA SHEET** 

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#### Microstructure

In the as-welded condition the microstructure is ferritic with a component of acicular ferrite for optimum toughness.

#### Welding guidelines

Preheat according to base material and thickness. Although AWS consumable specifications require PWHT many fabrications will be left as-welded. The need for PWHT will generally be determined by applicable design codes.

#### **Related alloy groups**

The 1%Ni low alloy consumables (data sheet A-40) and 3%Ni types (data sheet A-42) are also designed for applications requiring low temperature toughness.

Process	Product	Specification
MMA	Tufmet 2Ni.B	AWS E8018-C1
TIG/MIG	2Ni	AWS ER80S-Ni2



TUFMET 2Ni.	В	2.5	5%Ni N	IMA e	electrod	le for (	good lo	ow tem	peratur	e toughness			
Product description	MMA electrode wir giving very low we Recovery is about	eld metal hydro	ogen leve	ls.						resistant coating			
Specifications		BS EN ISO 2560-A         E 46 6 2Ni B 42           BS EN ISO 2560-B         E5518-N5 P U           BS 2493         2Ni.BH											
ASME IX Qualification	QW432 F-No 4,	QW432 F-No 4, QW442 A-No 10											
Composition (weld metal wt %)	min 0. max 0.10 1.	An         Si           50            25         0.80           75         0.3	S  0.030 0.015	P  0.030 0.010	Ni 2.00 2.75 2.4	Cr  0.2 0.05	Mo  0.2 0.05	Cu  0.3 0.05	V  0.05 0.01	Nb  0.05 <0.01			
All-weld mechanical properties	** Maximum	- 60°C - 60°C - 75°C N ISO-A prop according to E -30J as-welded	perties are DIN 8529	Pa % % J J e as-wel is optio	nal.	52 2 2 7 10 6 5 & BS	00 20 5 3 0 00 5 EN ISO-						
Operating parameters	DC +ve or AC (OC	CV: 70V min)								î î			
	ø mm min A max A	2.5 70 110		3.2 80 140		4.0 100 180							
Packaging data	ø mm length mm kg/carton pieces/carton	2.5 350 12.0 609		3.2 380 13.8 405		4.0 450 16.8 270							
Storage	3 hermetically sea hydrogen < 5ml/10 For electrodes that Redry 250 – 300°C cycles, 10h total. Storage of redried maximum 6 weeks 60% RH, > 18°C.	0g weld metal have been exp /1-2h to ensure electrodes at	during 8 bosed: $H_2 < 10n$ 100-20	h worki nl/100g, 0°C in 1	ng shift. 300-350° holding o	C/1-2h t	o ensure r 50-150	H <sub>2</sub> <5ml/ °C in hea	100g Ma ated quive	aximum 420°C, 3 ers: no limit, but			
Fume data	Fume composition,	wt % typical: Mn	Ni	С	r (	<b>^</b>	Dh	F	050	3			
	Fe	1111	1 11	0		Cu	Pb	Г	UES	(mg/m <sup>3</sup> )			



2Ni							So	lid wire t	for TIG a	nd MIG	welding	
Product description	Solid copper of	oated wi	re for T	[G and M]	IG.							
Specifications	AWS A5.28 BS EN 440 a	ind 1668		R80S-Ni2 3 2Ni2 - N		/ 2Ni2 - T	TIG)					
ASME IX Qualification	QW432 F-No 6, QW442 A-No 10											
Composition (wire wt %)	C           min         0.06           max         0.12           typ         0.08	Mn 0.8 1.25 1	Si 0.40 0.80 0.5	S  0.025 0.010	P  0.02 0.01		Cu  0.35 0.10					
All-weld mechanical properties	Typical values PWHT 605°C/		ed (AW)			TI		Į	r + 5%CO <sub>2</sub>	MAG: Ar + 20%C0 <sub>2</sub>		
	Tensile strengt 0.2% Proof str Elongation on Impact energy Hardness cap/ * Minimum pr required for m practice and P Note that supe	ess 4d - 1 mid roperties nost fabri WHT for	cations. AWS I	MPa 5 MPa 4 % J HV WHT 620% Proof str E8018-C1/	C/1h a ess va /Tufme	ues below et 2Ni.B).	v AWS are	e found aft				
Typical operating parameters	Shielding Current Diameter Parameters * Ar + 1-5% Less oxidi	12 $O_2$ and p		ry mixtur	28 es also			best mech	anical prope	rties, see a	bove.	
Packaging data	ø mm 1.2 1.6 2.0 2.4 3.2	Т 5	TIG  Kg tube To order Kg tube		15	MIG 5kg spool   						
Fume data	MIG fume con	npositior	n (wt %)	(TIG fun	ne negl	igible)						
	_	Fe 54	Mn 6	Cr <sup>3</sup>			Mo <0.1	Cu C 1.2	DES (mg/m <sup>3</sup> ) 5	)		



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#### **Product description**

3.5%Ni alloyed steel electrode with basic flux, metal powder type coating on low carbon mild steel core wire. Recovery is approximately 120% with respect to core wire, 65% with respect to whole electrode. Moisture resistant coating giving very low weld metal hydrogen levels.

#### Specifications

AWS A5.5	E8018-C2
BS EN ISO 2560-A	E 46 6 3Ni B 42
BS EN ISO 2560-B	E5518-N7 P
BS 2493	3NiBH
DIN 8529	ESY 4687 3NiB

#### **ASME IX Qualification**

QW432 F-No 4, QW442 A-No 10.

#### Materials to be welded

3.5%Ni alloyed steels specifically for service at cryogenic temperatures down to -80°C.

- BS1501Grade 503 and A203 Grades D,E,F Plate
- Forgings BS1503 Grade 503 and ASTM A350 Grade LF3 BS1504 Grade 503 LT60 and ASTM A352 Castings
- Grade LC3
- Pipe ASTM A333 Grade 3

#### Applications

Construction of cryogenic plant and associated pipework eg. petrochemical industry, demanding resistance to weld brittle fracture when operating at temperatures down to -80°C in the manufacture, storage and distribution of volatile liquids and liquified gases.

As with Tufmet 2Ni.B, it can be used for welding C-Mn and low alloy steels for critical applications demanding a combination of strength and reliable toughness down to temperatures in the region of -60°C.

For applications specifying impact properties at -100°C, the use of matching 3.5%Ni weld metal may be unacceptable because of its sensitivity to procedure, heat input etc, which results in excessive scatter of the impact properties. In this situation nickel-base filler metals are usually recommended eg. Metrode 20.70.Nb TIG root, with Nimrod AKS or 182KS fill and cap. For all-TIG applications such as thinwall pipework, Metrode 2Ni TIG root followed by 20.70.Nb may be used, or **20.70.Nb** throughout.

#### **Microstructure**

In the as-welded condition the microstructure is ferritic with a component of acicular ferrite for optimum toughness.

#### Welding guidelines

Preheat and interpass temperature according to base material thickness.

#### DATA SHEET A-42

### TUFMET 3Ni.B

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Ni	
min		0.30				3.00	
max	0.10	1.25	0.80	0.020	0.030	3.75	
typ	0.05	0.5	0.3	0.01	0.015	3.3	

#### All-weld mechanical properties

As welded or PWHT 60	As welded or PWHT 605°C/1h <sup>(1)</sup>						
Tensile strength		MPa	560-680 <sup>(2)</sup>	620			
0.2% Proof stress		MPa	460	540			
Elongation on 4d		%	19	> 22			
Elongation on 5d		%	17	25			
Reduction of area		%		70			
Impact energy	-60°C	J		100			
	-75°C	J	30	> 90			

(1)BS & BS EN ISO-A properties are as-welded, AWS & BS EN ISO-B after PWHT.

(2)Maximum according to DIN 8529 is optional.

DC +ve

#### **Parameters**

		Û <		Ê Î
2.5	3.2	4.0	5.0	

ø mm	2.5	3.2	4.0	5.0	
min A	70	80	100	140	
max A	110	140	180	240	
		_			

#### Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	350	380	450	450
kg/carton	12.0	13.5	16.8	17.4
pieces/carton	627	393	243	159

#### Storage

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin will give hydrogen <5ml/100g weld metal during 8h working shift.

For electrodes that have been exposed:

**Rebake** 250-300°C/1-2h to ensure H<sub>2</sub> <10ml/100g, 300- $350^{\circ}$ C/1-2h to ensure H<sub>2</sub> <5ml/100g. Maximum 420°C, 3 cycles, 10h total.

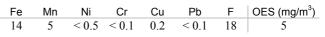
Storage of rebaked electrodes at 100-200°C in holding oven or 50-150°C in heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, >18°C.

#### **Related alloy groups**

There is no matching TIG wire for this electrode, Metrode 2Ni TIG wire is available which is suitable for root runs (data sheet A-41).

#### **Fume data**

Fume composition, wt % typical:





## Low Alloy Steels

## MnMo HIGH STRENGTH STEELS

#### Alloy type

Low alloy steel consumables with MnMo additions for welding high strength steels.

#### Materials to be welded

These consumables are used for a variety of ferritic CMn and low alloy steels.

**E9018-D1** is used for materials with a minimum tensile strength requirement of 620MPa (90ksi); eg. AISI 4130 (90ksi condition), ASTM A487 grades 2A, B & C (cast).

**E10018-D2** is used for materials with a minimum tensile strength requirement of 690MPa (100ksi); eg. AISI 4130, 4140, 8630; BS970 grades 709M40 (En19); DIN 42CrMo4 (1.7225), 34CrMo4 (1.7220); ASTM A487 grades 4B, 4D & 6A (cast).

#### **Applications**

Fabrication of higher strength steels for use in the stress relieved condition.

For **offshore oil well-head process pipework** and **fittings**, these low nickel consumables satisfy NACE MR0175 requirements intended to ensure resistance to sulphide-induced stress corrosion cracking in sour service, combined with good sub-zero toughness.

Also finds applications for the repair of medium strength low alloy steel castings where a stress-relief only (rather than N+T) is to be applied.

#### Microstructure

DATA SHEET

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In the stress relieved condition the microstructure consists of tempered bainite.

#### Welding guidelines

The actual preheat and PWHT requirements will depend on the base material being welded. Normally preheat/interpass temperatures will be in the range 100- $250^{\circ}$ C.

#### **PWHT**

The PWHT requirements will depend on a number of factors including, base material, property requirements, need to conform to NACE etc. Temperatures will normally be about 620°C but when welding 4130 using E10018-D2 temperatures up to about 645°C may be required to temper the HAZ.

#### **Additional information**

Although MnMo wire is the nearest match to the E9018-D1/E10018-D2 electrodes in terms of composition when welding base materials requiring high temperature or prolonged soak PWHT (eg. 4130) it may not retain the required strength. In these circumstances the 1CrMo or 2CrMo wires may prove useful (data sheets A-12 and A-13). See also alloy WB36 (data sheet A-23).

#### **Products available**

Process	Product	Specification
MMA	E9018-D1	AWS E9018-D1
	E10018-D2	AWS E10018-D2
TIG/MIG	MnMo	AWS ER80S-D2

## /InMo HIGH STREN



Storage	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin hydrogen &lt; 5ml/100g for longer than a working shift of 8h. For electrodes that have been exposed:</li> <li>Redry 250 - 300°C/1-2h to ensure H<sub>2</sub> &lt; 10ml/100g, 300 - 350°C/1-2h to ensure H<sub>2</sub> &lt; 5ml/100g. M 420°C, 3 cycles, 10h total.</li> <li>Storage of redried electrodes at 50 - 200°C in holding oven or heated quiver: no limit, but maximum recommended. Recommended ambient storage conditions for opened tins (using plastic lid): &lt; 60% RI</li> </ul>							
	Storage of redried ele	ectrodes at			0	1	,	
Fume data	Storage of redried ele	ectrodes at nmended a	mbient stor		0	1	,	
Fume data	Storage of redried ele recommended. Recor	ectrodes at nmended a	mbient stor		0	1	,	

E9018-D1						All-p	osition	al MnM	lo low	alloy ste	el MM/	A elec	trode
Product description				basic flux drogen le		on high j	purity mil	d steel co	re wire.	Moisture r	esistant co	oating p	rovides
	Recov	ery is abo	out 1209	% with res	pect to c	core wire	e, 65% wi	th respect	to who	le electrode	е.		
Specifications	AWS BS 24 DIN 8	93		E901 MnM (ESY		InMoB)							
ASME IX Qualification	QW43	QW432 F-No 4, QW442 A-No 11											
Composition (weld metal wt %)	min max typ	C  0.10 0.07	Mn 1.25 1.75 1.5	Si  0.80 0.4	S  0.025 0.01	P  0.025 0.015	Cr   0.15	Ni   0.15	Mo 0.25 0.45 0.35	Cu   0.05			
All-weld mechanical properties	Tensile 0.2% F Elonga Elonga Reduct	620°C/11 e strength Proof stres ation on 4 ation of 5 energy ess	ss d d	- 30°C - 50°C	М	IPa IPa % % J J HV	min 630 550 17 15  47 30 	typica 670 605 25 20 50 90 55 210					
Operating parameters	DC +v ø mm min A max A	e or AC		70V min) 2.5 70 110		3.2 80 140		4.0 100 180		5.0 140 240		Ĥ	Û
Packaging data	ø mm length kg/cart pieces/	on		2.5 350 12.0 621		3.2 380 13.8 387		4.0 450 15.9 228		5.0 450 16.8 153			



E10018-D2								MnM	lo low	alloy steel	MMA electrode
Product description	very lo	ow weld i	metal hy	drogen le	evels.	on high purity mild steel core wire. Moisture resistant coating provider wire, 65% with respect to whole electrode.					stant coating provides
Specifications	AWS BS 24 BS EI DIN 8	193 N 757		(2Mr (E 62	018-D2 nMoBH) 24 MnMo 7 6264 M	,					
ASME IX Qualification	QW43	32 F-No	4, QV	<b>/442</b> A-N	No 11						
Composition (weld metal wt %)	min max typ	C 0.07 0.15 0.10	Mn 1.65 2.00 1.8	Si 0.20 0.60 0.4	S  0.025 0.01	P  0.025 0.015	Cr  0.15	Ni  0.9 0.6	Mo 0.25 0.45 0.35	Cu   0.05	
All-weld mechanical properties	typical after PWHT: Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Impact energy 0°0 - 40°0 Hardness * PWHT according to A			MPa 6 MPa 6 % % % % % % % M % HV HRC AWS.		in 10 10 6 8 - - - - - - - -	620°C/1h * 760 690 25 21 65  >27 250  30 to meet <221		645°C/4h ** 700 620 26 22 67 >100 >60 230 <22 RC in HAZ for	oilfield sour service	
Operating parameters	ø mm	e or AC	(OCV: 7	70V min) 2.5		3.2		4.0		5.0	
	min A max A			70 110		80 140		100 180		140 240	200 300
Packaging data	ø mm length kg/cart pieces			2.5 350 12.0 633		3.2 380 12.6 351		4.0 450 16.8 243		5.0 450 17.1 159	6.0 450 16.5 105



MnMo Solid MnMo alloyed wire for TIG a									InMo a	lloyed	wire for	TIG a	Ind MIC
Product description	Solid o	copper co	ated wir	e for TIG	and MI	G.							
Specifications	BS EI	NISO 16	ì834-В	ER80S-D2, ER90S-D2 4M31 (G4Mo) A31									
ASME IX Qualification	QW43	32 F-No	6, <b>QW</b>	<b>442</b> A-N	lo 11								
Composition		С	Mn	Si	S	Р	Ni	Мо	Cu				
(wire wt %)	min	0.07	1.60	0.50				0.40	)				
	max	0.12	2.10	0.80	0.025	0.025	0.15	0.60	0.4				
	typ	0.1	1.9	0.6	0.005	0.01	0.05	0.5	0.1				
All-weld mechanical properties		l values a & PWHT	s-welded	b			TI	IG			MAG 5%CO₂		MAG 20%CO <sub>2</sub>
					min	* AW	620°	C/1 (	645°C/4	AW	620°C/1	AW	620°C/1
	Tensile	e strength		MF	Pa 55	0 720	64	0	610	725	>635	625	605
	0.2% F	Proof stre	SS	MF	Pa 47	0 610	53	0	530	625	>525	510	490
	Elonga	ation on 4	d	(	% 17	27	32	2	31	29	>25	28	25
	Impact	energy	- 30	0°C	J 27			00		>100		>55	>100
			- 4	5°C	J				>130	>70	>110		
	Hardne	ess		Н	V	250	22	0	220	235	220	215	205
	(highe	$r CO_2 + 0$	$J_2$ ) have	lower stre							based on 1		
	seldon strengt	n used; al th is four	d with A	ely this with Ar + 5%C (sest appro	O <sub>2</sub> , an eo	conomic j	procedur	e to o	btain as-v		properties e		
Typical operating	seldon strengt	n used; al th is four	d with A	r + 5%C	O <sub>2</sub> , an eo	conomic j n to elect	procedur	e to o	btain as-v				
Typical operating parameters	seldon strengt	n used; al th is foun <b>DS-G</b> (an	d with A	Ar + 5%Co sest appro	O <sub>2</sub> , an economication	conomic j n to elect	procedur rode E1(	e to o 0018-1	btain as-v				
	seldon strengt ER10	n used; al th is foun <b>DS-G</b> (an	d with A	Ar + 5%C0 sest appro TIG Argon DC-	$O_2$ , an ecoximatio	conomic p n to elect Ar + 5-	procedur rode E1( MIG	e to o 0018-1	btain as-v				
	seldon strengt ER10	n used; al th is foun <b>DS-G</b> (an ing tt	d with A	Ar + 5%C0 sest appro TIG Argon	$O_2$ , an ecoximatio	conomic j n to elect Ar + 5- I	orocedur rode E10 MIG 20%CO	e to o 0018-1	btain as-v				
	seldon strengg ER100 Shieldi Curren Diame Param	n used; al th is foun <b>DS-G</b> (an ing tt ter eters	d with A d the clo	TIG Argon DC- 2.4mm 120A, 14	O <sub>2</sub> , an economic of the second secon	conomic j n to elect Ar + 5- 1. 280	MIG 20%CO DC+ 2mm A, 26V	$2^{*}$	btain as-v D2).	welded p	properties e	quivale	nt to AWS
	seldon streng ER100 Shieldi Curren Diame Param	n used; al th is foun <b>DS-G</b> (an ing tt ter eters	d with A d the clo	TIG Argon DC- 2.4mm 120A, 14 rides the h	O <sub>2</sub> , an economic of the second secon	conomic j n to elect Ar + 5- 1. 280	MIG 20%CO DC+ 2mm A, 26V	$2^{*}$	btain as-v D2).	welded p		quivale	nt to AWS
parameters	seldon streng ER100 Shieldi Curren Diame Param	n used; al th is foun <b>DS-G</b> (an ing it ter eters Ar + 5%C	d with A d the clo	TIG Argon DC- 2.4mm 120A, 14 rides the h	O <sub>2</sub> , an economic of the second secon	Ar + 5- I 280 rrength ar	MIG 20%CO DC+ 2mm A, 26V	$2^{*}$	btain as-v D2).	welded p	properties e	quivale	nt to AWS
parameters	seldon streng ER10 Shieldi Curren Diame Param * 2	n used; al th is foun <b>DS-G</b> (an ing it ter eters Ar + 5%C	d with A d the clo	TIG Argon DC- 2.4mm 120A, 14 rides the h able. TIG	O <sub>2</sub> , an ec oximatio	Ar + 5- I 280 rrength ar	MIG 20%CO 20%CO DC+ 2mm A, 26V ad best in	$2^{*}$	btain as-v D2).	welded p	properties e	quivale	nt to AWS
parameters	seldon streng ER100 Shieldi Curren Diame Param * 4 1 ø mm 1.2 1.6	n used; al th is foun <b>DS-G</b> (an ing it ter eters Ar + 5%C	d with A d the clo	TIG Argon DC- 2.4mm 120A, 14 rides the h able. TIG  5kg tub	O <sub>2</sub> , an ec oximatio	Ar + 5- I 280 rrength ar	MIG 20%CO 20%CO 20%CO 20+ 2mm A, 26V d best in MIG	$2^{*}$	btain as-v D2).	welded p	properties e	quivale	nt to AWS
parameters	seldon streng ER100 Shieldi Curren Diame Param * 4 1 ø mm 1.2 1.6 2.4	n used; al th is foun <b>DS-G</b> (an ing it ter eters Ar + 5%C	d with A d the clo	TIG Argon DC- 2.4mm 120A, 14 rides the h able. TIG TIG 5kg tub 5kg tub	O2, an economic of the second	Ar + 5- I 280 rrength ar	MIG 20%CO 20%CO 20%CO 20+ 2mm A, 26V d best in MIG	$2^{*}$	btain as-v D2).	welded p	properties e	quivale	nt to AWS
parameters	seldon streng ER100 Shieldi Curren Diame Param * 4 1 ø mm 1.2 1.6	n used; al th is foun <b>DS-G</b> (an ing it ter eters Ar + 5%C	d with A d the clo	TIG Argon DC- 2.4mm 120A, 14 rides the h able. TIG  5kg tub	O2, an economic of the second	Ar + 5- I 280 rrength ar	MIG 20%CO 20%CO 20%CO 20+ 2mm A, 26V d best in MIG	$2^{*}$	btain as-v D2).	welded p	properties e	quivale	nt to AWS
parameters Packaging data	seldon streng ER100 Shieldi Curren Diame Param * 4 1 Ø mm 1.2 1.6 2.4 3.2	h used; al th is foun OS-G (an ing tt ter eters Ar + 5%C mixtures	d with A d the clo	TIG Argon DC- 2.4mm 120A, 14 rides the h able. TIG TIG 5kg tub 5kg tub	O <sub>2</sub> , an economic of the second secon	Ar + 5- I 280 Frength ar 15k	MIG 20%CO DC+ 2mm A, 26V d best in MIG g spool  	$2^{*}$	btain as-v D2).	welded p	properties e	quivale	nt to AWS
	seldon streng ER100 Shieldi Curren Diame Param * 4 1 Ø mm 1.2 1.6 2.4 3.2	h used; al th is foun OS-G (an ing tt ter eters Ar + 5%C mixtures	d with A d the clo	TIG Argon DC- 2.4mm 120A, 14 rides the h able. TIG 	O <sub>2</sub> , an economic of the second secon	Ar + 5- I 280 Frength ar 15k	MIG 20%CO DC+ 2mm A, 26V d best in MIG g spool  	2 *	btain as-v D2).	velded p	properties e	quivale	nt to AWS



## Low Alloy Steels

### **HIGH STRENGTH Ni-Mo LOW ALLOY**

#### Alloy type

A range of Mn-Ni-Mo low alloy consumables covering tensile strength requirements from 620MPa (90ksi) up to 825MPa (120ksi). Some are designed for as-welded applications whilst others are predominantly used following a stress relief PWHT.

#### Materials to be welded

These consumables are used for a variety of high strength steels. Depending on strength requirements, some examples are:

Tufmet 1NiMo	API 5A L80; BS 4360 grade 55F; RQT 601 (Corus); HY80; Navy
E11018-M	Q1(N). Q1(N); HY80; RQT 701 (Corus);
Tufmet	QT445; NAXTRA 70; Hystal77. HY80 & Q1(N);
3NiMo	possibly HY100 & Q2(N).

#### **Applications**

All the consumables are used for a range of high strength low alloy steels. The E11018-M and Tufmet 3NiMo electrodes in particular are used for military applications by the MoD and US Navy for construction and repair of naval craft and submarines. The Tufmet 1NiMo was developed for the offshore industry where high strength and -50°C toughness is required in the as-welded condition.

All of the consumables also have applications for general structural steel fabrications in HSLA steels, which may be used for cranes, earth moving equipment, and other highly stressed structural components.

#### **Microstructure**

DATA SHEET

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The microstructure of all the consumables is predominantly ferrite; some will contain high proportions of acicular ferrite for optimum as-welded toughness (eg. Tufmet 1NiMo and Tufmet 3NiMo).

#### Welding guidelines

Preheat according to base material and thickness, although materials likely to be welded by the higher strength consumables will normally require 100°C minimum preheat.

With some HSLA steels interpass temperatures above 200°C may result in a reduction of strength and toughness.

PWHT generally dependent on base material and application, the solid wire ER110S-G is not recommended for applications requiring PWHT. Further information can be found under each individual product.

#### **Related alloy groups**

The 1NiMo.B electrode (data sheet A-61) is used for applications requiring maximum retained strength after extended PWHT.

The MnMo consumables (data sheet A-50) may be suitable for some of the same applications.

Process	Product	Specification
MMA	Tufmet 1NiMo	AWS E9016-G
	E11018-M	AWS E11018-M
	Tufmet 3NiMo	AWS E12016-G
TIG/MIG	ER110S-G	AWS ER110S-G



	General Data for all MMA Electrodes										
Storage	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin will give hydrogen &lt;5ml/100g weld metal during 8h working shift. For electrodes that have been exposed:</li> <li>Redry 250 – 300°C/1-2h to ensure H<sub>2</sub> &lt; 10ml/100g, 300 – 350°C/1-2h to ensure H<sub>2</sub> &lt; 5ml/100g. Maximum 420°C, 3 cycles, 10h total.</li> <li>Storage of redried electrodes at 100 – 200°C in holding oven, or 50 – 150°C in heated quivers: no limit, but maximum 6 weeks recommended.</li> </ul>										
Fume data	Fume composition, wt % typical:										
	Fe Mn Ni Cr Cu F OES (mg/m <sup>3</sup> )										
	14 <7 <0.5 <0.5 0.2 18 5										

TUFMET 1NIN	Ιο			All-positional MMA electrode with high strength and toughness							
Product description	ensure and str	MMA electrode with a low hydrogen basic flux on a high purity mild steel core wire. Moisture resistant coating ensures very low weld metal hydrogen levels. Provides minimum strength of 620MPa (90ksi) in the as-welded and stress-relieved condition. Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.									
Specifications	AWS A5.5         E9016-G           DIN 8529         EY 5576 Mn1NiN           Approval:         Statoil R-SF-163										
ASME IX Qualification	QW43	QW432 F-No 4, QW442 A-No 10									
Composition (weld metal wt %)	min max typ	C 0.030 0.075 0.05	Mn 1.30 1.80 1.5	Si 0.25 0.60 0.35	S  0.02 0.008	P  0.02 0.01	Ni 0.6 1.0 0.85	Mo  0.3 0.15			
All-weld mechanical		I values as				0.01	min		welded PWI	HT 600°C/4-8h	
properties	Tensile 0.2% F Elonga Elonga	e strength Proof stress ation on 4d ation on 5d t energy		0°C - 50°C	MPa MPa % J		620-730 550-660 20 20  60		670 600 28 25 	630 525  130 >100	
Operating parameters		OCV: 60V 1 tion on DC			ourable as	above	,				Î
	ø mm			2.5		3.2		4.0	5.0	6	6.0
	min A max A			60 100		80 140		100 180	140 240		00 00
Packaging data	ø mm			2.5		3.2		4.0	5.0	6	6.0
	length			350		450		450	450		50
	kg/cart			13.5		15.0		18.0	16.8		8.0
	pieces	carton		663		447		300	180	1	35



E11018-M				All-p	ositior	nal MM	IA elect	rode	with hig	jh stren	gth and	toughness
Product description							al powder metal hydr			ı high pu	rity mild st	eel core wire.
	MoD a	Conforms to military electrode specification used for Q1(N) and HY80 type steels used in naval construction by MoD and US Navy. Also suitable for similar high strength steels requiring a minimum strength of 760MPa (110ksi) in the as-welded and stress-relieved condition.										
	Recov	Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.										
Specifications	BS 24	AWS A5.5         E11018-M           BS 2493         2NiMo.BH           DIN 8529         (EY 6965 Mn2NiCrMo B)										
ASME IX Qualification	QW43	32 F-No	4, <b>QW</b>	<b>442</b> A-1	No 12							
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	V		
(weld metal wt %)	min		1.30					1.50	0.25			
	max	0.10	1.80	0.60	0.030	0.030	0.40	2.50	0.50	0.05		
	typ	0.05	1.7	0.35	0.012	0.012	0.2	2.2	0.4	0.02		
All-weld mechanical	Typical as welded and PWHT							А	s-welded	PWH	IT 620°C/2h	
properties	Tensile	e strength	ı			MPa	760		820		830	
		Proof stre				MPa	680-760	)	730		760	
	0	ation on 4				%	20		23			
	-	ation on 5				%	20		22		16	
		tion of ar	ea	. 2000		%			65 125			
	Impact	energy		+ 20°C - 50°C		J J	30		125 80		 40	
	Latera	l expansio	n	- 50°C	mm	ı (mils)			0.9 (37)		40	
	Latera	i expansio	511	- 30 C	11111				0.9 (37)			
Operating parameters	DC +v	ve or AC	(OCV: 7	0V min)					Ū			î Î
	ø mm			2.5		3.2		4.0		5.0		
	min A			70		80		100		140		
	max A			110		140		180		240		
Packaging data	ø mm			2.5		3.2		4.0		5.0		
	length	mm		350		380		450		450		
	kg/cart			12.0		14.1 16.2 16.8						
	pieces	/carton		582		381		234		153		



TUFMET 3Ni	lo			All-p	positior	nal MM/	۹ el	ectrode w	rith hig	gh streng	th and toughness
Product description		electrode es very lov		•	0		a hig	h purity mild	steel c	ore wire. Mo	bisture resistant coating
	Also s welde	The electrode was specially designed for welding HY80 and Q1(N) castings which are N+T following welding Also suitable for other high strength steels requiring minimum tensile strength of about 820MPa (120ksi) in the as welded and stress-relieved condition; or yield strength up to about 800MPa in the as-welded condition. Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.									
Specifications	AWS Appro	A5.5 ovals:			)16-G ) NES 76	69 for Q1(N) in Q+T condition.					
ASME IX Qualification	QW4	32 F-No	4, QV	<b>V442</b> A-1	No 10						
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо		
(weld metal wt %)	min	0.02	0.8				0.6		0.4		
	max typ	0.06	1.5	0.5	0.025	0.025	1.0		0.8		
All -weld mechanical properties	Typica	I values:				min		As-welded		ess relieved )-620°C/1h	Q+T 900°C/1-6h WQ + 635-650°C/1-6h WQ
		e strength		MPa	830		950	000	920	710-770	
		0.2% Proof stress			MPa	740		870		870	590-660
	Elonga	ation on 4	d		%	14		20		22	
	Elonga	ation on 5	d		%			18		20	20-25
		tion of are	ea		%			55		58	65-70
	Impac	t energy		0°C	J			65			
	СТОД	I		- 50°C - 5°C	J mm			45 		30 	65-135 >0.46
Operating parameters	DC +v	ve or AC	OCV:	70V min)	I						
	ø mm			3.2		4.0		5.0			
	min A			80		100		140			
	max A	L.		140		180		240			
Packaging data	ø mm			3.2		4.0		5.0			
	length			380		450		450			
	kg/car			13.8		17.7		16.5			
	pieces	carton		381		267		156			



ER110S-G						ŀ	High str	ength	solid T	IG and MIG wire	
Product description	Solid copper wire 760MPa (110ksi)								led tensile	strength up to about	
Specifications	AWS A5.28 BS EN ISO 168	AWS A5.28ER110S-G (Classified on the basis of mechanical properties in the as-welded condition)SS EN ISO 16834-AMn3Ni1CrMo									
ASME IX Qualification	QW432 F-No 6,	QW432 F-No 6, QW442 A-No 12									
Composition (wire wt %)	C           min         0.05           max         0.12           typ         0.1	Mn 1.4 1.8 1.6	Si 0.4 0.8 0.5	S  0.020 0.01	P  0.020 0.01	Cr 0.2 0.4 0.3	Ni 1.2 1.8 1.4	Mo 0.2 0.4 0.3	V 0.04 0.13 0.09	Cu  0.25 0.1	
All-weld mechanical properties	Typical values as Tensile strength 0.2% Proof stress Elongation on 4d Impact energy Hardness cap/mid * Minimum v shielding ga	l values fo			66 1 - - MAG w	50 50 - - elds are t		btained		MAG Ar+20%CO <sub>2</sub> 730 660 21 50 255 CO <sub>2</sub> content pove.	
Typical operating parameters	Shielding Current Diameter Voltage * Ar + 5%CC mixtures als	$\mathbf{D}_2$ provid		V	MI $Ar + 5-20$ $DC$ $1.2r$ $280A$ angth and	0%CO <sub>2</sub> * C+ nm 26V	act proper	ties, see	above. C	ther proprietary gas	
Packaging data	ø mm 1.0 1.2 2.4		TIG  5kg tube	,	MI 20kg s 15kg s	spool spool					
Fume data	MIG fume compo		wt %) (T Mn 10	IG fume no Cr <sup>3</sup> 1	egligible Ni 0.4	) Mo <1.5	Cu 1.2	0	ES (mg/m <sup>3</sup> 5	²)	

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#### **Product description**

MMA electrode with low hydrogen basic flux coating on high purity mild steel core wire. Moisture resistant coating ensures very low weld metal hydrogen levels.

Recovery is about 120% with respect to the core wire, 65% with respect to whole electrode.

#### **Specifications**

AWS A5.5	E9018-G
DIN 8529	ESY 5554 1NiMo B
	(carbon may slightly exceed 0.10%)

#### **ASME IX Qualification**

QW432 F-No 4, QW442 A-No 10.

#### Materials to be welded

ASTM	A302 grades C &D. A508 class 1, 1A, 2 & 3.
	A533 grades A-D, class 1 & 2.
AISI	4130 and similar alloys.
BS	1501 grades 271 & 281.
	3604 grades HFS 591 & CFS 591.
DIN	15NiCuMoNb5 (1.6368).

#### **Applications**

Designed for welding low alloy steels used for **pressure vessels** (often thick wall) and other applications where high strength must be maintained after extended, or multiple, PWHT cycles. These steels may also be used at modest elevated temperature and tests have shown typically 15% reduction in tensile strength at +300°C compared to the room temperature values for 1NiMo.B weld metal.

It is also used for welding type 4130, and other high strength steels, requiring good sub-zero toughness for **oilfield** and **well-head equipment**. In comparison with the MnMo types (data sheet A-50) 1NiMo.B has improved resistance to softening at high tempering parameters.

#### Microstructure

In the PWHT condition the microstructure consists of tempered high strength ferrite.

#### Welding guidelines

Preheat and PWHT requirements dependent on base material.

#### DATA SHEET A-61

### 1NiMo.B

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Cr	Ni *	Мо	Cu	
min	0.07	0.8	0.2				0.8	0.20		
max	0.12	1.5	0.5	0.020	0.025	0.30	1.2	0.45	0.10	
typ	0.10	1.2	0.3	0.010	0.015	0.1	0.9	0.35	0.05	
* Nic	typ 0.10 1.2 0.3 0.010 0.015 0.1 0.9 0.35 0.05 * Nickel normally 1.0% max to conform to NACE MR0175.									

#### All-weld mechanical properties

PWHT 610-650°C/1	-6h		min	typical
Tensile strength		MPa	620-780*	640-700
0.2% Proof stress		MPa	530 **	540-630
Elongation on 4d		%	17	24-30
Elongation on 5d		%		21-26
Reduction of area		%		70
Impact energy	- 20°C	J		75-110
	- 40°C	J		60
	- 60°C	J		45
Hardness		HV		220

\* Maximum according to DIN 8529 is optional.

\*\* Meets 550MPa minimum (DIN) according to yield point.

### Parameters

DC +ve or			$\Box$	
AC (OCV: 70V	min)			
ø mm	3.2	4.0	5.0	
min A	80	100	140	
max A	140	180	240	

#### Packaging data

ø mm	3.2	4.0	5.0
length mm	380	450	450
kg/carton	14.7	16.8	18.0
pieces/carton	390	240	168

#### Storage

**3 hermetically sealed ring-pull metal tins** per carton, with unlimited shelf life. Direct use from tin will give **hydrogen** <5ml/100g weld metal during 8h working shift.

For electrodes that have been exposed:

**Redry** 250-300°C/1-2h to ensure  $H_2 <10ml/100g$ , 300-350°C/1-2h to ensure  $H_2 <5ml/100g$ . Maximum 420°C, 3 cycles, 10h total.

**Storage** of redried electrodes at 100-200°C in holding oven or 50-150°C in heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, >18°C.

#### Fume data

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Pb	F	OES (mg/m <sup>3</sup> )
14	5	0.5	< 0.1	< 0.2	< 0.1	18	5

Rev 00 06/01





## Low Alloy Steels

## LOW ALLOY Ni-Cu CONSUMABLES FOR WEATHERING STEELS

#### Alloy type

Low alloy steel with Ni-Cu-Cr additions for welding weathering steels.

#### Materials to be welded

ASTM	A588 Grades A, B, C, K. A242 Types 1, 2.
DIN	1.8960, 1.8961, 1.8963.
BS	4360 Grades WR50A, WR50B, WR50C.
Proprietary	Corten A, B1 (Corus and US Steel)

#### **Applications**

Mainly used for weathering steels containing a similar controlled copper addition and claimed to offer a threefold improvement in corrosion resistance and a more stable patina compared with plain CMn steel.

#### Applications include architectural structures, bridges and exhaust gas flues, chimneys.

This weld metal also resists preferential corrosion in seawater, particularly in arctic waters high in oxygen and salinity, and has applications for welding microalloyed and CMn steels in ice-breaker vessels and offshore structures.

#### **Microstructure**

In the as-welded condition the microstructure is ferritic

with a high proportion of acicular ferrite for optimum toughness.

DATA SHEET

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#### Welding guidelines

Preheat according to joint thickness and restraint. Normally left in the as-welded condition so no PWHT required.

#### Additional information

The Chromet 1L electrode (data sheet A-12) may be preferred for welding vanadium treated Corten B1 steel intended for non-critical elevated temperature applications eg. chimney stacks.

#### **Related alloy groups**

The 2%Ni consumables (data sheet A-41) provide comparable weathering resistance and are also compatible with the weathering steels.

Process	Product	Specification
MMA	1NiCu.B	AWS E8018-W2
TIG/MIG/SAW	ER80S-W	AWS ER80S-G
SAW flux	LA121	BS EN SA FB 1



1NiCu.B	MMA electrode for welding Corten type weathering steels											
Product description	MMA electrode with a basic flux, metal powder type coating on low carbon mild steel core wire. More resistant coating giving very low weld metal hydrogen levels. Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.											
	Recover	ry is abo	out 120%	6 with resp	bect to c	ore wir	e, 65% wit	th respect	to who	le electro	de.	
Specifications	AWS A BS EN DIN 852	ISO 25	60-B	E8018-W2 E5518-NCC1 A EY 5043 NiCuB								
ASME IX Qualification	QW432 F-No 4, QW442 A-No (not allocated)											
Composition (weld metal wt %)		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu		
	min	0.04	0.50	0.35			0.45	0.40		0.30		
	max typ	0.12	1.30	0.80	0.02	0.03	0.70	0.80	0.02	0.75		
A.H			1	0.0	0.01	0.015				0.5		
All-weld mechanical properties	As welde Tensile s				м	Pa 5	min 50-720 *	typica 610				
	0.2% Pro	0				Pa J	460	520				
	Elongati				1,1	%	19	25				
	Elongati					%	17	20				
	Reductio		a			%		65				
	Impact e	energy		$+20^{\circ}C$		J		150				
				-20°C -40°C		J J	27	100 70				
				-40 ℃ -60℃		J		40				
	* M	aximun	accord	ing to DIN	8529 i	-		10				
Operating parameters	DC +ve or AC (OCV: 70V min)											
	ø mm			2.5		3.2		4.0				
	min A			70		80		100				
	max A			110		140		180				
Packaging data	ø mm			2.5		3.2		4.0				
	-	length mm 35			380			450				
	kg/carton pieces/carton			12.0 420	15. 375			16.5 240				
	<b>3 hermetically sealed ring-pull metal tins</b> per carton, with unlimited shelf life. Direct use from tin will give hydrogen $< 5ml/100g$ weld metal during 8h working shift. For electrodes that have been exposed: <b>Redry</b> 250 – 300°C/1-2h to ensure H <sub>2</sub> $< 10ml/100g$ , 300-350°C/1-2h to ensure H <sub>2</sub> $< 5ml/100g$ . Maximum 420°C 3 cycles, 10h total. <b>Storage</b> of redried electrodes at 100 – 200°C in holding oven or 50-150°C in heated quivers:: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): $< 60\%$ RH, $> 18°C$ .											
Storage	hydroge For elec <b>Redry</b> 2 3 cycles <b>Storage</b> maximu	en < 5ml trodes t 250 - 30 , 10h to e of redu m 6 wee	/100g w hat have 0°C/1-2 tal. ied elected	veld metal e been expo h to ensure ctrodes at	during 8 osed: e H <sub>2</sub> < 10 100 - 2	8h work 0ml/100 200°C ii	ing shift. )g, 300-35 n holding	oven or 5	50-150°	C in heat	ed quivers:: no limit, b	
_	hydroge For elec <b>Redry</b> 2 3 cycles <b>Storage</b> maximu 60% RH	en < 5ml strodes t 250 - 30 a, 10h to b of redu m 6 wee H, > 18°	/100g w hat have 0°C/1-2 tal. ied elec eks recon C.	veld metal e been expo h to ensure ctrodes at	during 8 osed: e H <sub>2</sub> < 10 100 - 2	8h work 0ml/100 200°C ii	ing shift. )g, 300-35 n holding	oven or 5	50-150°	C in heat	ed quivers:: no limit, b	
Storage Fume data	hydroge For elec <b>Redry</b> 2 3 cycles <b>Storage</b> maximu 60% RH	en < 5ml strodes t 250 - 30 a, 10h to b of redu m 6 wee H, > 18°	/100g w hat have 0°C/1-2 tal. ied elec eks recon C.	veld metal e been expo h to ensure ctrodes at mmended.	during 8 osed: e H <sub>2</sub> < 10 100 - 2	8h work 0ml/100 200°C ii	ting shift. Dg, 300-35 n holding l ambient s	oven or 5 storage co	50-150°	C in heat	ed quivers:: no limit, b	



ER80S-W				Sol	id wire	e for T	IG, MIC	G an	d SAW	of Corten weatherin	g steels
Product description	Solid o	copper co	ated wir	e for TIG	, MIG a	nd SAV	V.				
Specifications		A5.28 N ISO 16	834-A	ER803 (Mn31	S-G Ni1Cu)						
ASME IX Qualification	QW43	32 F-No	6, <b>QW</b>	442 A-N	lo Not al	llocated					
Composition (wire wt %)	min	C 0.04	Mn 1.0	Si 0.5	S 	P 	Cr 		li C .6 0.		
	max typ	0.12 0.09	1.6 1.4	1.0 0.7	0.025	0.025	0.4	1.	.2 0. .8 0.		
All-weld mechanical properties	Tensile Yield s 0.2% F Elonga Reduc	I values a e strength tress Proof stres ation on 4 tion of Are energy	ss d	l - 20°C	Μ	IPa IPa IPa % J	min. 550  470 24 	A	r-20%CO 610 525 500 28 62 110		
		ess mid/ca	ар	- 50°C	I	J HV			75 190/245		
Typical operating parameters	Shieldi Curren Diame Param	it ter		TIG Argon DC- 2.4mm 120A, 14	1		MIG 5-20%C DC+ 1.2mm 80A,26V	-		SAW A121 DC+ .5mm DA, 28V	
Packaging data	ø mm 1.0 1.2 1.6 2.4 2.5			TIG  5kg tub 5kg tub 			MIG 5kg spool 5kg spool   		2:	SAW    kg coil	
Fume data	MIG f	ume com	position	(wt %) (1	ΓIG fum	e neglig	ible)				
			Fe 52	Mn 8	Cr <sup>3</sup>	N 0.		Mo : 0.5	Cu 1.6	OES (mg/m <sup>3</sup> ) 5	

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### **Product description**

MMA electrode for rail welding utilising basic low hydrogen flux coating with low moisture absorption characteristics. Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

#### **Specifications**

None strictly applicable, nearest AWS E12016-G and nearest BS EN E69 Z Z B.

#### **ASME IX Qualification**

QW432 F-No -, QW442 A-No -.

#### Materials to be welded

Rail steels with up to 0.8% carbon and nominal tensile strength of > 700 MPa.

#### Applications

This electrode is especially designed for the butt welding of rails with square preparation. It can also be used for welding similar cross-sections such as bars, thick plates, flanges, etc. The electrode is specially designed to enable good fusion to the side walls to take place without excessive slag interference.

Weld metal has good resistance to collapse under compression by rolling loads.

Applications include **rails** for **rolling stock** and **crane rails** in **dockyards**, **mines**, **steelworks** and **petrochemical plants**.

Note that this technique has not been generally accepted as an alternative to the thermit process for in-situ welding of passenger track.

#### Microstructure

Mainly auto-tempered bainitic ferrite.

#### Welding guidelines

Preheat typically 200°C for >0.5% C rail steel, increasing to  $300^{\circ}$ C for >0.7% C rail steel. It is important to maintain these minimum temperatures during welding. Maximum suggested interpass temperature 400°C. Slow cool under insulation after welding.

This electrode is normally used in the downhand (flat) position with a slag-over-slag technique. Rail ends are square butt welded by setting 15-20mm apart with a prepared 4-6mm thick steel insert at the weld root, then copper shims are stacked to form an enclosure for the weld pool whilst allowing excess slag to run free.

Good surface profile underneath the weld root area will maximise fatigue resistance of the joint. Initial support



## DATA SHEET A-80

## RAILROD

for depositing the root can utilise a copper backing plate or wire-reinforced window glass. Before and during welding it is important to use a sufficient preheat-interpass range, and to retard cooling.

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Cr	Ni	Мо
min	0.06	0.7	0.2			2.0		
max	0.12	1.5	0.8	0.020	0.025	2.6	0.5	0.5
typ	0.09	1	0.5	0.008	0.012	2.3	0.2	0.2

#### All-weld mechanical properties

As welded			typical
Tensile strength		MPa	900
0.2% Proof stress		MPa	700
Elongation on 4d		%	17
Impact energy *	+ 20°C	J	18-48
	0°C	J	14-43
Hardness		HV	280

\* For comparison, typical thermit rail weld: 8J @ 20°C, 5J @ 0°C.

#### **Parameters**

DC +ve or AC (OCV: 70V min)

ø mm	3.2	5.0	6.0	
min A	100	200	240	
max A	160	280	360	

#### Packaging data

ø mm	3.2 *	5.0	6.0 *	
length mm	380	450	450	
kg/carton	15.0	17.7	18.3	* supplied to order
pieces/carton	447	183	135	

#### Storage

**3 hermetically sealed ring-pull metal tins** per carton, with unlimited shelf life. Direct use from tin will give **hydrogen** <5ml/100g weld metal during 8h working shift.

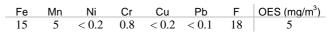
For electrodes that have been exposed:

**Redry** 250-300°C/1-2h to ensure  $H_2 <10ml/100g$ , 300-350°C/1-2h to ensure  $H_2 <5ml/100g$ . Maximum 420°C, 3 cycles, 10h total.

**Storage** of redried electrodes at 100-200°C in holding oven or 50-150°C in heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, >18°C.

#### Fume data

Fume composition, wt % typical:





# **Stainless Steels**

# **12%Cr MARTENSITIC STAINLESS**

## Alloy type

12%Cr (410) martensitic stainless steel; the 13.1.BMP electrode also has 1.5%Ni.

## Materials to be welded

	wrought	cast
ASTM	410, 403	A487 grade CA15
UNS	S41000, S40300	
DIN	1.4006 (X10Cr13)	1.4006 (G-X10Cr13)
	1.4000, 1.4024	
BS	410S21 (En56A)	410C21
	403S17	

The 13.1.BMP with 1.5%Ni is also suitable for ASTM A487 CA15M and DIN 1.4008 (G-X8CrNi13).

## Applications

These consumables are designed for welding wrought or cast martensitic 12%Cr (type 410) stainless steel. Fabrication welds of matching composition such as this must be tempered by appropriate PWHT, owing to high hardness (~450HV) and low ductility in the as-welded condition. Conventional 410 has variable toughness but following PWHT the 13.1.BMP electrode with 1.5%Ni has good impact properties down to -10°C or lower depending on the heat treatment schedule.

Plain 12%Cr steels are the most simple and economic alloys with stainless properties. Variants with Ti (409), Al (405) or low carbon (410S) are more or less fully ferritic with typically lower strength than type 410. These types, and the newer "utility ferritics", are normally welded without PWHT using 309/309L consumables (data sheet B-50). The same applies to type 410 when PWHT is not practicable.

Type 410 contains just sufficient carbon to enable airhardening transformation to a predominantly martensitic microstructure. Structural properties below ambient are limited by its relatively high ductile-brittle transition temperature (particularly weldments), and up to about 550°C by its modest creep resistance. It has useful resistance to general corrosion in non-aggressive media, sulphide-induced SCC in sour crude oil service, and oxidation up to about 800°C. DATA SHEET **B-10** 

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Typical applications include **hydrocrackers**, reaction **vessels**, **distillation plants** and associated **pipework** in **refineries**; **furnace parts**, **linings**; surfacing **run-out rolls** in steel mills; cast **valve bodies**, **turbine parts** and **burner nozzles**.

## Microstructure

In the PWHT condition the microstructure consists of tempered martensite with some retained ferrite.

## Welding guidelines

Preheat of 150-250°C is required for heavier sections. Following welding, components should be cooled to room temperature before PWHT. Weld metal and HAZ's have poor ductility and toughness in the aswelded condition, careful handling is recommended prior to PWHT to minimise physical shock.

## **PWHT**

**Plain 410** - A typical industrial PWHT following welding for plain 410, consists of slowly cooling to room temperature to allow full transformation to take place (range is Ms-350°C Mf-100°C), then temper at 680-760°C followed by air cool. To ensure <22HRC (NACE) in the weld area, PWHT at 745°C is preferred.

**13.1.BMP** – The optimum properties are obtained after PWHT at around 700°C, close to the  $Ac_1$  temperature for this weld metal, which (due to the added nickel) has a lower  $Ac_1$  than plain 410. If needed PWHT time can be extended but higher temperatures may cause rehardening with fresh martensite formation on cool-out. Superior toughness can be achieved with a double temper (cool to ambient between cycles) and this is recommended to conform to NACE, 22HRC maximum.

## **Products available**

Process	Product	Specification
MMA	13.RMP	AWS E410-26
	13.1.BMP	DIN E 13 1 MPB
TIG/MIG	12Cr	AWS ER410

## lower depending on



	Genera	al da	ta fo	or all	410	MMA	A ele	ctroc	les				
Storage	for longer th moisture pic For electrod <b>Redry</b> 300 - <b>Storage</b> of n	han a wo ck-up and les that ha – 350°C/ redried el	rking shi l increase ave been 1-2h to r lectrodes	ift of 8h. e the risk of exposed: estore to a at 100 – 2	Excession of porosion s-packee 00°C in	ve exposu ty. d conditio holding o	re of elec n. Maxin oven or he	etrodes to num 420° eated quiv	humid c C, 3 cyc er: no lir	t use from tin is satisfactory conditions will cause some cles, 10h total. mit, but maximum 6 weeks tic lid): < 60% RH, > 18°C.			
Fume data	Fume comp	Fume composition, wt % typical:											
		Fe	Mn	Ni	Cr	Cu	Мо	V	F	OES (mg/m <sup>3</sup> )			
		20	2	< 0.5	3	< 0.2	<0.1	< 0.1	18	1.7			

13.RMP										13%Cr	MMA electrode			
Product description	low w	eld metal	hydrog	en levels	. Diamet	ers abov	e 3.2mm	are not r	ecommer	oisture resistan nded for positi le electrode.	t coating giving very onal welding.			
Specifications	AWS BS EI BS 29 DIN 8	N 1600 926		13.R	R 52	130								
ASME IX Qualification	QW43	QW432 F-No 1, QW442 A-No 6												
Composition (weld metal wt %)	min max typ	C  0.08 0.06	Mn  1.0 0.5	Si  0.90 0.30	S  0.025 0.010	P  0.030 0.015	Cr 11.0 13.5 11.5	Ni  0.60 0.4	Mo  0.5 0.2	Cu  0.50 0.05				
All-weld mechanical properties	0.2% F Elonga Elonga	e strength Proof stre ation on 4 ation on 5 tion of are BS & B This giv AWS P	ss d d S EN PV ves a rela WHT: 7	atively lo 30-760°C	M 0-870°C ow streng C for 1 hor	th condit ur, furna	$\begin{array}{c c c c c c c c c c c c c c c c c c c $			min 450  20  t 55°C/h. max. nax., air cool te	ambient. This gives			
Operating parameters	DC +v ø mm min A max A	ve or AC	(OCV: 7	70V min) 2.5 70 110		3.2 80 140		4.0 100 180	Ų	5.0 140 240				
Packaging data	ø mm length kg/cart pieces			2.5 350 12.6 609		3.2 380 14.1 378		4.0 380 14.1 219		5.0 450 16.8 150				



13.1.BMP									10700		%Ni MMA ele			
Product description	Basic low hydrogen metal powder MMA electrode made on pure low carbon core wire. Moisture resistant coating giving very low weld metal hydrogen levels. Diameters above 3.2mm are not recommended for positional welding.													
	Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.													
Specifications	BS E BS 29	AWS A5.4       (E410-15)         BS EN 1600       (E 13 B 52)         BS 2926       (13.BMP)         DIN 8556       E 13 1 MPB 26 130												
ASME IX Qualification	QW432 F-No 1, QW442 A-No 6													
Composition		С	Mn	Si	S	Р	Cr	Ni	Mo *	Cu				
(weld metal wt %)	min	0.02	0.4				11.0	1.0	0.15					
	max	0.06	1.0	0.50	0.025	0.030	14.0	2.0	0.50	0.5				
	typ	0.04	0.7	0.25	0.01	0.02	13	1.5	0.3	0.05				
	<ul> <li>Molybdenum is controlled to satisfy minimum requirements for ASTM A487 CA15M castings (0.15- 1.0% Mo).</li> </ul>													
All-weld mechanical properties	Туріса	al after PW	/HT				min *		790°C/5ł 700°C/5		680°C/2h + 620°C/2h			
	Tensile strength				MPa	ı 🔤	620		655		760			
		Proof stres			MPa		450	455			685			
		ation on 4				% 18 % 15			26		20			
	Elongation on 5d					% 15 %		23 70		17				
	Reduction of area Impact energy + 20°C						105			67				
	impac	cenergy		- 10°C		J J			90		60			
	Hardn	ess		10 0	•	HRC <22 **			18		19			
	* **	* Tensile properties based on ASTM CA15 and CA15M castings. Specifications for wrought grades vary tensile strength 415-700MPa.												
Operating parameters	DC +v	ve or AC	OCV:	70V min)								Î		
	ø mm			3.2		4.0		5.0						
	min A			80		100		140						
	max A	L Contraction of the second seco		140		180		240						
Packaging data	ø mm			3.2		4.0		5.0 *						
	length	mm		380		450		450						
	kg/car	ton		15.0		16.5								
	kg/carton 15.0 pieces/carton 375					225		144						
	P													



12Cr			12%	6Cr sol	lid wire	e for TI	G & I	MIG wel	ding of 410 stain	less stee		
Product description	Solid wire for TI	G & MI	G.									
Specifications	AWS A5.9 BS 2901: Pt2 BS EN 12072 DIN 8556		ER410 410S94 13 SG X 8Cr 14 (1.4009) nearest									
ASME IX Qualification	QW432 F-No 6,	QW44	42 A-N	lo 6								
Composition (wire wt %)	C *           min         0.06           max         0.12           typ         0.1           *         BS 2901: Pt2	Mn  0.6 0.4 requires	Si 0.25 0.50 0.3 \$ 0.09-0	S 0.02 0.01 0.25%C.	P  0.03 0.02	Cr 12.0 13.5 12.5	Ni  0.6 0.4	Mo  0.3 0.03	Cu  0.3 0.2			
All-weld mechanical properties	Typical values aft Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Impact energy Hardness cap/mic	5	HT MPa MPa % % + 20°C J HV HRC			MA 0°C/1h (A 695 530 22 19 50 <20 225/230	WS)	-20%CO <sub>2</sub> 740°C 67 51 20 18 50 20 215/2 18/2				
Typical operating parameters	Shielding Current Diameter Parameters * Also requir ** Most econo carbon cont	1 ed as a p omic gas	is Ar-2	n 2V or root ru: 0%CO <sub>2</sub> .	Ar / 22 ns. This ga		02	ighest resi	stance to weld metal p	orosity and		
Packaging data	ø mm 1.2 1.6 2.4		TIG  2.5kg tu 2.5kg tu			MIG kg spool kg spool						
Fume data		osition (v Fe 55	wt %) (′ Mn 4	TIG fum Cr <sup>3</sup> 8	e neglig N <0.	i Ci		OES (mg. 5	/m³)			



# **Stainless Steels**

# **410NiMo MARTENSITIC STAINLESS**

## Alloy type

12%Cr-4.5%Ni-0.5%Mo (410NiMo) soft martensitic alloy.

## Materials to be welded

	wrought	cast
ASTM	F6NM	CA6NM
UNS	S41500	
<b>BS EN / DIN</b>	1.4313	G-X5CrNi 13 4
BS		425C11
AFNOR		Z6 CND 1304-M

## **Applications**

High strength (>760MPa) martensitic stainless steel with better resistance to corrosion, hydro-cavitation, sulphide-induced SCC, and good sub-zero toughness when compared with plain 12%Cr steels (e.g. type 410/CA15).

Weld metal of this type greatly overmatches the strength of equivalent parent material and is remarkably resistant to softening during PWHT. These properties can be exploited for welding martensitic precipitationhardening alloys if corrosion conditions are compatible with lower alloy weld metal, with the advantage of a single PWHT at 450-620°C for tempering. The 410NiMo consumables are also used for **overlaying** mild and CMn steels.

13%Cr-4%Ni alloys are used in cast or forged form for hydraulic turbines, valve bodies, pump bowls, compressor cones, impellers and high pressure pipes in power generation, offshore oil, chemical and petrochemical industries.

## DATA SHEET B-11

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## Microstructure

In the PWHT condition the microstructure consists of tempered martensite with some retained austenite.

## Welding guidelines

Preheat-interpass range of 100-200°C is recommended to allow martensite transformation during welding. Cool to room temperature before PWHT.

#### **PWHT**

For maximum resistance to sulphide-induced SCC in sour oil conditions NACE MR0175 specifies a hardness of <23HRc. This is often difficult to achieve because weld metal and HAZ are very resistant to softening by PWHT. A double temper for 5-10h is necessary. Common practice is  $675^{\circ}$ C/10h +  $605^{\circ}$ C/10h with intermediate air cool to ambient. Recent work indicates  $650^{\circ}$ C +  $620^{\circ}$ C is optimum, and that intermediate air cooling to ambient or lower is essential. Another authority suggests raising the first PWHT cycle for full austenitisation anneal at  $770^{\circ}$ C/2h prior to final temper. Control of distortion may be more critical in this case. In the case of the Supercore 410NiMo flux cored wire it has not been possible to reduce the hardness to 23HRC irrespective of the PWHT carried out.

If 410NiMo consumables are considered for welding plain 12Cr martensitic stainless steels such as type 410 or CA15, the PWHT should not exceed about 650°C unless a second temper at 590-620°C is applied.

## **Products available**

Process	Product	Specification
MMA	13.4.Mo.L.R	AWS E410NiMo-26
TIG/MIG	ER410NiMo	AWS ER410NiMo
FCW	Supercore 410NiMo	AWS E410NiMoT1-1/4



13.4.Mo.L.R							R	utile M	MA ele	ctrod	e for 410NiMo				
Product description	Rutile metal powder type made on pure low carbon core wire. Moisture resistant coating giving very low weld metal hydrogen levels. Diameters above 3.2mm are not recommended for positional welding.														
	Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.														
Specifications		<b>DIN 8556</b> E13 4 MPR 26 130													
ASME IX Qualification	QW432 F	QW432 F-No 1, QW442 A-No 6													
Composition (weld metal wt %)	min	 06 1.0	Si  0.90 0.25	S  0.025 0.01	P  0.03 0.01	Cr 11.0 12.5 12	Ni 4.0 5.0 4.5	Mo 0.40 0.70 0.6	Cu  0.50 0.05						
All-weld mechanical properties	Typical prop Tensile stre 0.2% Proof Elongation o Elongation o Reduction o	ngth stress on 4d on 5d			Pa Pa % %	min 760 500 15 10	PWHT (1) 940 695 17 15		As-weld 100 780 4.5 3 10	0 0 5					
	Impact ener Hardness (1) AW	gy 7S & BS PV		H-620⁰C fe	J J J HV	   ır, air cool	2 270 ed. See		27 13 8 350 ge for deta	) ils on I	PWHT. ept for surfacing				
Operating parameters	DC +ve or A	lications w AC (OCV:		dness of a	330-400	)HV is use	eful.			1 <b>k</b> =					
	ø mm min A max A		2.5 70 110		3.2 80 140		4.0 100 180	-	5.0 140 240						
Packaging data	ø mm length mm kg/carton pieces/carto	n	2.5 350 12.6 534		3.2 380 15.0 363		4.0 450 18.0 240		5.0 450 16.8 171						
Storage	for longer t moisture pie For electroo <b>Redry</b> 300 <b>Storage</b> of	han a work ck-up and i les that hav – 350°C/1- redried ele	cing shift of increase the ve been exp -2h to restor ctrodes at	of 8h. E. e risk of posed: ore to as- 50 – 200	xcessive porosity packed 0°C in h	e exposure 7. condition olding ove	e of elect . Maxim en or hea	trodes to num 420 ated quiv	°C, 3 cycle ver: no lim	ondition es, 10h it, but	om tin is satisfactory ns will cause some total. < 60% RH, > 18°C				
Fume data	Fume comp	osition, wt	% typical					N4-	.,	_					
		Fe	Mn	Ni	С	r C	Cu	Мо	V	F	OES (mg/m <sup>3</sup> )				



## Solid wire for welding 410NiMo martensitic stainless steel

Product description	Solid v	Solid wire for TIG and MIG.											
Specifications	-	N ISO 14 N ISO 14		13 4 (SS41	10NiMo) 10NiMo) (3CrNi 1)		s strictly conform see composition.						
ASME IX Qualification	QW432 F-No 6												
Composition (wire wt %)	min max typ *	C  0.05 0.02 AWS requ	Mn * 0.4 1.0 0.8 uires 0.6	Si *  0.60 0.4 %Mn ma	S  0.02 0.005 ax and 0.	P  0.03 0.015 50% Si n	Cr 11.0 12.5 12.3 nax.	Ni 4.0 5.0 4.5	Mo 0.4 0.7 0.5	Cu  0.3 0.1			
All-weld mechanical properties	Tensile 0.2% F Elonga Elonga Impact	I values a e strength Proof stres ation on 4 ation on 5 e energy ess cap/m	ss d d	HT 610⁰ <b>C</b> 0°C -50°C	610° <b>C/1h:</b> MPa MPa % % 0°C J								
Typical operating parameters		it ter			n 2V ør root ru	or 1- 1 22 ns.	MIG ith 1-2% 5%CO <sub>2</sub> DC+ 1.2mm 0A, 28V llso suita	**					
Packaging data	ø mm 1.0 1.2 1.6 2.0 2.4			TIG  2.5kg tu To ord 2.5kg tu	er		MIG o order kg spool  						
Fume data	MIG f	ume com	position Fe 54	(wt %) ( Mn 5	TIG fum Cr <sup>3</sup> 8	e negligi Ni 3.2		Мо :0.5	Cu <0.5	OES (mg/m <sup>3</sup> )			



SUPERCORE	410N	liMo		Flux c	ored wi	re for v	velding	1410NiN	lo m	artensitic	stainless steel			
Product description	All-po	sitional ru	utile flux	x cored wir	e made on	a high p	urity stai	nless steel s	strip					
	Metal	recoverv	about 9(	0% with res	spect to w	ire								
		-			-									
Specifications		A5.22 N ISO 17	633-Δ	E410N T 13 4	iMoT1-1/ РМ2	4								
	-	BS EN ISO 17633-B TS410NiMo-FM1												
ASME IX Qualification	QW43	<b>2</b> F-No	б											
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	Со			
(weld metal wt %)	min						11.0	4.0	0.4					
	max	0.06	1.0	1.0	0.025	0.030	12.5	5.0	0.7	0.3	0.05			
	Тур	0.03	0.7	0.4	0.005	0.017	11.8	4.5	0.5	0.03	0.03			
All-weld mechanical	Typical	values:				M	lin	610ºC/1⊧	1	610ºC/10h	650ºC/10h +620ºC/10h			
properties	Tensile	strength			MPa	76	50	940		870				
		Proof stres			MPa		00	850		700				
	0	tion on 40			%		5	20		23				
	-	tion on 50			%		5	17		19				
		tion of are	a	. 2000	%		-	50		55				
	Impact	energy		+ 20°C - 40°C	J J	-	-	45 30		50 40	50 35			
	Hardne	200		- 40 C	J HV	-	-	330		40 310	310			
	Thartand				HRC			31		27	28			
	AWS I	AWS PWHT = $593-621^{\circ}C/1$ hour. BS EN PWHT = $580-620^{\circ}C/2$ hours.												
Operating parameters				$CO_2$ or $100^{\circ}$				voltage by 1	l-3V)	:				
	ø mm	ra	inge		tvp	ical		stickout						
	1.2			A, 25-32V		0A, 28V		15-25m						
	1.6	2	00-350A	A, 26-34V	26	0A, 30V		15-25m						
Packaging data	The as Resista possibi	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 of	compositi	on (wt s	%):										
			Fe	Mn	Cr <sup>∨ı</sup>	Ni	Мо	Cu	C	DES (mg/m <sup>3</sup> )				
			18	3	2.5	1	0.2	< 0.5		2				





# MARTENSITIC PRECIPITATION HARDENING STAINLESS STEELS

## Alloy type

High strength martensitic precipitation hardening stainless steels.

### Materials to be welded

#### FV520 Types:

A564, A693, A705; Grade XM-25
S45000
3146 Grade ANC 20.
'S' grades; 2S.143; 3S.144; 3S.145
FV520B (Firth Vickers)
Custom 450 (Carpenter)

## 630 / 17.4.PH Types:

ASTM	A564; Grade 630
	A747; CB7Cu-1 (cast)
UNS	S17400
BS EN	10088-2; X5CrNiCuNb 16-4 (1.4542)
DIN	1.4548, 1.4549
Proprietary	17-4PH (Armco Steel)
	Custom 630 (Carpenter)

## Applications

Used for welding very high strength martensitic stainless steels, precipitation hardened by additions of copper. Strength can be up to three times that of standard 300 series austenitic stainless steels.

The FV520/450 type alloys have corrosion resistance comparable to 304 stainless steel. The 630/17-4PH types, with no Mo and higher carbon, do not have such good resistance to intergranular and pitting corrosion as the FV520/450 types.

Applications include **pump shafts**, **impellers**, **hydraulic equipment** used in **oil** and **gas industries**, **petrochemical**, **marine** and **nuclear engineering**.

### Microstructure

In the PWHT condition the microstructure consists of precipitation hardened tempered martensite with some retained austenite.

## DATA SHEET B-12

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## Welding guidelines

Preheat not usually necessary for thickness up to 15mm, for thicker restrained sections, a preheat-interpass temperature range of 100-200°C is recommended. Temperatures above 200°C will suppress martensite transformation with consequent microstructural coarsening.

#### **PWHT**

When matching composition consumables are used for welding these materials a PWHT must be carried out. Normal practice is for the materials to be used in the overaged condition. PWHT for over-ageing consists of: 750°C for 2 hours, air cool to 15°C; followed by 550°C for 2 hours and air cool.

## Additional information

On cooling the weld metal transforms from austenite to martensite ( $M_s$ ) below about 250°C, but a significant fraction of austenite is still retained at ambient temperature. Since sub-zero cooling is impractical, this austenite is destabilised by annealing at 750-850°C. Carbide precipitation in the austenite raises its  $M_s$  temperature to enable complete transformation when cooled, ensuring more effective tempering and ageing during the second PWHT cycle. Omission of the inconvenient first PWHT cycle may give properties with greater batch variability. The use of 410NiMo (B-11) allows a simplified PWHT to be used, and when PWHT is not possible 2205 duplex (B-60) or superduplex (B-61 & B-62) consumables may allow PWHT to be avoided without compromising mechanical properties too much.

## **Products available**

Process	Product	Specification
MMA	FV520-1	
	17.4.Cu.R	(AWS E630-16)
TIG	FV520B	
	17-4PH	AWS ER630
MCW	Metcore FV520	



## **General Data for all MMA Electrodes**

Storage	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactor for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause son moisture pick-up and increase the risk of porosity. For electrodes that have been exposed:</li> <li>Redry 300 – 350°C/1-2h to restore to as-packed condition. Maximum 420° C, 3 cycles, 10h total.</li> <li>Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weel recommended. Recommended ambient storage conditions for opened tins (using plastic lid): &lt; 60% RH, &gt; 18°C</li> </ul>									
Fume data	Fume	composit	ion, wt %	typical:						
		Fe	Mn	Ni	Cr	Cu	Мо	V	F	OES (mg/m <sup>3</sup> )
		15	3	0.5	4	0.8	0.2	< 0.1	18	1.2

FV520-1						MM	IA elec	trode fo	or FV5	20 base	material			
Product description	metal hydrogen le	Rutile metal powder coating on pure low carbon steel core wire. Moisture resistant coating gives very low well metal hydrogen levels. Diameters above 3.2mm are not recommended for positional welding. Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.												
Specifications	There are no natio	There are no national specifications for this electrode.												
ASME IX Qualification	QW432 F-No,	QW44	<b>12</b> A-N	lo										
Composition (weld metal wt %)	C           min            max         0.05           typ         0.03	Mn 0.4 1.0 0.6	Si 0.2 0.5 0.3	S  0.030 0.010	P  0.030 0.015	Cr 13.0 15.5 14	Ni 4.5 6.0 5	Mo 1.2 2.0 1.5	Cu 1.2 2.0 1.6	Nb           0.15           0.5           0.3				
All-weld mechanical properties			12 12 13 14 4 50°C/4 h			0 0 5 5 5 t recomm		r structural lied PWHT						
Operating parameters	DC +ve or AC (O ø mm min A max A		/ min) 2.5 70 110		3.2 80 140		4.0 100 180	Ų						
Packaging data	ø mm length mm kg/carton pieces/carton	3	2.5 350 3.5 530	1	3.2 380 4.4 345		4.0 450 17.1 246							



17.4.Cu.R						MM	A elect	rode fo	r 17-4l	PH base	material			
Product description	metal hydrogen l	Rutile metal powder coating on pure low carbon steel core wire. Moisture resistant coating gives very low weld metal hydrogen levels. Diameters above 3.2mm are not recommended for positional welding. Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.												
Specifications	There are no nati	onal spe	ecificatio	ns for this	electrode	e but it is	s similar t	o AWS A	5.4 E63	0-26.				
ASME IX Qualification	QW432 F-No	QW432 F-No, QW442 A-No												
Composition	С	Mn	Si	S	Р	Cr	Ni	Мо	Cu					
(weld metal wt %)	min					14.0	3.5		1.5					
,	max 0.10	1.0	0.8	0.030	0.030	16.5	4.5	0.5	2.5					
	typ 0.02	0.7	0.25	0.01	0.01	15	4	0.2	2					
All-weld mechanical	Typical properties	s PWHT			Over	-aged *								
properties	Tensile strength			MPa	1	035								
	0.2% Proof stress	6		MPa	6	35								
	Elongation on 4d			%		10								
	Elongation on 5d			%		9								
	Reduction of area	a		%		24								
	Hardness			HV	3	30								
	* $750^{\circ}$ C/2 hours, air cool to $15^{\circ}$ C + $550^{\circ}$ C/2 hours, air cool.													
Operating parameters	DC +ve or AC (0	OCV: 70	OV min)					U	$\checkmark$					
	ø mm		2.5		3.2		4.0							
	min A	-	70		80		100							
	max A		110		140		180							
Packaging data	ø mm		2.5		3.2		4.0							
	length mm		350	í	380		450							
	kg/carton		12.3	1	5.0		18.6							
	pieces/carton		528		345		246							

## FV520B

## Solid TIG wire for welding FV520 stainless steel

Product description	Solid	wire for T	G.									
Specifications	There	are no nat	ional spe	ecificatio	ons for this	s wire.						
ASME IX Qualification	QW43	<b>32</b> F-No -	-, <b>QW</b> 4	<b>142</b> A-N	lo							
Composition		C	Mn	Si	S	Р	Cr	Ni	Мо	Cu	Nb	
(wire wt %)	min		0.5	0.2			13.2	5.0	1.2	1.2	0.15	
. ,	max	0.07	1.0	0.5	0.03	0.03	14.7	6.0	2.0	2.0	0.5	
	typ	0.05	0.7	0.3	0.01	0.02	14	5.5	1.6	1.7	0.3	
All-weld mechanical	Typica	I PWHT				Aged *		Over-age	d **	Over-ageo	***	single cycle 550°C
properties	Tensile	e strength			MPa	1345		1100		1025		1200
	0.2% F	Proof stres	s		MPa	1240		1050		760		1000
	Elonga	ation on 4d			%	5		19		22		19
	Elonga	ation on 5d			%	5		16		21		16
	Reduc	tion of area	а		%	15		50		60		50
	Impact	t energy	+ 2	0°C	J	7		60		125		125
			- 20	0°C	J			20		85		75
	Hardne	ess mid			HV	450		380		315		400
	*	850°C/2	hours, a	ir cool to	o 20°C + 4	450°C/4 ho	urs, air	cool. Not	recom	mended for	r structu	ıral work.
	**	750°C/2	hours, a	ir cool to	o 20°C + 5	550°C/2 ho	urs, air	cool. Mo	re com	monly appl	ied PW	HT.
	***	750°C/2	hours, a	ir cool to	$0.20^{\circ}\text{C} + 6$	520°C/2 ho	urs, air	cool.				



## FV520B (continued)

Typical operating			TIG						
parameters	Shielding		Argon	*					
•	Current		DC-						
	Diameter		2.4mn	n					
	Parameters		120A, 1-	4V					
	* Also ree	quired as		or root runs	5.				
Packaging data	ø mm		TIG						
	1.6		5kg tuł	be					
	2.4		5kg tuł						
Fume data	Fume compos	sition (w	t %) (TIG	fume negli	gible)				
		Fe	Mn	Cr <sup>3</sup>	Ni	Мо	Cu	OES (mg/m <sup>3</sup> )	
	_	52	4	11	4	< 0.5	2.7	4.5	

## 17-4PH

Solid TIG wire for welding 17-4PH stainless steel

Product description	Solid w	rire for T	IG weldi	ng.								
Specifications	AWS A	5.9	ER	.630								
ASME IX Qualification	QW432	<b>2</b> F-No 6	5									
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	Nb	
(wire wt %)	min		0.25				16.00	4.5		3.25	0.15	
	max	0.05	0.75	0.75	0.03	0.03	16.75	5.0	0.75	4.00	0.30	
	typ	0.03	0.6	0.4	0.005	0.02	16.3	4.8	0.2	3.5	0.2	
All-weld mechanical	Typical	PWHT				Over	-aged *					
properties	Tensile	strength			MPa	9	930					
	0.2% Pr	roof stres	S		MPa	7	740					
	Elongat	ion			%		10					
	0											
	0		ours, air	cool to 1		C/2 hou	urs, air coo	ol; or 104	40°C, air	cool + 62	0°C/4 hours	
Typical operating	0		ours, air	cool to 1		°C/2 hou	urs, air coo	ol; or 104	40°C, air	cool + 62	.0°C/4 hours	<b>.</b>
•••••	* 75	50°C/2 h	ours, air	TIG	5°C + 550°	°C/2 hou	ırs, air coo	ol; or 104	40°C, air	cool + 62	0°C/4 hours	
•••••	0	50°C/2 h	ours, air		5°C + 550°	°C/2 hou	urs, air coo	ol; or 104	40°C, air	cool + 62	0°C/4 hours	l.
•••••	* 75 Shieldin	50°C/2 h	ours, air	TIG Argon *	5°C + 550°	C/2 hou	urs, air coo	ol; or 104	40°C, air	cool + 62	0°C/4 hours	i.
•••••	* 75 Shieldin Current	50°C/2 h ng er		TIG Argon * DC-	5°C + 550°	C/2 hou	urs, air coo	bl; or 104	40°C, air	cool + 62	0°C/4 hours	
•••••	* 75 Shieldin Current Diamete Parame	50°C/2 h		TIG Argon * DC- 2.4mm 120A, 14	5°C + 550°	C/2 hou	ırs, air coo	bl; or 104	40°C, air	cool + 62	0°C/4 hours	
parameters	* 75 Shieldin Current Diamete Parame	50°C/2 h		TIG Argon * DC- 2.4mm 120A, 14	5°C + 550°	C/2 hou	ırs, air coo	bl; or 104	40°C, air	cool + 62	0°C/4 hours	i.
parameters	* 75 Shieldin Current Diamete Parame * A	50°C/2 h	red as a	TIG Argon * DC- 2.4mm 120A, 14 purge for	5°C + 550° V root runs.	C/2 hou	ırs, air coo	bl; or 104	40°C, air	cool + 62	0°C/4 hours	i.
parameters	* 75 Shieldin Current Diamete Parame * A Ø mm	50°C/2 h	red as a	TIG Argon * DC- 2.4mm 120A, 14 purge for TIG	V root runs.	C/2 hou	ırs, air coo	bl; or 104	40°C, air	cool + 62	0°C/4 hours	
parameters Packaging data	* 75 Shieldin Current Diamete Parame * A Ø mm 1.6 2.4	50°C/2 h 19 er ters 1so requi	red as a	TIG Argon * DC- 2.4mm 120A, 14' purge for TIG 2.5kg tub 2.5kg tub	V root runs.		ırs, air coo	bl; or 104	40°C, air	cool + 62	0°C/4 hours	
Typical operating parameters Packaging data Fume data	* 75 Shieldin Current Diamete Parame * A Ø mm 1.6 2.4	50°C/2 h Ig er ters Iso requi	red as a	TIG Argon * DC- 2.4mm 120A, 14' purge for TIG 2.5kg tub 2.5kg tub	V root runs. e e		Irs, air coo	CL		ES (mg/m		



# **Stainless Steels**

## **308L STAINLESS STEELS**

### Alloy type

### Materials to be welded

ASTM	BS EN & DIN
304L	1.4306
304	1.4301
304LN	1.4311
CF3	1.4308
CF8	
BS	UNS

304S11 304S15/16/31 304S61 304C12 304C15

**Applications** 

S 30403

S 30400 S 30453

Used to weld 18/8 stainless steels including 301, 302, 303, nitrogen bearing 304LN and titanium stabilised 321. Service temperatures are typically -100°C to about 400°C.

Applications include food, brewery, pharmaceutical equipment, architectural and general fabrication, and nuclear engineering.

The 308L consumables covered here are not suitable for 304/304H in elevated temperature structural applications, see data sheets C-10 and C-12. For cryogenic applications (-196°C) see data sheet B-37.

## **Microstructure**

Austenite with a controlled level of ferrite, normally in the range 3-10FN depending on the application.

#### **B-30** DATA SHEET

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## Welding guidelines

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

## Additional information

There is a Technical Profile available on sub-arc welding with 308S92. There is also additional information available covering the Supercore flux cored wires.

## **Related alloy groups**

308L stainless steel consumables for LNG, and other cryogenic applications, are in data sheet B-37. Stainless steel consumables for high temperature applications on 304H can be found in data sheets C-10 or C-12.

#### **Products available**

Process	Product	Specification
MMA	Supermet 308L	AWS E308L-17
	Ultramet 308L	AWS E308L-16
	Ultramet B308L	AWS E308L-15
	Ultramet 308LP	AWS E308L-16
TIG	308892	AWS ER308L
MIG	Supermig 308LSi	AWS ER308LSi
SAW	308892	AWS ER308L
	SSB	BS EN SA AF2
	LA491	BS EN SA FB255
	L2N	BS EN SF CS 2
FCW	Supercore 308L	AWS E308LT0-4
	Supercore 308LP	AWS E308LT1-4

308L austenitic stainless steels for joining 304L base materials.



# General Data for all 308L MMA Electrodes

			siuge cond		opened this	(using pla	astic lid): < 60% RH, >
ne composition, w	vt % typical	1:					
Fe	Mn	Cr	Ni	Мо	Cu	F *	OES (mg/m <sup>3</sup> )
8	5	5	0.8	-	< 0.2	16	1
	Fe 8	Fe         Mn           8         5	8 5 5	Fe         Mn         Cr         Ni           8         5         5         0.8	Fe         Mn         Cr         Ni         Mo           8         5         5         0.8         -	Fe         Mn         Cr         Ni         Mo         Cu           8         5         5         0.8         -         <0.2	Fe Mn Cr Ni Mo Cu F*

SUPERMET 3	08L						Ge	eneral	purpos	se rutile	e 308	LMM	A elec	trode
Product description	'Low hy gives ac Designe downha	vdrogen' cid rutile ed for ea and and l	manu opera ase of HV po	facturin bility co use, ex ositions;	g technol ombined ceptiona smaller	te flux on logy ensu with cont l weld be sizes offe to core w	res high i rolled sil ead appe er all-pos	resistance icon cor arance a itional c	te to weld ntent for i and high operabilit	d metal po maximun weld me y.	orosity. n cracki etal inte	'Superi ing/corr egrity, j	met Tech osion res	nology' istance.
Specifications	AWS A BS EN BS 292 DIN 85	A5.4   1600 26	ut 11.	E E 19	308L-17 19 9 LR 9.9.L.AR 19 9 LR	32	ne, 05 %	with res			cuode.			
ASME IX Qualification	QW43	<b>2</b> F-No	5, <b>Q</b>	W442	A-No 8									
Composition (weld metal wt %)	min max typ	C  0.04 0.02	Mn 0.5 2.0 0.8	Si  0.90 0.6	S  0.025 0.01	P  0.030 0.02	Cr 18.0 21.0 19.5	Ni 9.0 11.0 10	Mo  0.5 0.02	Cu  0.5 0.05	FN 3 10 6			
All-weld mechanical properties	0.2% P Elongat Elongat Reducti	led strength roof stres tion on 4 tion on 5 tion of are energy *	ss d d	+ 20	0°C	MPa MPa % % J	min 520 320 35 30 	t	ypical 590 450 45 40 45 80					
Operating parameters	DC +ve ø mm min A	e or AC (		: 50V m 1.6 25	in)	2.0 50		2.5 60		3.2 75	2	4.0 00		5.0 30
	max A			45		70		90		20		55		210
Packaging data	ø mm length r kg/carto pieces/e	n		1.6 250 8.7 1350		2.0 300 10.5 846		2.5 300 11.4 609	3	3.2 350 2.0 333	4	4.0 450 6.5 243	4	5.0 150 6.5 156



ULTRAMET 30	)8L						AI	l-pos	sitional r	utile N	/IMA e	ectrod	e for 3	304L
Product description	an adv	anced rutil	e flux d	lesign – thi	is include	s opti	mum ve	ersatil	rity 304L c ity for dow 2.5/3.2mm	nhand w	elding w	ith high c	cosmetic	finish
	Recov	ery is abou	ıt 110%	with resp	ect to con	e wir	e, 65%	with	respect to	whole el	ectrode.			
Specifications	AWS BS EI BS 29 DIN 8 Appro	N 1600 926 556		E308L-1 E 19 9 L 19.9.LR E 19 9 L TÜV	R 3 2									
ASME IX Qualification	QW43	32 F-No 5	, <b>QW</b>	442 A-No	o 8									
Composition (weld metal wt %)	min max	C  0.04	Mn 0.5 2.0	Si  0.90	\$  0.025 0.01	F  0.0 0.0	- 30	Cr 18.0 21.0 19	Ni 9.0 11.0 9.5	Mo  0.50 0.1	Cu  0.5 0.1	FN 3 10 6		
	typ	<0.03	1	0.6	0.01	0.0	JZ	19	9.5	0.1	0.1	0		
All-weld mechanical properties	0.2% F Elonga Elonga Reduc	ded e strength Proof stress ation on 4d ation on 5d tion of area e energy	a	-100°C		Pa Pa % % J	min 520 320 35 30 		typical 590 450 45 42 50 35		1050°C 54 29 50 48 64	0 0 ) 3 4		
		0,	-	-196°C	eet B-37)	J	*		 ogenic app	olication	>6	60		
Operating parameters	DC +v	e or AC (0	DCV: 5	0V min)						U			Ê	Î
	ø mm			2.5		3.2			4.0		5.0			
	min A max A			60 90		75 120			100 155		130 210			
Packaging data	ø mm			2.5		3.2			4.0		5.0			
	length kg/cart pieces			300 11.4 618	1	350 3.5 396			350 13.5 261		350 13.5 165			

## **ULTRAMET B308L**

Basic coated MMA pipe-welding electrode for 304L

Product description	purity weldin advers	304L con g applica e wind an	e wire. tions incl d drafts.	Ultramet	t <b>B308L</b> i	s particul ork in the A	larly suite ASME 50	ed to the 5/6G posit	most den ion. Und	nanding ler site co	vertical a	stem and high and overhead t is tolerant to
Specifications	AWS BS EN BS 29 DIN 8	N 1600 26		E308L-1 E 199L 19.9.LB E 199L	B 4 2							
ASME IX Qualification	QW43	<b>2</b> F-No	5, <b>QW</b> 4	42 A-No	o 8							
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN	
(weld metal wt %)	min		0.5				18.0	9.0			3	
	max	0.04	2.0	0.90	0.025	0.030	21.0	11.0	0.50	0.5	10	
	typ	0.03	1.2	0.3	0.01	0.015	19	10	0.05	< 0.1	6	



# ULTRAMET B308L (continued)

	<u> </u>	,					
All-weld mechanical	As welded			min	typical		
properties	Tensile strength		MPa	520	600		
	0.2% Proof stress		MPa	320	440		
	Elongation on 4d		%	35	44		
	Elongation on 5d		%	30	40		
	Reduction of area		%		60		
	Impact energy	+20°C	J		80-120		
		-196°C	J		35-50		
Operating parameters	DC +ve only.				Ų		Ê Î
	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		350		
	kg/carton	12.0	13.5		13.5		
	pieces/carton	681	396		261		

ULTRAMET 3	08LF					All-po	sitional	pipe v	velding	and r	oot wel	ding ele	ctrode
Product description	is a fu 5G/6C a gas p	lly all-po b. The Ul purge. T	ositiona ltramet he elec	al electro 308LP e trode is	ode capat electrode also suit	ble of the has also b	most den been desig ertical-do	nanding t gned to d wn weld	fixed pip eposit sir ing on th	ework and ngle-side nin sheet	pplication root runs material.	el. Ultrame s including without the	g ASME
Specifications	AWS BS EI	A5.4 N 1600			308L-16 19 9 L R								
ASME IX Qualification	QW43	<b>32</b> F-No	5, <b>Q</b>	<b>W442</b>	A-No 8								
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN		
(weld metal wt %)	min		0.5				18.0	9.0			3		
	max	0.04	2.5	0.90	0.025	0.030	21.0	11.0	0.5	0.5	10		
	typ	0.02	0.8	0.8	0.01	0.02	19	10	0.01	0.1	6		
All-weld mechanical	As wel	ded					min	ty	pical				
properties	Tensile	e strengtl	۱			MPa	520	-	580				
		Proof stre				MPa	320		460				
	-	ation on 4				%	35		37				
	0	ation on 5				%	30		35				
	Reduc	tion of ar	ea			%			35				
Operating parameters	DC +v	ve or AC	(OCV	: 50V m	in)				Û				÷
	ø mm			2.0		2.5		3.2					
	min A			50		60		75					
	max A			70		90		120	)				
Packaging data	ø mm			2.0		2.5		3.2					
	length	mm		300		300		350	)				
	kg/car	ton		11.7		12.0		14.1	l				
	pieces	/carton		1086	i	702		447	,				



308L solid wire

## 308S92 and SUPERMIG 308LSi

Product description	Solid v	vires for 7	TIG, MI	G and sub	-arc weld	ling.						
Specifications	BS EN	N ISO 14 N ISO 14 01: Pt2		ER308 199L SS308 308S92	L 2	z Sub-arc 9 (1.4316	E G S 30	<b>1permig 3(</b> R308L Si 19 9 L Si S308L Si 08S93 G X2CrNi				
ASME IX Qualification	QW43	<b>2</b> F-No 6	5, <b>QW</b>	442 A-No	o 8							
Composition (wire wt %)	min max typ	C  0.025 0.01	Mn 1.0 2.0 1.7	Si * 0.30 0.65 0.4	S  0.020 0.01	P  0.030 0.015	Cr 19.5 21.0 20	Ni 9.0 11.0 10	Mo  0.3 0.1	Cu  0.3 0.15	FN 3 12 10	
	* Sup	ermig 308	BLSi: Si	range is (	).65 – 1.0	)%, typica	lly 0.8%	).				
All-weld mechanical properties		ded strength Proof stres				IPa IPa		TIG 605 465		typical MIG 570 435	SAW + 57 45	0
	Elonga Elonga	tion on 4d tion on 5d energy		-130°C -196°C *		% % J		465 35 33 110 80		435 42 40 70 30-60	45 41 31 50 30	l 7 )
		ess cap/m pplication		ring cryog	]	J HV ghness see		200/220		200/220	195/	
Typical operating parameters		t ter eters proprieta		TIG Argon DC- 2.4mm 100A, 12' nd Ar-He ng flux), <b>J</b>	gas mixt		%O <sub>2</sub> * C+ nm , 26V < 3%CC	35	SAW SSB** DC+ 2.4mm 0A, 28	L		
Packaging data	ø mm 0.8 1.0 1.2 1.6 2.0 2.4 3.2		TIG 308S92 2.5kg tu 2.5kg tu 2.5kg tu 2.5kg tu 2.5kg tu 2.5kg tu 2.5kg tu	be be be be	1	MIG ermig 308L 5kg reel 5kg reel 5kg reel   	.Si	30 25k	AW 8S92        g coil g coil			
Fume data	MIG fu	ume comp	osition	(wt %) (T	IG and S	AW fume	negligil	ole)				
			Fe	Mn	Cr <sup>3</sup>	Ni	Мо	Cu	0	DES (mg/m <sup>3</sup> )		
			32	12	16	8	< 0.	5 < 0.5	5	3.1		



## SUPERCORE 308L, 308LP

Rutile flux cored wires

Product description	Flux cored wires – the wires are made with an austenitic stainless steel sheath and rutile flux sy <b>308L</b> combines easy operability, high deposit quality and exceptional weld bead appearance f HV welding. <b>Supercore 308LP</b> is designed for all-positional welding including fixed pipewor is about 90% with respect to the wire.										pearance for downhand a
				vire is not nmended t					g PWHI	f or sol	ution annealing – for the
Specifications & Approvals	BS E	A5.22 N ISO 1 N ISO 1 ovals		E308 T 19	rcore 30 LTO-4 9 L R M 8L-FM0	3	<b>Superco</b> E308LT T 19 9 I TS308L TÜV	L P M 2	P		
ASME IX Qualification	QW43	<b>32</b> F-No	6, <b>QW</b>	<b>442</b> A-N	lo 8						
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN
(weld metal wt %)	min		0.5	0.2			18.5	9.0			3
	max	0.04	2.0	1.0	0.025	0.030	20.5	11.0	0.3	0.3	12
	typ	0.03	1.3	0.7	0.02	0.02	19.5	10	0.1	0.1	8
All-weld mechanical	As we	lded					min	typ	ical		
properties	Tensile	e strength	ı		М	Pa	520	5	60		
		Proof stre			Μ	Pa	320		00		
	-	ation on 4				%	35		3		
	Elongation on 5d					%	30		2		
		tion of ar	ea			%			50		
	Impact	t energy		+ 20°C		J			80		
	Hardn	ess		-110°C	F	J IV			10 00		
Operating parameters	Super	core 308	<b>L</b> is also	suitable s as below amp-vo 120 - 2 120 - 2	for use v for Ar-2	with $100\%$ 20% CO <sub>2</sub> -35V -32V	% CO <sub>2</sub> . (Superco	-	with 100 BV 6V	0%CO <sub>2</sub> 1 	gon should not exceed 85 requires approx 3V highe tickout 5 – 20mm 5 – 20mm 5 – 25mm
Packaging data	Spools (1.6m) The as Resist possib	m) and S s-packed ance to n pility of p	upercore shelf life noisture orosity,	n barrier f 308LP – e is virtual	oil with 15kg. ly indefi n is high ed that p	cardboar nite. , but to n art-used	d carton: naintain t spools ar	Superco he high i e returne	re 308L ntegrity d to poly	(1.2mm) of the w	) – 12.5kg; Supercore 30 vire surface and prevent a
Fume data		composit	•	U U				,			
			Fe	Mn	Ni	Cr	<sup>3</sup> C	r <sup>6</sup>	Cu	F	OES (mg/m <sup>3</sup> )
	1										



# **Stainless Steels**

# **347 STAINLESS STEEL**

## Alloy type

347 austenitic stainless steel for joining 321 and 347 base materials.

## Materials to be welded

ASTM-ASME
321
347
CF8C (cast)

**BS EN & DIN** 1.4541 1.4543/1.4561/1.4550 1.4552 (cast)

**BS** 321S31 347S31 347C17 (cast) **UNS** S32100 S34700

## Applications

Used to weld titanium and niobium stabilised 18/8 stainless steel types 321 and 347. Also suitable for unstabilised grades such as 304/304L. Service temperatures are typically -100°C to about 400°C.

Applications are similar to 308L (B-30) and include food, brewery, pharmaceutical equipment, architectural and general fabrication, and nuclear engineering.

The 347 consumables covered here are generally not suitable for service in elevated temperature structural applications where 0.04-0.08% carbon is specified for creep resistance, see data sheets C-11 and C-12.

For cryogenic applications requiring >0.38mm (15mils) charpy lateral expansion at -196°C, use unstabilised weld metal with low carbon and controlled ferrite (B-30).

## DATA SHEET B-31

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## Microstructure

Austenite with a controlled level of ferrite, normally in the range 3-12FN.

## Welding guidelines

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

## Additional information

There is a Technical Profile available on sub-arc welding with 347S96. There is also additional information available covering the Supercore flux cored wires.

## **Related alloy groups**

The 308L consumables cover many of the same base materials and applications (B-30). For elevated temperature applications 347H consumables should be used (C-11).

Process	Product	Specification
MMA	Ultramet 347	AWS E347-16
	Ultramet B347	AWS E347-15
TIG/MIG/SAW	347896	AWS ER347
SAW flux	SSB	BS EN SA AF2
FCW	Supercore 347	AWS E347T0-4

## **Products available**



# General Data for all 347 MMA Electrodes

Storage	for longer than a moisture pick-up For electrodes tha <b>Redry</b> 200 – 300 <b>Storage</b> of redrie	working and incre at have be °C/1-2h to d electroo	shift of ase the en exp o restor les at 5	f 8h. Exc risk of po osed: re to as-pa $60 - 200^{\circ}$	essive exp prosity. acked cond C in holdin	dition. Max	ectrodes to kimum 400 heated qui	life. Direct use from tin is satisfactory o humid conditions will cause some 0° C, 3 cycles, 10h total. ver: no limit, but maximum 6 weeks using plastic lid): < 60% RH, > 18°C.	
Fume data	Fume compositio	n, wt % t <u>y</u>	ypical:						
	F	e I	Иn	Ni	Cr	Cu	F *	OES (mg/m <sup>3</sup> )	
	8	3	5	0.8	5	< 0.2	16	1	
	* F=28% for basic coated Ultramet B347 but this does not affect the OES.								

<b>ULTRAMET 3</b>	47					A	ll-posit	ional ru	itile MN	/A ele	ctrode	for 32	1/347
Product description		ed rutile		l 347 electesign, incl									
	Recove	ery is abo	ut 110%	6 with resp	pect to co	ore wire,	65% with	n respect	to whole	electrod	e.		
Specifications	AWS BS EN BS 29 DIN 85	1600 26		19.9.N	Nb R32								
ASME IX Qualification	QW43	2 F-No :	5, <b>QW</b>	<b>442</b> A-N	o 8								
Composition (weld metal wt %)	min max typ	C  0.04 0.02	Mn 0.5 2.0 0.7	Si  0.9 0.7	S  0.025 0.01	P  0.030 0.02	Cr 18.0 21.0 19	Ni 9.0 11.0 9.5	Mo  0.50 0.05	Nb 10xC 1.00 0.4	Cu  0.50 0.07	FN 4 12 6	
All-weld mechanical	As weld		0.7	0.7	0.01	0.02	min	typic		0.1	0.07	0	
properties	Tensile 0.2% P Elonga Elonga Reduct	strength roof stres tion on 4c tion on 5c ion of are energy	1	+ 20°C -196°C -196°C			560 350 30 25   	650 500 40 37 52 70 20 53	0 0 ) ? )	50°C + V	VO)		
Operating parameters	DC +ve	e or AC (	OCV: 5									Ê	Û
	ø mm			2.5		3.2		4.0		5.0			
	min A max A			60 90		75 120		100 155		130 210			
Packaging data	ø mm			2.5		3.2		4.0		5.0			
	length i kg/carte pieces/	on		300 11.4 660		350 13.5 399		350 13.5 261		450 16.5 159			



ULTRAMET B	347				Ba	asic pipe	-weld	ing eleo	ctrode	for 32	1/347
Product description	MMA electrode wi resistance and hene fixed pipework qua conditions. Comp slag does not self-l Recovery is about	ce freedom fro alified in the A ared with rutile ift, it is easily r	m weld po SME 5G/ e types, the removed a	orosity. 6G posite basic f nd gives	The election and lux give welds	ctrode is pa l is tolerant es a more co of exceptio	articular to adve onvex fi nal appe	ly suited erse wind llet bead earance a	to positi and drau profile a nd qualit	onal wel ughts un nd altho	lding of Ider site
Specifications	AWS A5.4 BS EN 1600 BS 2926 DIN 8556	19.9.1	9 Nb B 42								
ASME IX Qualification	QW432 F-No 5,	QW442 A-N	lo 8								
Composition (weld metal wt %)		Mn         Si           0.5            2.0         0.9           1.2         0.3	S  0.025 0.01	P  0.030 0.02	Cr 18.0 21.0 19	Ni 9.0 11.0 9.5	Mo  0.50 0.05	Nb 10xC 1.00 0.5	Cu  0.50 0.07	FN 4 12 6	
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Impact energy	- 50°C	MP: MP: % %	a 5 a 3 ó 5	nin 60 50 30 25 	typical 650 500 40 37 52 90					
Operating parameters	DC +ve ø mm min A max A	2.5 60 90		3.2 75 120		4.0 100 155	Ų	5.0 130 210		Î	Û
Packaging data	ø mm length mm kg/carton pieces/carton * 350mm is the star	2.5 300 12.0 669 ndard length, 4		3.2 350 13.5 396 vailable	to order	4.0* 350/450 13.5/17.4 258/267		5.0 450 17.4 162			

## 347S96

## Solid welding wire for TIG, MIG & SAW of 321/347

Product description	Solid w	ire for TIG	, MIG	and SAW								
Specifications		ISO 1434 ISO 1434		ER347 19 9 Nb SS347 SG X5C	rNiNb 19	9 (1.455	1)	BS 29	901: PT	<b>2</b> 347	S96	
ASME IX Qualification	QW432	<b>2</b> F-No 6,	QW4	42 A-No	8							
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	Cu	FN
(wire wt %)	min		1.0	0.30			19.0	9.0		10xC		4
	max	0.08	2.5	0.65	0.020	0.030	21.0	11.0	0.3	1.0	0.3	12
	typ	< 0.04	1.5	0.4	0.005	0.02	19.5	9.7	0.2	0.6	0.1	8
All-weld mechanical	Typical	values as v	velded			TIC	G					
properties	Tensile	strength			MPa	66	0					
	0.2% Pr	oof stress			MPa	45	0					
	Elongat	ion on 4d			%	42	2					
	Elongat	ion on 5d			%	40	)					
	Impact e	energy		- 50°C	J	15	0					
				- 196°C	J	35	5					
	Hardnes	ss cap/mid			HV	220/2	240					



## 347S96 (continued)

Typical operating		TIG		MIG	3	SA	W	
parameters	Shielding	Argon *		Ar+2%O <sub>2</sub> **		SSB ***		
•	Current	DC-		DC	+	D	C+	
	Diameter	2.4mm		1.2		2.4	mm	
	Parameters	100A, 12V	7	260A,	26V	350A	, 28V	
	-	red as a purge fo			201 00			
	1 1	rietary Ar and Ar compensating) al			<3%CO <sub>22</sub> .			
Packaging data	ø mm	TIG		MIG	3	SA	Ŵ	
	1.0			15kg sj	pool	-	-	
	1.2			15kg sj	pool	-	-	
	1.6	2.5kg tube	;			25kg	g coil	
	2.0	To order				-	-	
	2.4	2.5kg tube	•			25kg	g coil	
	3.2	2.5kg tube	•			25kg	g coil	
Fume data	MIG fume compos	sition (wt %) (TI	G and SA	W fume r	negligible)			
	Fe	e Mn	Cr <sup>3</sup>	Ni	Мо	Cu	OES (mg/m <sup>3</sup> )	
	32	. 12	16	8	<0.5	< 0.5	3.1	

## **SUPERCORE 347**

## Downhand rutile flux cored wire for 321/347

Product description	operab		1 deposi	t quality a								47 combines eas Metal recovery i
Specifications		A5.22 N ISO 17 N ISO 17			T0-4 9 Nb R N 7-FM0	<i>I</i> 3						
ASME IX Qualification	QW43	32 F-No	6, <b>QW</b>	<b>/442</b> A-N	lo 8							
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	Cu	FN
(weld metal wt %)	min		0.5				18.0	9.0		8xC		4
	max	0.08	2.0	1.0	0.025	0.030	21.0	11.0	0.3	1.0	0.3	12
	typ	0.03	1.2	0.4	0.01	0.02	19	10.5	0.1	0.5	0.1	8
All-weld mechanical	As wel	ded					min	typica	1			
properties	Tensile	e strength			M	IPa	550	600				
	0.2% F	Proof stres	SS		Ν	IPa	350	435				
	Elonga	ation on 4	d			%	30	47				
	Elonga	ation on 5	d			%	25	42				
	Reduc	tion of are	ea			%		50				
	Impact	energy		+ 20°C		J		90				
Operating parameters												d not exceed 859
	-								-	•	e and inci	eased spatter.
	Currer	nt: DC+v	e range	s as belov	v (for 10	0%CO <sub>2</sub> i	ncrease v	oltage by	2-3V):			
	ø mm			amp-vo	lt range			typical		S	tickout	
	1.2			120-28	0A, 22-3	34V		180A, 26	V	1	5-20mm	
Packaging data	The as Resista possib	-packed s ance to m ility of po	shelf life oisture prosity,	it is advis	lly indef n is high ed that p	inite. , but to r part-used	naintain t spools a	U U	l to pol			e and prevent an
Fume data	Fume	composit	ion (wt Fe	%) Mn	Ni	Cr	<sup>3</sup> C	Cr <sup>6</sup> C	Cu	F	OES (m	g/m³)
											, ,	



# **Stainless Steels**

## **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 ( $-196^{\circ}$ 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.

## DATA SHEET B-32

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## **Additional information**

There are Technical Profiles available on Superoot 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	316892	AWS ER316L
MIG	Supermig 316LSi	AWS ER316LSi
SAW	316892	AWS ER316L
	SSB	BS EN SA AF2
	LA491	BS EN SA FB255
	L2N	BS EN SF CS 2
FCW	Supercore 316L	AWS E316LT0-4
	Supercore 316LP	AWS E316LT1-4
	Superoot 316L	AWS R316LT1-5



# General Data for all 316L MMA Electrodes

Storage	for longer th moisture pic For electrod <b>Redry</b> 200 - <b>Storage</b> of r	han a worl k-up and the es that hav - 300°C/1 redried ele	king shift increase the ve been ex -2h to rest ectrodes at	of 8h. Ex e risk of p posed: ore to as-p 50 – 200°	cessive exporosity. packed cor C in hold	posure of ndition. N	electrodes Aaximum 40 or heated qu	to humio 00° C, 3 aiver: no	rect use from tin is satisfa d conditions will cause cycles, 10h total. limit, but maximum 6 v lastic lid): < 60% RH, >						
Fume data	Fume compo	Fume composition, wt % typical:													
		Fe	Mn	Cr	Ni	Мо	Cu	F *	OES (mg/m <sup>3</sup> )						
		8	7	5	1	0.5	< 0.2	16	1						
	* F=28% fo	Ŭ	7 ated Ultra	U	1 L but this		=		16						

SUPERMET 3	16L						Ge	eneral (	ourpos	e rutil	e 316L	MMA	electrode
Product description	'Low h gives a Desigr downh	ydroger acid rutil aed for and and	' manu e opera ease of HV p	facturin ability co f use, ex ositions	g technol ombined ceptiona ; smaller	logy ensur with cont	res high r rolled sil ad appe r all-pos	resistance icon con arance a itional op	e to weld tent for n nd high perability	metal p naximur weld m y.	orosity. " n crackin etal integ	Superm g/corros	l carbon level. et Technology' sion resistance. imarily in the
Specifications	AWS BS EN BS 29 DIN 8	N 1600 926		E 1	316L-17 19 12 3 9.12.3.L. 19 12 3	LR 32 AR							
ASME IX Qualification	QW43	<b>32</b> F-No	5, <b>Q</b>	W442	A-No 8								
Composition (weld metal wt %)	min max typ * DIN	C  0.04 0.02 & BS I	Mn 0.5 2.0 0.8 EN req	Si  0.90 0.6 uire Mo	S  0.025 0.01 2.5 - 3.0	P  0.030 0.02 0%.	Cr 17.0 20.0 19	Ni 11.0 13.0 12	Mo* 2.0 3.0 2.7	Cu  0.5 0.1	FN 3 10 6		
All-weld mechanical properties	0.2% F Elonga Elonga Reduc Impact	e strengt Proof stre ation on a tion of a c energy	ess 4d 5d rea *	-19	0°C 6°C welded c	MPa MPa % % J J J	min 520 320 30 25    applicatio		rpical 600 480 42 39 60 70  96°C		1050	°C + W 550 320 52 49 52  35	Q
Operating parameters	ø mm	e or AC	(OCV	7: 50V n 1.6	nin)	2.0		2.5		.2	4.0	-	€Ê Ê.0
	min A max A			25 45		50 70		60 90		75 20	10 15		130 210
Packaging data	ø mm length kg/cart pieces			1.6 250 8.7 1344		2.0 300 10.5 846		2.5 300 11.4 603	3. 12	50 2.6 39	4.0 45 17 24	0 4	5.0 450 16.8 159



ULTRAMET 3	16L					All-po	ositional r	utile N	/IMA e	lectro	de foi	r 316L
Product description	MMA electrode – an advanced rutile and weld metal in	e flux d	esign – thi	is include	s optir	num versat	ility for dow	nhand w	elding v	vith high	cosmet	tic finish
	Recovery is about	t 110%	with resp	ect to con	e wire	, 65% with	respect to v	whole el	ectrode.			
Specifications	AWS A5.4 BS EN 1600 BS 2926 DIN 8556 Approvals		19.12.3.	3 L R 3 2 LR 3 L R 2 3		yd, LRS						
ASME IX Qualification	QW432 F-No 5,	QW4	442 A-No	o 8								
Composition (weld metal wt %)	C           min            max         0.04           typ         <0.03           * DIN & BS EN	Mn 0.5 2.0 1 require	Si  0.90 0.6 e Mo 2.5 -	S  0.025 0.01 - 3.0%.	P  0.03 0.0			Mo* 2.0 3.0 2.6	Cu  0.5 <0.1	FN 3 10 6		
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Impact energy * Hardness * See data sheet E	-	- 20°C 100°C 196°C r as-welde	M	Pa Pa % % J J J HV	min 520 320 30 25      blications a	typical 580 480 43 41 65 70 40  230 at -196°C.		5	C + WQ 40 52 50 58  40 85		
Operating parameters	DC +ve or AC (O ø mm min A max A	CV: 50	0V min) 2.5 60 90		3.2 75 120		4.0 100 155		5.0 130 210		Î	Û
Packaging data	ø mm length mm kg/carton pieces/carton		2.5 300 11.4 618	3	3.2 350 2.9 393		4.0 350 13.5 261		5.0 450 16.5 159			

## **ULTRAMET B316L**

## Basic coated MMA pipe-welding electrode for 316L

Product description	purity 304L core w	esigned and manufactured to give high moisture resistance using a basic flux system and high ire. <b>Ultramet B316L</b> is particularly suited to the most demanding vertical and overhead s including fixed pipework in the ASME 5G/6G position. Under site conditions it is tolerant to rafts.
	Recovery is about 1	10% with respect to core wire, 65% with respect to whole electrode.
Specifications	AWS A5.4 BS EN 1600 BS 2926 DIN 8556	E316L-15 E 19 12 3 L B 4 2 19.12.3.LB E 19 12 3 L B 20+
ASME IX Qualification	QW432 F-No 5,	QW442 A-No 8



# ULTRAMET B316L (continued)

		•		/								
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN	
(weld metal wt %)	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	As weld	ded					min	typical				
properties	Tensile	strength			М	Pa	520	600				
	0.2% P	roof stress	5		М	Pa	320	470				
	Elonga	tion on 4d				%	30	37				
	Elonga	tion on 5d				%	25	33				
	Reduct	ion of area	ı			%		50				
	Impact	energy *	-	50°C		J		80				
			-	196°C		J		45				
		expansion		196°C		ım	0.38	0.5				
	* See d	lata sheet l	B-38 fo	r as-welde	ed cryogei	nic appli	cations at	−196°C.				
Operating parameters	DC +ve	e only.							U			Ê Î
	ø mm			2.5	3	3.2		4.0		5.0		
	min A			60	,	75		100		130		
	max A			90	1	20		155		210		
Packaging data	ø mm			2.5	3	3.2		4.0		5.0		
	length r	mm		300	3	50		350		450		
	kg/carte			12.0	1	3.5	1	13.5	1	16.5		
	pieces/	carton		681	3	96		261		159		

## **ULTRAMET 316LP**

All-positional pipe welding and root welding electrode

Product description	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. Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.												
Specifications	AWS BS EN	A5.4 N 1600			316L-16 19 12 3 I								
ASME IX Qualification	QW43	<b>32</b> F-No	5, <b>Q</b>	W442	A-No 8								
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN		
(weld metal wt %)	min		0.5				17.0	11.0	2.0		3		
	max	0.04	2.5	0.90	0.025	0.03	0 20.0	13.0	3.0	0.5	10		
	typ	0.02	0.8	0.8	0.01	0.02	2 19	12	2.7	0.1	6		
All-weld mechanical	As wel	ded					min	ty	pical				
properties	Tensile	e strengtl	า			MPa	520		600				
	0.2% F	Proof stre	SS			MPa	320		485				
	Elonga	ation on 4	ld			%	30		37				
	Elonga	ation on 5	id			%	25		35				
	Reduc	tion of ar	ea			%			35				
Operating parameters	DC +v	e or AC	(OCV:	50V m	in)				Û			Î	÷
	ø mm				2.0		2.5	3.	2				
	min A				50		60	7	5				
	max A				70		90	12	20				
Packaging data	ø mm				2.0		2.5	3.	2				
	length	mm			300		300	35	50				
	kg/cart	on			11.7		12.3	14	.4				
	pieces	/carton			1089		747	45	59				



Solid 316L wire

## 316S92 and SUPERMIG 316LSi

Product description	Solid	wires for '	TIG, M	IG and su	ib-arc we	elding.								
Specifications	BS EI	N ISO 14 N ISO 14 001: Pt2 556		ER31 19 12 SS31 316S SG X (1.44	2 3 L 6L 92 X2CrNiM		EF G SS 31 SC (1	R316L S 19 12 3 3316L S 6S93	L Si i NiMo 19 1		W=TIG, G	=MIG, S=SAW		
ASME IX Qualification	QW432 F-No 6, QW442 A-No 8													
Composition (wire wt %)	min max typ * Su	C  0.03 0.01 permig 3	Mn 1.0 2.0 1.4 <b>316LSi</b> :	Si * 0.30 0.65 0.5 Si range	S  0.020 0.01 is 0.65 -	P  0.030 0.015 - 1.0%, t	Cr 18.0 20.0 18.5 ypically (	Ni 11.0 14.0 12.8 0.85%.	Mo 2.5 3.0 2.6	Cu  0.3 0.15	FN 3 10 6			
All-weld mechanical properties	0.2% F Elonga Elonga Impact	e strength Proof stres ation on 40 ation on 50 c energy *	ss d d nid	-130°C -196°C or as-wel		MPa 5 MPa 3 % 3 % 1 J J HV yogenic applicat		s at -196	TIG 605 465 35 33 > 100 > 60 200/220 5°C.		typical MIG 570 435 42 40 > 70 30-60 200/220	SAW + SSB 570 450 41 37 > 45 30 195/215		
Typical operating parameters		it ter			n 2V He gas n	26 nixtures v			SAW SSB DC 2.4m 350A,	** + 1m				
Packaging data	Ø mm         TIG           Ø mm         316S92           0.8         To order           1.0         2.5kg tub           1.2         2.5kg tub           2.6         2.5kg tub           2.0         2.5kg tub           2.4         2.5kg tub           3.2         2.5kg tub				Sı	MIG permig 3 15kg re 15kg re 15kg re   	eel eel		SAW 316S9:    25kg co 25kg co	pil				
Fume data				Mn (wt %) (	TIG and Cr <sup>3</sup>	SAW fu N	i N	Mo Cu OES		(mg/m <sup>3</sup> ) 3.3				



#### SUPERCORE 316L, 316LP Rutile flux cored wires **Product description** 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. 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. **Specifications &** Supercore 316L Supercore 316LP Approvals **AWS A5.22** E316LT0-4 E316LT1-4 **BS EN ISO 17633-A** T 19 12 3 L R M 3 T 19 12 3 L P M 2 **BS EN ISO 17633-B** TS316L-FM0 TS316L-FM1 TÜV, Germanischer Lloyd TÜV, Germanischer Lloyd Approvals (1.2 & 1.6mm) **ASME IX Qualification** QW432 F-No 6, QW442 A-No 8 Composition С Mn Si S Ρ Cr Ni Мо Cu FN min 0.5 0.2 17.0 11.0 2.5 3 (weld metal wt %) -------max 0.04 2.0 1.0 0.025 0.030 20.0 13.0 3.0 0.3 12 0.03 1.3 0.5 0.02 0.02 12 2.7 0.1 8 typ 19 \* 0.9mm diameter Supercore 316L is typically 2.3% Mo and does not conform to BS EN ISO 17633-A. As welded min typical All-weld mechanical properties 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 --- $+20^{\circ}C$ 70 Impact energy J \_\_\_ -110°C J 40 \_\_\_ Hardness cap/mid HV 200/210 --Shielding gas: 80% Ar-20% CO<sub>2</sub> at 20-251/min. Proprietary gases may be used but argon should not exceed 85%. **Operating parameters** Supercore 316L is also suitable for use with 100% CO<sub>2</sub>. **Current:** DC+ve ranges as below for Ar-20%CO<sub>2</sub> (Supercore 316L with 100%CO<sub>2</sub> requires approx 3V higher): amp-volt range typical stickout ø mm 0.9 (Supercore 316L only) 75 - 170A, 20 - 30V 15 - 20mm120A, 26V 1.2 120 - 280A, 21 - 35V 180A, 28V 15 - 20mm1.2P 15 - 20 mm120 - 250A, 20 - 32V160A, 26V 1.6 200 - 350A, 26 - 36V 250A, 30V 15 – 25mm Packaging data Spools vacuum-sealed in barrier foil with cardboard carton: Supercore 316L (0.9mm & 1.2mm) - 12.5kg; Supercore 316L (1.6mm) and Supercore 316LP – 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 %) Fe Mn Ni Cr<sup>3</sup> Cr<sup>6</sup> Cu F OES (mg/m<sup>3</sup>) 4 5 14 12 2.5 4 < 1 1.2



Product description	Flux cored TIG wire <b>Superoot 316L</b> is made with a seamless austenitic stainless steel sheath, which results in robust moisture resistant wire and rutile flux system. Superoot 316L is designed specifically for situations where 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.													
	Metal	Metal recovery is 90% with respect to the whole wire.  AWS A5.22 R316LT1-5												
Specifications		A5.22 N ISO 17	'633-B		6LT1-5 6L-RI1									
ASME IX Qualification	QW43	32 F-No												
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu				
(weld metal wt %)	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				
	Typica	ally 5FN.												
All-weld mechanical	As wel	lded					typical							
properties		e strength			М	Pa	605							
		Proof stres			М	Pa	450							
	-	ation on 4				%	38							
	Note:	In practi	ce, mech	nanical pi	operties	of the roo	ot bead are	assessed	d with th	ne whole joint and sub	sequent fille			
Typical operating				TIG										
parameters	Shield	-		Argon	*									
	Currer			DC-										
	Diame			2.2mm										
	Voltag	e back-purg	 is roa	90A, 12	2 V									
					root 3161	. require	s the use o	of a kevł	nole we	lding technique. Furt	her details a			
		ble on req		oroupe	1000010101	Brequire	s the use (	or a negr		ang teeninque. Turt				
Packaging data	ø mm			TIG										
	2.2			1kg tul	be									
Fume data	Fume	composit	ion (wt	%)										
i unio uutu														
			Fe	Mn	Ni	Cr <sup>3</sup>	Cu	ı	F	OES (mg/m <sup>3</sup> )				



**B-33** 

# **Stainless Steels**

## **NON-MAGNETIC 316L**

## Alloy type

Nil-ferrite, modified 316L alloy for non-magnetic, cryogenic and nitric acid applications.

## Materials to be welded

For type 316L and similar parent materials where ferrite-free and non-magnetic weld metal is required; also suitable for 304/304L and 316/316L for cryogenic service.

May be suitable for welding 200 series stainless steels, eg. UNS S20910 (XM-19), Nitronic 50 (Armco) and other nitrogen strengthened stainless steels.

## **Applications**

The high nickel and nitrogen levels provide a fully austenitic and non-magnetic weld deposit with maximum magnetic permeability of 1.01. A typical tensile strength above 600MPa is also achieved by means of the controlled level of nitrogen. A high manganese content ensures freedom from microfissuring in the ferrite-free weld metal.

Applications exploiting non-magnetic properties include welding of 316L fittings for minesweepers and offshore downhole instrumentation collars.

The fully austenitic microstructure gives excellent strength and toughness at cryogenic temperatures for joining 304L and 316L LPG and LNG storage vessels. Useful toughness is also maintained down to liquid helium temperatures -269°C (4°K) for superconducting Impact testing procedures at this applications. temperature are complex and expensive, with results of questionable validity. To qualify the toughness of weld metal for service at 4°K, the ASME Code Committee has proposed >0.53mm (21mils) at  $-196^{\circ}C$  (77°K). This proposal is based on correlations between fracture toughness and Charpy data at these temperatures.

Unlike conventional 316L weld metal containing ferrite, which suffers preferential attack in concentrated nitric acid, the nil-ferrite alloy has excellent resistance and is suitable for deposition directly onto CMn steel to provide corrosion resistant overlays.

DATA SHEET

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## **Microstructure**

Fully austenitic.

## Welding guidelines

No preheat required, and maximum interpass temperature 150°C.

## Additional information

ASTM A262 practice C (Huey) corrosion test (immersion in boiling, 65%, nitric acid for five 48 hour periods): typical corrosion rates are 0.7–1.2µm/48hr (0.13-0.22mm/year). Stamicarbon requirement is 3.3µm/48hr.

## **Related alloy groups**

The 310L and 904L alloys may also be useful for low magnetic permeability applications.

## **Products available**

Process	Product	Specification
MMA	Ultramet 316NF	BS EN E 1815 3 L R
	Ultramet B316NF	BS EN E 1815 3 L B
TIG/MIG	ER316MnNF	BS EN 20 16 3 Mn L
FCW	Supercore 316NF	(BS EN T 18 16 5 N L R)

Rev 03 03/07



## **General Data for all MMA Electrodes**

Storage	for longer than a work moisture pick-up and For electrodes that hav <b>Redry</b> 200 – 300°C/1 <b>Storage</b> of redried ele	cing shift c increase the ve been exp -2h to resto ctrodes at	of 8h. Exc e risk of po posed: ore to as-pa 50 – 200°	essive exp prosity. acked cond C in holdin	dition. Max	ectrodes t kimum 400 heated qui	life. Direct use from tin is o humid conditions will 0° C, 3 cycles, 10h total. ver: no limit, but maxim using plastic lid): < 60%	cause some
Fume data	Fume composition, wt	% typical:	:					
	Fe	Mn	Ni	Cr	Cu	F *	OES (mg/m <sup>3</sup> )	
	8	10	1.5	5	< 0.2	16	1	
	* F=28% for basic coa	ted Ultram	net B316N	F but this	does not aff	fect OES.		

ULTRAMET 3	16NF						A	I-positio	onal ruti	le MM/	A electrode	
Product description	Rutile (low silica) content ensures fr					e. Specia	l contro	ol of residu	als couple	d with a h	igh manganese	
	Recovery is about	120% v	with res	pect to c	ore wire,	65% with	respec	t to whole	e electrode			
Specifications	BS EN 1600         E 18 15 3 L R 3 2           BS 2926         18.15.3.LMnR           DIN 8556         E 18 15 3 L R 23           AWS A5.4         (E316LMn-16)         Nearest classification											
ASME IX Qualification	QW432 F-No -, QW442 A-No -											
Composition (weld metal wt %)	Cminmax0.04typ< 0.03Maximum magnet	Mn 2.5 4.0 3.0 tic perm	Si  0.9 0.4 eability	S  0.025 0.01 1.01.	P  0.030 0.02	Cr 16.5 19.5 18	Ni 14.0 17.0 16	Mo 2.5 3.5 2.8	Cu  0.5 < 0.1	N 0.1 0.2 0.15		
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Impact energy Lateral expansion * Useful impac recommendati	t prope	- 196°C - 196°C rties ar	2* m	MPa MPa % % J m (mils) iined dow	min 560  30    vn to 4°I		typical 610 430 38 35 54 60 0.7mm $\Theta^{\circ}$ C) and	(28mils) exceeds		ASME Code	
Operating parameters	DC +ve or AC (O ø mm min A max A		V min) 2.5 60 90		3.2 75 120		4.0 100 155	U	5.0 130 210		Ê	
Packaging data	ø mm length mm kg/carton pieces/carton	1	2.5 300 13.5 684		3.2 350 15.0 402		4.0 350 15.0 267		5.0 350 16.5 189			



ULTRAMET B	316N	IF				Bas	sic all-p	ositio	onal MN	MA pipe	e welding electrode
Product description		carbonate-fl nese to ensu					core wire	e. Spec	ial contro	ol of resid	uals coupled with a high
	Recove	ery is about	120%	with res	pect to c	ore wire,	65% with	respec	t to whol	le electrod	le.
Specifications	BS EN BS 29 DIN 8 AWS	26 556		18.15 E 18	15 3 L B 5.3.LMnF 15 3 L B 5LMn-15	3 20+	earest clas	ssificat	ion		
ASME IX Qualification	QW43	<b>2</b> F-No -,	QW4	<b>42</b> A-N	0 -						
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	Ν
(weld metal wt %)	min		2.5				16.5	14.0	2.5		0.1
	max	0.04	4.0	0.9	0.025	0.030	19.5	17.0	3.5	0.5	0.2
	typ Maxim	< 0.03 um magnet	3.5 ic pern	0.4 neability	0.01 7 1.01.	0.02	18	16	2.8	< 0.1	0.15
All-weld mechanical	As weld	ded					min		typical		
properties	Tensile	strength				MPa	560		610		
	0.2% P	roof stress				MPa	300		440		
	-	tion on 4d				%			38		
	-	tion on 5d				%	30		35		
		ion of area		10.000	<b>N</b>	%			50		
	Impact	0,		- 196°C		J			50	(041	<b>`</b>
		expansion		- 196°C		m (mils) inad dawr		26000	0.6	(24mils	s) posed ASME Code
		ecommenda		erties af	e mainta	med down	1104 K (	-209 (	) and ex	ceeds proj	posed ASME Code
Operating parameters	DC +ve	e									
	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 i			300		350		350			
	kg/carte			12.0		13.5		13.5			
	pieces/	carton		678		393		252			



ER31	<b>6M</b>	nNF
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## Non-magnetic solid wire for TIG and MIG

Product description	Solid wire for TIG and MIG.											
pecifications AWS A5.9 BS EN ISO 14343- DIN 8556				ER316LMn 3-A 20 16 3 Mn L SG-X2CrNiMnMoN 20 16 (1.4455)								
ASME IX Qualification	QW432 F-No - QW442 A-No -											
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	Ν	
(wire wt %)	min		6.0	0.30			19.0	15.0	2.5		0.12	
. ,	max	0.025	8.0	0.65	0.02	0.030	21.0	18.0	3.5	0.3	0.20	
	typ	0.02	7	0.5	0.01	0.02	20	16	3	0.15	0.15	
	Maximum magnetic permeability 1.01.											
All-weld mechanical	Typica	l values a	s welde	d			TIG					
properties	Tensile	e strength				MPa	732					
		Proof stres				MPa	527					
	Elonga	ation on 40	k			%	39					
	0	ation on 50				%	34					
	Reduc	tion of are	a			%	68					
		energy		- 100°C		J	140					
		energy		- 196°C		J	95					
		l expansio		- 196°C	* mn	ı (mils)	1.0 (40)					
	Hardne	ess cap/m	Id			HV	175/220					
		Useful im recommer		operties are	maintaiı	ned down	to 4°K (-2	269°C) an	d excee	ds propos	ed ASME Code	
Typical operating				perties are	maintaiı		to 4°K (-2	269°C) an	d excee	ds propos	ed ASME Code	
		ecommer		-	maintaiı	M Ar+2	IG %O <sub>2</sub> *	269°C) an	d excee	ds propos	ed ASME Code	
	1	recommer		TIG	maintaiı	M Ar+2	IG	269°C) an	d excee	ds propos	ed ASME Code	
	r Shieldi	recommer ing it		TIG Argon	maintain	M Ar+2 D	IG %O <sub>2</sub> *	269°C) an	d excee	ds propos	ed ASME Code	
	Shieldi Curren	recommer ing nt ter		TIG Argon DC-		M Ar+2 D	IG %O <sub>2</sub> * C+ mm	269°C) an	d excee	ds propos	ed ASME Code	
	Shieldi Curren Diame Param	recommer ing it ter eters	idation.	TIG Argon DC- 2.4mm	V	M Ar+2 D 1.2 260A	IG %O <sub>2</sub> * C+ mm ., 26V		d excee	ds propos	ed ASME Code	
parameters	Shieldi Curren Diame Param	recommer ing it ter eters	idation.	TIG Argon DC- 2.4mm 100A, 12V	V	M Ar+2' D0 1.2 260A vith <3%0	IG %O <sub>2</sub> * C+ mm ., 26V		d excee	ds propos	ed ASME Code	
parameters	Shieldi Curren Diame Param * Prop	recommer ing it ter eters	idation.	TIG Argon DC- 2.4mm 100A, 12V r-He gas m	V	M Ar+2' D0 1.2 260A vith <3%0 M	IG $\%O_2 *$ C+ mm , 26V CO <sub>2</sub> also su		d excee	ds propos	ed ASME Code	
parameters	Shieldi Curren Diame Param * Prop ø mm	recommer ing it ter eters	idation.	TIG Argon DC- 2.4mm 100A, 12 <sup>v</sup> r-He gas m TIG	V	M Ar+2' D0 1.2 260A vith <3%0 M 15kg	IG $%O_2 *$ C+ mm , 26V CO <sub>2</sub> also so IG spool		d excee	ds propos	ed ASME Code	
parameters	Shieldi Curren Diame Param * Prop ø mm 1.0	recommer ing it ter eters	idation.	TIG Argon DC- 2.4mm 100A, 12 <sup>v</sup> r-He gas m TIG	√ ixtures v	M Ar+2' D0 1.2 260A vith <3%0 M 15kg	IG %O <sub>2</sub> * C+ mm , 26V CO <sub>2</sub> also su IG spool spool		d excee	ds propos	ed ASME Code	
parameters	Shieldi Curren Diame Param * Prop ø mm 1.0 1.2	recommer ing it ter eters	idation.	TIG Argon DC- 2.4mm 100A, 12 <sup>v</sup> r-He gas m TIG	√ ixtures v e	M Ar+2 D0 1.2 260A vith <3%0 M 15kg 15kg	IG %O <sub>2</sub> * C+ mm , 26V CO <sub>2</sub> also su IG spool spool		d excee	ds propos	ed ASME Code	
parameters Packaging data	Shieldi Curren Diame Param * Prop ø mm 1.0 1.2 1.6 2.4	recommer ing it ter eters prietary A	r and A	TIG Argon DC- 2.4mm 100A, 12 <sup>v</sup> r-He gas m TIG  2.5kg tub	√ ixtures v e e	M Ar+2' D0 1.2 260A vith <3% M 15kg 15kg	IG %O <sub>2</sub> * C+ mm , 26V CO <sub>2</sub> also su IG spool spool 		d excee	ds propos	ed ASME Code	
Typical operating parameters Packaging data Fume data	Shieldi Curren Diame Param * Prop ø mm 1.0 1.2 1.6 2.4	recommer ing it ter eters prietary A	r and A	TIG Argon DC- 2.4mm 100A, 12 r-He gas m TIG  2.5kg tub 2.5kg tub	√ ixtures v e e	M Ar+2' D0 1.2 260A vith <3% M 15kg 15kg	IG %O <sub>2</sub> * C+ mm , 26V CO <sub>2</sub> also su IG spool spool 			ds propos		



SUPERCORE	316I	NF									Rutile flux cored wire	
Product description	Flux cored wire made with an austenitic stainless steel sheath and rutile flux system designed primarily for downhand welding.											
	Metal	Metal recovery is about 90% with respect to the wire.										
Specifications	AWS A5.22(E316LT0-4) nearest equivalentBS EN ISO 17633-A(T 18 16 5 NL R M 3) nearest equivalentApprovalTÜV											
ASME IX Qualification	QW432 F-No -, QW442 A-No -											
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Ν		
(weld metal wt %)	min		2.0	0.2			17.0	14.0	2.5	0.08		
	max typ	0.04	$\frac{3.0}{2.5}$	$\frac{1.0}{0.4}$	0.025	0.03	19.0 18	16.0 15	3.5	0.20		
		typ         0.03         2.5         0.4         0.01         0.025         18         15         3         0.12           Maximum magnetic permeability 1.01.         0.025         18         15         3         0.12										
All-weld mechanical properties	As wel	ded					min			typical		
	Tensile	e strength	ı			MPa	560			605		
		Proof stre				MPa	300	410				
	0	ation on 4				%	30			37		
	-	ation on 5	d			%	25			34		
		energy .			6°C *	J		15 .1 \		50		
		l expansi	on	- 19	6°C *	mm		15mils) 0.6				
	Hardness HV									185		
		Useful in recomme			s are mai	intained do	own to 4°	°K (-269	°C) and	l exceeds	proposed ASME Code	
<b>Operating parameters</b> Shielding gas: 80% Ar-20% CO <sub>2</sub> at 20-251/min. Proprietary gases may be used but argon should not e								argon should not exceed 80%.				
	The wire is suitable for use on $100\%$ CO <sub>2</sub> with some loss of cosmetic appearance and increased spatter <b>Current:</b> DC+ve parameters as below (for $100\%$ CO <sub>2</sub> increase voltage by ~3V):										nd increased spatter.	
									stickout			
	1.2					250A-32	V	180A-	29V		12-20mm	
Packaging data	Spools vacuum-sealed in barrier foil with cardboard carton: 12.5kg 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		composit	-		-			*				
		1	Fe	Mn	Ν	li C	r <sup>3</sup>	Cr <sup>6</sup>	Cu	F	OES (mg/m <sup>3</sup> )	
	12 18 2 4 4 <1 6 1.2										1.2	



# **318 STAINLESS STEEL**

#### Alloy type

Nb stabilised, Mo-bearing stainless steel.

#### Materials to be welded

wrought	cast
316Ti, 316Cb	CF10MC
1.4571/1.4573,	1.4579/1.4581
1.4580/1.4583	
320\$31/33	318C17
S31635, S31640	
	316Ti, 316Cb 1.4571/1.4573, 1.4580/1.4583 320S31/33

#### **Applications**

Use to weld titanium or niobium-stabilised grades of molybdenum-bearing austenite stainless steels, or as an alternative electrode for unstabilised grades such as 316/316L. It is not recommended for structural service above about 400°C.

It is also used for depositing **corrosion resistance overlays** and valve seat inlays on medium carbon alloy steels, and for this reason the electrode is normally supplied with a typical ferrite content of 3-14FN.

#### Microstructure

Austenite with 3-14FN (3-12% ferrite), typically 10FN.

### DATA SHEET B-34

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#### Welding guidelines

No preheat, maximum interpass temperature 250°C.

#### Additional information

Supermet 318 is not recommended for cryogenic applications, nor elevated temperature structural service.

#### **Related alloy groups**

The 316L consumables can be used for many of the same base materials and applications (data sheet B-32). For cryogenic applications see controlled ferrite 316L consumables (data sheet B-32) and for elevated temperature see 316H ((C-13) or 16.8.2 (C-12) consumables.

Process	Product	Specification
MMA	Supermet 318	AWS E318-17
TIG/MIG/SAW	318896	AWS ER318
SAW flux	SSB	BS EN SA AF2
	SSCr	BS EN SA FB2
	LA491	BS EN SA FB255



	Design downh Low h	Rutile-aluminosilicate flux on high purity 304L core wire giving very low (<0025%) typical carbon levels. Designed for ease of use, exceptional weld bead appearance, and high weld metal integrity, primarily in the downhand and H-V welding positions. Smaller sizes up to 3.2mm offer excellent all-positional operability. Low hydrogen manufacturing technology ensures high resistance to weld metal porosity. Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.										
Specifications	BS E BS 29	AWS A5.4       E318-17         3S EN 1600       E 19 12 3 Nb R 32         3S 2926       19.12.3Nb.AR         DIN 8556       E 19 12 3 Nb R 23										
ASME IX Qualification	QW4	32 F-No	5, <b>QV</b>	<b>/442</b> A-1	No 8							
Composition (weld metal wt %)	min max typ	C  0.04 0.025	Mn 0.5 2.0 0.8	Si  0.90 0.7	S  0.025 0.01	P  0.030 0.02	Cr 17.0 20.0 19	Ni 11.0 13.0 11.5	Mo 2.5 3.0 2.7	Nb 10 x C 1.0 0.6	Cu  0.50 0.1	FN 6 13 9
All-weld mechanical properties	0.2% I Elonga Elonga Reduc	Ided e strength Proof stres ation on 40 ation on 50 tion of are t energy	s 1 1	+ 20C		IPa IPa % % % J	min 560 350 25 25  	typica 630 500 36 35 55 65				
Operating parameters	DC +ve or AC (OC ø mm min A		OCV: :	55V min) 2.5 60		3.2 75		4.0		5.	-	Î
	max A			90		120		155		21	0	
Packaging data	ø mm length kg/car pieces			2.5 300 11.4 564		3.2 350 14.1 387		4.0 350 13.2 237		5. 45 18 16	50 .0	
Storage	for lon moistu For ele <b>Redry</b> Storag	nger than ure pick-u ectrodes the v 200 – 30 ge of redri	a work p and in nat hav 0°C/1-2 ied elec	ing shift on the been exp the to restored the to restored	of 8h. E the risk of posed: ore to as- 50 - 200	xcessive porosity packed 0°C in ho	exposure condition olding ov	e of electr . Maximu en or heat	odes to um 400 ted quiv	• humid con • C, 3 cycle ver: no limi	use from tin i nditions will es, 10h total. t, but maxin c lid): < 60%	cause son
Fume data	Fume	compositi	on, wt	% typical	:							
			Fe 8	Mn 7	Ni 1	C 5			Cu ).2	F (	DES (mg/m <sup>3</sup> ) 1	



#### Solid 318 stainless steel wire for TIG, MIG and SAW

Product description	Solid wire for TIC	Solid wire for TIG, MIG and SAW.										
Specifications	AWS A5.9 BS 2901: Pt2 DIN 8556 BS EN ISO 1434 BS EN ISO 1434	<b>43-A</b> 19 12	oNb 19 1	2 (1.457	6)							
ASME IX Qualification	QW432 F-No 6,	QW432 F-No 6, QW442 A-No 8										
Composition (wire wt %)	min max 0.07	Mn         Si           1.0         0.30           2.0         0.65           1.8         0.45	S  0.02 0.01	P  0.030 0.02	Cr 18.5 20.0 19.5	Ni 11.0 13.0 11.5	Mo 2.5 3.0 2.5	Nb 10xC 1.0 0.6	Cu  0.3 0.2	FN 3 12 10		
All-weld mechanical properties	Typical values as v Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Impact energy Hardness cap/mid	velded + 20°C		Pa % % J	TIG 655 440 42 35 90 00/215							
Typical operating parameters	** Also prop	rent DC- neter 2.4mm					SA SSB DC 2.41 350A	*** C+ mm				
Packaging data	ø mm 1.2 1.6 2.4	TIG  2.5kg tu 2.5kg tu	MIG 15kg spool  			SAW   25kg coil						
Fume data	MIG fume compo	e Mn	ΓIG and S Cr <sup>3</sup> 15	SAW fui Ni 11	N	gible): Ao .5	Cu <0.5	OES (m 3.2				



## **317L STAINLESS STEEL**

#### Alloy type

19%Cr-13%Ni-3.5%Mo (317L) austenitic stainless steel.

#### Materials to be welded

	wrought	cast
ASTM/UNS	317/S31700	CG8M
	317L/S31703	CG3M
DIN/BS EN	1.4438	
BS	317S16	317C16
	317S12	317C12

#### **Applications**

Use to weld 317/317L stainless steels in which the raised Mo level provides improved resistance to pitting in high chloride environments and to some acids (not nitric acid). These steels are used in **marine**, **chemical process**, **papermaking**, and **food processing** applications.

Also suitable for 316/316L and their stabilised versions when the benefits of higher molybdenum weld metal are required to maximise weld area pitting resistance.

Not suitable for structural service above about 400°C, or for cryogenic applications.

### DATA SHEET B-35

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#### Microstructure

Austenite with 3-10FN (3-9% ferrite), typically 5FN.

#### Welding guidelines

No preheat required, and a maximum interpass of 150°C is desirable. Normally used in the as-welded condition.

#### **Additional information**

The 317LM and 1.4539 alloys, with 4-5% Mo, can be welded with the overmatching 904L consumables (data sheet B-40).

#### **Related alloy groups**

317L falls between the lower alloyed 316L (data sheet B-32) and the higher alloyed 904L (data sheet B-40) materials.

Process	Product	Specification
MMA	Ultramet 317L	AWS E317L-16
TIG/MIG	ER317L	AWS ER317L
FCW	Supercore 317LP	AWS E317LT1-4



ULTRAMET 3	17L				А	ll-posit	ional M	1MA ele	ectrode	for 3	17L stai	nless steel
Product description	Rutile flux on high purity 304L core wire giving very low (<0.025%) typical carbon levels. A controlled addition of nitrogen, in conjunction with ~3.8% Mo, provides improved pitting corrosion resistance compared to 316L. Ultramet 317L gives both welder and weld metal all the benefits of advanced rutile electrode design. These features include optimum versatility for downhand and positional welding, combined with high cosmetic finish and full volumetric weld metal integrity. The smaller electrode sizes are particularly suited to vertical and overhead welding applications including fixed pipework. Low hydrogen manufacturing technology ensures high resistance to weld metal porosity. Recovery is about 115% with respect to core wire, 65% with respect to whole electrode.											
Specifications	AWS BS EI BS 29	N 1600			34NL	R 32 nearest eq	uivalent					
ASME IX Qualification	QW43	32 F-No 5	5, <b>QN</b>	<b>/442</b> A-N	o 8							
Composition (weld metal wt %)	min max typ	C  0.04 0.02	Mn 1.0 2.5 1.2	Si  0.90 0.6	S  0.025 0.01	P  0.030 0.02	Cr 18.0 20.0 19	Ni 12.0 14.0 13	Mo 3.5 4.0 3.8	Cu  0.50 0.1	N 0.08 0.20 0.12	FN 3 10 5
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Impact energy			+ 20°C - 50°C	(	Pa 5 Pa 3 %	nin 550 30 25  	typical 620 470 38 36 45 55 30				
Operating parameters		e or AC (	OCV: :	,					Ų			Î
	ø mm min A max A			2.5 60 90		3.2 75 120		4.0 100 155		5.0 130 210		
Packaging data	ø mm length mm kg/carton pieces/carton			2.5 300 12.0 669		3.2 350 13.5 381		4.0 350 13.5 225		5.0 350 13.5 165		
Storage	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisf for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause moisture pick-up and increase the risk of porosity.</li> <li>For electrodes that have been exposed:</li> <li>Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.</li> <li>Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 recommended. Recommended ambient storage conditions for opened tins (using plastic lid): &lt; 60% RH, &gt;</li> </ul>								ill cause some al. imum 6 weeks			
Fume data	Fume	compositi	on, wt	% typical:								
			Fe 8	Mn 6	Ni 1	Cr 6	Cu <0.1			F	OES (mg. 0.8	/m <sup>3</sup> )



ER317L		Solid wire for TIG and MIG welding 317L stainless steel										
Product description	Solid	Solid wire for TIG and MIG welding of 317L stainless steel.										
Specifications	BS E	A5.9 901: Pt2 N ISO 14: N ISO 14:		317 <b>S</b> 92 19 13 4								
ASME IX Qualification	QW43	32 F-No 6	, QW	442 A-N	o 8							
Composition (wire wt %)	min max typ	C  0.03 0.015	Mn 1.0 2.5 1.5	Si 0.30 0.65 0.4	S  0.02 0.01	P  0.030 0.02	Cr 18.5 20.0 19	Ni 13.0 15.0 14	Mo 3.0 4.0 3.5	Cu  0.3 0.15	FN 2 10 5	
All-weld mechanical properties	Tensile 0.2% F Elonga	l values as e strength Proof stress ation on 4d t energy	6	d + 20°C	M M	Pa	TIG 630 450 35 75					
Typical operating parameters	Curren Diame	riso required as a p				Ar+2 D 1.2 220A uns.	IIG %O <sub>2</sub> ** C+ 2mm A, 26V <3%CO <sub>2</sub>	also sui	table.			
Packaging data	ø mm 1.2 1.6 2.4											
Fume data	MIG f	ume comp	osition	(wt %) (T	'IG fume	e negligibl	e)					
		I	e	Mn	Cr <sup>3</sup>	Ni	Мо	С	Cu	OES (mg/r	m <sup>3</sup> )	
			28	12	15	12	2	<(	).5	3.3		



## All-positional rutile flux cored wire for 317L

Product description	design	Flux cored wire made with an austenitic stainless steel sheath and rutile flux system. <b>Supercore 317LP</b> is designed for all-positional welding including fixed pipework but provides excellent operability in the flat and HV positions as well. Metal recovery is about 90% with respect to the wire.											
Specifications	BS EI	A5.22 N ISO 17 N ISO 17				13 4 N L	P M 2)						
ASME IX Qualification	QW43	QW432 F-No 6, QW442 A-No 8											
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	Ν	FN	
(weld metal wt %)	min		0.5	0.2			18.0	12.0	3.0			3	
	max	0.04	2.5	1.0	0.025	0.030	20.0	14.0	4.0	0.5	0.20	10	
	typ	0.03	1	0.6	0.02	0.02	19	13	3.5	0.1	0.07	6	
All-weld mechanical	As wel	ded					min	typ	ical				
properties	Tensile	Tensile strength MPa				Pa	550	57	70				
	0.2% F	Proof stres	s		Μ	Pa	350	44	40				
	Elonga	Elongation on 4d			%		20	27					
	Elongation on 5d				%	20	2						
		tion of area				%			0				
	Impact energy		Impact energy			J			5				
	Hardne	ess		-50°C	H	J IV		45 220					
Operating parameters				20%CO <sub>2</sub> as below amp-vol 120 - 2	for Ar-2 t range	20%CO <sub>2</sub>	:	gases ma typical 180A, 26		S	gon shoul tickout 5 – 20mn	d not excee	ed 85%.
Packaging data	The as Resista possib	Spools vacuum-sealed in barrier foil with cardboard carton: 15kg spool. 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.									vent any		
Fume data	Fume	compositi	ion (wt	%)									
			Fe	Mn	Ni	Cr <sup>3</sup>	С	r <sup>6</sup> (	Cu	F	OES (m	g/m³)	
			17	10	1.5	3	5	5 <	< 1	5	1		



# **CRYOGENIC 308LCF CONSUMABLES**

#### Alloy type

Controlled ferrite 308L austenitic stainless steels for joining 304L base materials used in cryogenic applications.

#### Materials to be welded

ASTM	BS EN & DIN
304L	1.4306
304	1.4301
304LN	1.4311
CF3	1.4308
CF8	
DC	
BS	UNS
304S11	S 30403
304S15/16/31	S 30400
304S61	S 30453

#### Applications

Used to weld 18/8 stainless steels with service temperatures down to  $-196^{\circ}$ C. 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 308L consumables for general purpose fabrication can be found in data sheet B-30. The 308L consumables covered here are not suitable for 304/304H in elevated temperature structural applications, see data sheets C-10 and C-12.

### DATA SHEET B-37

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#### Microstructure

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

#### Welding guidelines

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

#### **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 308L stainless steel consumables are in data sheet B-30. Stainless steel consumables for high temperature applications on 304H can be found in data sheets C-10 or C-12.

#### **Products available**

Brococc	Product	Specification
FIUCESS	FIOUUCI	Specification
MMA	Ultramet 308LCF	AWS E308L-16
	Ultramet B308LCF	AWS E308L-15
TIG	ER308LCF	AWS ER308L
SAW	ER308LCF	AWS ER308L
	LA491	BS EN SA FB255
FCW	Supercore 308LCF	AWS E308LT1-4

304C12

304C15



## General Data for all 308L MMA Electrodes

		ctrodes at	$50 - 200^{\circ}$	°C in holdi	ng oven o		iver: no l	limit, but maximum 6 we		
Fume composition, wt % typical:										
	Fe	Mn	Cr	Ni	Мо	Cu	F *	OES (mg/m <sup>3</sup> )		
	8	5	5	0.8	-	< 0.2	16	1		
	Fume compo	recommended. Recom	recommended. Recommended a Fume composition, wt % typical Fe Mn 8 5	recommended. Recommended ambient sto Fume composition, wt % typical: Fe Mn Cr 8 5 5	recommended. Recommended ambient storage conditions were storage conditions we	recommended. Recommended ambient storage conditions for of Fume composition, wt % typical: Fe         Mn         Cr         Ni         Mo           8         5         5         0.8         -	recommended. Recommended ambient storage conditions for opened tins Fume composition, wt % typical: Fe         Mn         Cr         Ni         Mo         Cu           8         5         5         0.8         -         < 0.2	Fe Mn Cr Ni Mo Cu F*		

ULTRAMET 3	08LC	CF			Rut	ile MN	IA elec	ctrode fo	or cryc	genic	304L :	applic	ations
Product description	and po cryoge when 3	electrode – ositional ca enic service 304L is spe ery is abou	pabilit requiri cified f	y, <b>Ultram</b> ng >0.38n for service	net 308LC nm lateral up to 550	CF has a expansion of the company of	a control on at mir corrosion	led component lus 130-19 n condition	osition a 6°C. Al ns precl	and ferrit lso suitab ude the u	te conte ble for un se of 30	nt desig nusual o	ned for
Specifications	AWS BS EI BS 29 DIN 8	N 1600 926		E308L-1 E 19 9 L 19.9.LR 19 9 L R	R 3 2								
ASME IX Qualification	QW43	32 F-No 5,	QW4	<b>442</b> A-No	0 8								
Composition (weld metal wt %)	min max typ	C  0.04 <0.025	Mn 0.5 2.0 1	Si  0.90 0.6	S  0.025 0.01	P  0.030 0.02	Cr 18.0 21.0 18.5	Ni 9.0 11.0 10	Mo  0.50 0.1	Cu  0.5 <0.1	FN 2 5 3		
All-weld mechanical	As wel	ded					min	typica	I				
properties	0.2% F Elonga Elonga Reduc	e strength Proof stress ation on 4d ation on 5d tion of area t energy		-100°C -196°C	MPa MPa % % J J		520 320 35 30  	600 445 50 46 43 45 35					
		l expansion ch tested fo		-196°C	mm	1	0.38	0.50					
Operating parameters	DC +v	ve or AC (C	OCV: 50	OV min)					Ų			Ê	Û
	ø mm			2.5		.2		4.0		5.0			
	min A max A			60 90		'5 20		100 155		130 210			
Packaging data	ø mm			2.5	З	.2		4.0		5.0			
	length kg/cart pieces		300 11.4			350 13.5 396		350 13.5 261		450 16.2 159			



ULTRAMET B	308LCF		В	asic co	oated I	MMA pip	e-weld	ding el	ectrod	e for 304L
Product description	MMA electrode – purity 304L core w welding applicatio adverse wind and Recovery is about	vire. <b>Ultrame</b> ns including f drafts.	et B308LCF	is particurk in the A	ularly su ASME 59	ited to the G/6G positi	most der on. Und	nanding er site co	vertical	and overhead
Specifications	AWS A5.4 BS EN 1600 BS 2926 DIN 8556	19.9.L	L B 4 2							
ASME IX Qualification	QW432 F-No 5,	QW442 A-	No 8							
Composition (weld metal wt %)	C           min            max         0.04           typ         0.03	Mn         Si           0.5            2.0         0.90           1.2         0.3	S  0.025 0.01	P  0.030 0.015	Cr 18.0 21.0 18.5	Ni 9.0 11.0 10	Mo  0.50 0.05	Cu  0.5 <0.1	FN 2 5 3	
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Impact energy Lateral expansion * Batch tested for		MPa MPa % % J J J mm	mi 52 32 33 30  0.3 >0.38mm	0 0 5 0 - - - 88	typical 600 440 44 40 60 80-120 35-50 0.55 5°C.				
Operating parameters	DC +ve only. ø mm min A max A	2.5 60 90	7	.2 75 20		4.0 100 155	Ų			£ û
Packaging data	ø mm length mm kg/carton pieces/carton	2.5 300 12.0 681	3	.2 50 3.5 96		4.0 350 13.5 261				



ER308LCF						3	08L sol	id wire fo	r cryo	genic 3	04L ap	plications			
Product description	Batch	selected	solid wi	re for TIG	and sub-a	arc wel	ding.								
Specifications	BS EI	N ISO 1 N ISO 1 901: Pt2	4343-B	19 9 L SS308 308S92	S308L										
ASME IX Qualification	QW43	32 F-No	6, <b>QV</b>	<b>/442</b> A-N	o 8										
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN				
(wire wt %)	min		1.0	0.30			19.5	9.0			3				
	max typ	0.025	2.0	0.65	0.020	0.03		11.0	0.3	0.3	8				
	-71-	0.01	1.7	0.1	0.01	0.01		10			,				
All-weld mechanical properties	As wel	dod					min	TIG		typical SAW + LA491					
properties		aea e strengti	 ו		N	1Pa	510	605			70				
		Proof stre				IPa	320	465			50				
	Elonga	ation on 4	d			%	30	35			1				
	Elonga	ation on 5	id			%	30	33		3	7				
	Impact	tenergy		-130°C		J		110			0				
				-196°C		J		80			0				
	Latera	l expansi	on *	-196°C	1	nm	0.38	1.0		0.	.5				
	* ER3	308LCF	SAW wi	re batch te	sted, with	nLA491	l flux, for	Charpy late	ral expa	insion >0.3	38mm at	−196°C.			
Typical operating				TIG	5	SAW									
parameters	Shield	ing	A	rgon	L	A491									
	Curren	nt	]	DC-	I	DC+									
	Diame			4mm		4mm									
	Param	eters	100	A, 12V	350	A, 28V	f								
Packaging data	ø mm			TIG	5	SAW									
	1.6		2.5	kg tube											
	2.4			kg tube		kg coil									
	3.2		2.5	kg tube	251	kg coil									
Fume data	MIG f	ume con	positio	n (wt %) (T	IG and S	AW fu	me negligi	ble)							
			Fe	Mn	Cr <sup>3</sup>	Ni	Мс	o Cu OES (mg/m <sup>3</sup> )		3)					
			32	12	16	8	< 0	.5 < 0.5	5	3.1					



Product description				s a control sion at mir			and ferrit	te content	design	ed for c	ryogenic sei	vice requirin	
	-	core 3081		-	or all-po	ositional	welding i	ncluding	fixed p	ipework	. Metal rec	overy is abou	
Specifications	BS E	A5.22 N ISO 17 N ISO 17			LT1-4 9 L P M 8L-FM1	2							
ASME IX Qualification	QW43	<b>32</b> F-No	6, <b>QN</b>	<b>1442</b> A-N	08								
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN		
(weld metal wt %)	min		0.5	0.2			18.0	9.0			2		
	max	0.04	2.0	1.0	0.025	0.030	21.0	11.0	0.3	0.3	5		
	typ	0.03	1.4	0.6	0.01	0.02	18.6	10.5	0.1	0.1	3		
All-weld mechanical	As wel	ded					min	typical					
properties	Tensile	strength			М	Pa	520	54	0				
	0.2% F	Proof stres	s		Μ	Pa	320	400					
	Elonga	tion on 40	ł			%	35	5	0				
	Elonga	ition on 50	ł			%	30	4					
		tion of are	a			%		5					
	Impact energy			+ 20°C		J		7					
				-130°C		J		40					
	1	· · · · · · · · · ·	. +	-196°C		J		36 0.70					
		expansic		-196°C		nm	0.38		/0				
	* Bate	* Batch tested for Charpy lateral expansion $>0.38$ mm at $-196$ °C.											
Operating parameters	The w	<ul> <li>Shielding gas: 80% Ar-20% CO<sub>2</sub> at 20-251/min. Proprietary gases may be used but argon should not exceed 85% The wire is also suitable for use with 100% CO<sub>2</sub> when welding at downhand position.</li> <li>Current: DC+ve ranges as below for Ar-20% CO<sub>2</sub> (with 100% CO<sub>2</sub> requires approx 2-3V higher):</li> </ul>											
		nt: DC+v	e range	1		20%CO <sub>2</sub>		0%CO <sub>2</sub> re	equires a	approx 2	-		
	ø mm			amp-vol	t range		typical	9V/ (de	nhand			stickout	
	1.2			120 - 28	80A, 21	– 35V	180A, 28V (downhand) 160A, 26V (positional)			15 – 20mm			
	Spools vacuum-sealed in barrier foil with cardboard carton: 15kg (33 lbs) 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 a 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.												
Packaging data	The as Resista possib	-packed s ance to m ility of po	helf life oisture prosity,	e is virtual absorption it is advise	ly indefi i is high ed that p	nite. , but to m art-used :	naintain th spools ar	he high ir e returned	tegrity to poly			and prevent a	
Packaging data	The as Resista possib Where	-packed s ance to m ility of po	helf life oisture prosity, preferi	e is virtual absorption it is advise red storage	ly indefi i is high ed that p	nite. , but to m art-used :	naintain th spools ar	he high ir e returned	tegrity to poly			and prevent a	
	The as Resista possib Where	-packed s ance to m ility of po possible,	helf life oisture prosity, preferi	e is virtual absorption it is advise red storage	ly indefi i is high ed that p	nite. , but to m art-used :	naintain th spools an 0% RH n	he high ir e returned nax, 18°C	tegrity to poly				



# **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	
316S16/31/33	
316S61	
316C12	
316C16/71	

#### **Applications**

S 31603 S 31600

S 31653

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.

### DATA SHEET B-38

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#### Microstructure

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

#### Welding guidelines

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

#### **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.

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 E316LT1-4



## General Data for all 316L MMA Electrodes

Storage	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfacted 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.</li> <li>For electrodes that have been exposed:</li> <li>Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.</li> <li>Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 wee recommended. Recommended ambient storage conditions for opened tins (using plastic lid): &lt; 60% RH, &gt; 18°</li> </ul>											
Fume data	Fume composition, wt % typical:											
		Fe	Mn	Cr	Ni	Мо	Cu	F *	OES (mg/m <sup>3</sup> )			
	_	8	7	5	1	0.5	< 0.2	16	1			
	* F=28% for	* F=28% for basic coated Ultramet B316LCF but this does not affect the OES.										

ULTRAMET 3 <sup>2</sup>	16LC	CF			Rı	utile M	MA ele	ectrode	for cry	ogenic	316L :	applica	ations		
Product description	and po cryoge when 2	ositional c enic servic 316L is sp	capabili e requin ecified	ial rutile fli ity, <b>Ultran</b> ring >0.38 for service % with resp	met 316I mm later e up to 5	LCF has al expans 50°C and	a contro sion at mi d corrosio	olled con inus 130- on condit	nposition 196°C. A ions prec	and ferri Also suitab lude the u	te conte ole for un use of 31	nt desig nusual oc	ned for		
Specifications	AWS BS EI BS 29 DIN 8	N 1600 926		19.12.3.	t E 19 12										
ASME IX Qualification	QW43	QW432 F-No 5, QW442 A-No 8													
Composition (weld metal wt %)	min max typ * Doe	C  0.04 <0.03 es not conf	Mn 0.5 2.0 1 Form to	Si  0.90 0.6 DIN & BS	S  0.025 0.01 S EN whi	P  0.030 0.02 ich requi	Cr 17.0 20.0 18 ires Mo 2	Ni 11.0 13.0 12 2.5 - 3.0%	Mo* 2.0 3.0 2.2 6.	Cu  0.5 <0.1	FN 2 5 3				
All-weld mechanical	As wel														
properties	Tensile 0.2% F Elonga Reduc Impact	e strength Proof stres ation on 4 ation on 5 tion of are t energy I expansio ess	I a n *	+ 20°C -100°C -196°C -196°C rpy lateral	m H	Pa % % J J J V	min 520 320 25   0.38  mm at -1		ypical 595 440 43 39 48 70 50 30 0.45 230						
Operating parameters	DC +v	ve or AC (	OCV: 5	50V min)					Ų			Ê	Î		
	ø mm			2.5		3.2		4.0		5.0					
	min A max A			60 90		75 120		100 155		130 210					
Packaging data	ø mm			2.5		3.2		4.0		5.0					
	length kg/cart pieces			300 11.4 618		350 13.5 396		350 13.5 261		350 13.5 165					



ULTRAMET B	316L	.CF			E	Basic c	oated I	MMA pip	e-wel	ding el	ectrod	le for 316L		
Product description	purity weldir	304L core	e wire. ions inc	Ultramet cluding fix	t B316L	is particu	larly suit	ed to the i	nost der	nanding	vertical	estem and high and overhead it is tolerant to		
	Recov	ery is abou	ıt 110%	with resp	ect to con	re wire, 6	5% with	respect to	whole el	ectrode.				
Specifications	AWS BS EI BS 29 DIN 8	N 1600 926		19.12.3.	E 19 12									
ASME IX Qualification	QW43	32 F-No 5	, QW	442 A-No	o 8									
Composition		С	Mn	Si	S	Р	Cr	Ni	Mo *	Cu	FN			
(weld metal wt %)	min max	 0.04	0.5 2.0	 0.90	0.025	0.030	17.0 20.0	11.0 13.0	2.0 3.0	 0.5	2 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	As wel	ded					min	typical						
properties		e strength				Pa	520	600						
		Proof stress	6		М	Pa	320	470						
		ation on 4d				%	30 25	37						
	-	ation on 5d tion of area				% %		33 50						
		energy		-50°C		70 J		80						
	mpuo	lonorgy		-196°C		J		50						
	Latera	l expansior	ו* -	-196°C	n	nm	0.38	0.60						
	* Bate	ch tested fo	or Charj	py lateral o	expansior	n >0.38m	m at –196	5°C.						
Operating parameters	DC +v	e only.							Ų	$\checkmark$		£ î		
	ø mm			2.5	:	3.2		4.0						
	min A			60		75		100						
	max A			90	1	120		155						
Packaging data	ø mm			2.5		3.2		4.0						
	length			300		350		350						
	kg/cart			12.0		3.5	14.1							
	pieces	/carton		681		396		270						



ER316LCF

## Solid 316L wire for cryogenic applications

Product description	Solid w	vires for T	TIG and	sub-arc	welding.							
Specifications	BS EN	I ISO 14 I ISO 14 01: Pt2		ER31 19 12 SS31 316S SG X	2 3 L 6L 92	3 L W=TIG, S=SAW 5L						
ASME IX Qualification	QW43	<b>432</b> F-No 6, <b>QW442</b> A-No 8										
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN	
(wire wt %)	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							min			typical		
properties	As weld	ded							TIG	S	AW + LA491	
	strength			MPa		510	605			570		
		roof stres	s			MPa	320	465			450	
	Elongat	tion on 4d				%	30		35		41	
	Elongat	tion on 5d				%	25		33		37	
	Impact	energy		-130°C		J			> 100		> 45	
				-196°C		J			> 60		30	
	Lateral	expansio	n *	-196°C		mm	0.38		1.0		0.5	
	* ER3	16LCF S.	AW wi	e batch t	>0.38mm at -196°C.							
Typical operating			TIC	3		SAW						
parameters	Shieldir	ng	Arg	on		LA491						
-	Current	t	DC	-		DC+						
	Diamet	er	2.4n			2.4mm	ı					
	Voltage	•	100A,	12V		350A, 28	3V					
Packaging data	ø mm		TI	G		SAW						
	1.6		2.5kg	tube								
	2.4		2.5kg	tube		25kg co	il					
Fume data	MIG fu	ime comp	osition	(wt %) (	TIG and	SAW fu	ne neglig	ible)				
			-e	Mn	Cr <sup>3</sup>	Ni	М	0	Cu	OES (m	ng/m³)	
			30	12	15	11	1.	5	< 0.5	3.3	3	



SUPERCORE	316LCF	Rutile al	l posit	ional fl	ux core	ed wire	for cr	yoger	nic 316L applications
Product description	Supercore 316LCF hat >0.38mm lateral expan				and ferrit	e conten	t designe	ed for c	ryogenic service requiring
	<b>Supercore 316LCF</b> is 90% with respect to the		or all-po	sitional	welding i	ncluding	fixed pi	pework	k. Metal recovery is about
Specifications	AWS A5.22 BS EN ISO 17633-A BS EN ISO 17633-B			12 3 L P	M 2)				
ASME IX Qualification	QW432 F-No 6, QW	<b>/442</b> A-N	o 8						
Composition (weld metal wt %)	C         Mn           min          0.5           max         0.04         2.0           typ         0.03         1.4           * Does not conform to	Si 0.2 1.0 0.6 BS EN IS	S 0.025 0.01 O 17633	P  0.030 0.02 3-A whic	Cr 17.0 20.0 18.0 h require	Ni 11.0 13.0 12.4 s Mo 2.5	Mo * 2.0 3.0 2.2 5 - 3.0%.	Cu  0.5 0.1	FN 2 5 3
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Impact energy Lateral expansion * * Batch tested for Cha	+ 20°C -130°C -196°C -130°C -196°C rpy lateral	n n	Pa % % J J J im im	min 510 320 30 25    0.38 mm at -1	5. 4 3 4 7 4 3 0. 0.	ical 50 10 0 8 5 5 5 5 5 4 70 55		
Operating parameters Packaging data	The wire is also suitab <b>Current:</b> DC+ve range ø mm 1.2 Spools vacuum-sealed The as-packed shelf life Resistance to moisture	le for use v s as below amp-volt 120 – 28 in barrier f e is virtuall absorption	with 100 for Ar-2 a range 30A, 21 foil with by indefi is high,	% CO <sub>2</sub> w 20%CO <sub>2</sub> - 35V cardboan nite. but to m	when weld (with 100 typical 180A, 2 160A, 2 rd carton:	ling at de 0%CO <sub>2</sub> r 8V (dow 6V (posi 15kg (2 he high i	ownhand equires a mhand) ational) 33 lbs) ntegrity o	l position opprox 2	2-3V higher): stickout 15 – 20mm vire surface and prevent any
Fume data	possibility of porosity, Where possible, preferFume composition (wt	red storage						/thene v	wrappers.
	Fe	Mn	Ni	Cr <sup>3</sup>			Cu	F	OES (mg/m <sup>3</sup> )
	14	12	2.5	4	4	+ •	< 1	5	1.2



## **CONSUMABLES FOR 904L**

#### Alloy type

904L is a nominally 20%Cr-25%Ni-5%Mo-2%Cu fully austenitic alloy with good corrosion resistance.

#### Materials to be welded

**ASTM-ASME** N08904

BS 1449: 904S13 1504: 364C11 (cast) 1.4500 (cast)

#### **Proprietary alloys**

Uddelholm 904L 2RK65 (Sandvik) Cronifer 1925LC (VDM) 254SLX (Avesta Polarit) Uranus B6 & B6M (Creusot Loire)

DIN

1.4505

1.4506

1.4536

1.4539

1.4585

Suitable for copper-free variants of the above alloys and also to overmatch leaner alloys such as 317L, 317LN, 317LM, 1.4439 and 1.4440.

#### Applications

These consumables give a fully austenitic, low carbon weld metal with molybdenum and copper, with good resistance to corrosion in sulphuric, phosphoric and other inorganic and organic acids.

They are not normally chosen for resistance to corrosion in concentrated nitric acid. For service in severe chloride

#### **B-40** DATA SHEET

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pitting media, overmatching nickel-base weld metal is recommended, see alloy 625 (data sheet D-20).

It is the preferred weld metal for some lower alloy austenitics such as Creusot UHB 34L and UHB 734L for wet process phosphoric acid service.

Applications include tanks and process vessels, piping systems, agitators and rotors and cast pumps and valves for use in the **fertiliser**, **phosphoric**, **sulphuric** and **acetic** acid plants, and in salt and seawater environments. It is also used in some offshore applications, including overlays on mild and low alloy steels.

#### Microstructure

In the as-welded condition the weld metal microstructure is fully austenitic.

#### Welding guidelines

No preheat or PWHT is required, interpass should be controlled to 150°C maximum and heat input should also be controlled particularly with larger diameter MMA electrodes.

#### **Products available**

Process	Product	Specification
MMA	Ultramet 904L	E385-16
	Ultramet B904L	E385-15
TIG/MIG	20.25.4Cu	ER385

## General Data for all 904L MMA Electrodes

Storage	3 hermetics	ally sealed	ring-pull n	netal tins p	er carton,	with unlimi	ited shelf lit	fe. Direct	use from tin is satisfact	ory			
	for longer t	for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some											
	moisture pi	moisture pick-up and increase the risk of porosity.											
	For electroo	For electrodes that have been exposed:											
	<b>Redry</b> 150	<b>Redry</b> 150 – 250°C/1-2h to restore to as-packed condition. Maximum 250° C, 3 cycles, 10h total.											
	<b>Storage</b> of redried electrodes at $50 - 200^{\circ}$ C in holding oven or heated quiver: no limit, but maximum 6 recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, >												
Fume data	Fume comp	osition, wt	% typical:										
		Fe	Mn	Ni	Cr	Мо	Cu	F *	OES (mg/m <sup>3</sup> )				
8 8 2 7 1.5 0.5 18 0.7													
	* F=28% fo	* F=28% for basic coated Ultramet B904L but this does not affect OES.											



ULTRAMET 9	04L							Rutile	MMA e	electro	de for	welding	904L
Product description	MMA electrode (formerly 21.26.5.CuNb.R) with a special rutile flux on low carbon, high purity austenitic stainless steel core wire. Careful control of carbon, silicon, manganese and molybdenum contents to give resistance to microfissuring.												
	Recov	ery is abo	out 1309	% with res	pect to c	core wire	e, 65% wi	th respec	t to who	le electr	ode.		
Specifications	BS EI BS 29	AWS A5.4E385-16BS EN 1600E 20 25 5 Cu NL R 52BS 2926(Nearest 20.25.5.LCuNb.R)DIN 8556E 20 25 5 L Cu R26											
ASME IX Qualification	QW43	32 F-No	5										
Composition (weld metal wt %)	min	C 	Mn 1.0	Si 	S 	P 	Cr 19.5	Ni 24.0	Mo 4.2	Cu 1.2	Nb 	N 	
	max typ	0.03	2.5 1.2	0.90	0.02 0.015	0.030	21.5 20.5	26.0 25	5.2 4.8	2.0 1.8	0.5	0.25 0.09	
All-weld mechanical	As wel						min	typic					
properties		e strength Proof stre				IPa	560 320	620					
		ation on 4			IV.	IPa %	320 30	420 38					
	-	ation on 5				%	25						
	Ű	tion of are				%		50					
	-	t energy		- 196°C		J		50					
	Hardne	ess cap/r	nid		]	HV		185/2	00				
Operating parameters	DC +v	ve or AC	(OCV: <sup>^</sup>	70V min)								Ê	Û
	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		350					
	kg/cart			12.0		13.5		14.1					
	pieces	/carton		504		360		213					

## **ULTRAMET B904L**

### Basic all-positional MMA pipe-welding electrode for alloy 904L

Product description	Special basic flux on low carbon, high purity austenitic stainless steel core wire. Careful control of carbon manganese and molybdenum contents to give resistance to microfissuring.         Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.         AWS A5.4       E385-15         BS EN 1600       E 20 25 5 Cu NL B 62         BS 2926       (Nearest 20.25.5.LCuNb.B)         DIN 8556       E 20 25 5 L Cu B 20+										l of carbon	, silicon,	
Specifications													
ASME IX Qualification	QW4	32 F-No	5										
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	Nb	Ν	
(weld metal wt %)	min		1.0				19.5	24.0	4.2	1.2			
	max	0.03	2.5	0.90	0.02	0.030	21.5	26.0	5.2	2.0	0.5	0.25	
	typ	0.025	2	0.4	0.005	0.02	21	25	4.8	1.8	0.05	0.08	



## **ULTRAMET B904L (continued)**

All-weld mechanical	As welded			min	typical		
properties	Tensile strength		MPa	560	620		
	0.2% Proof stress		MPa	320	440		
	Elongation on 4d		%	30	41		
	Elongation on 5d		%	25	38		
	Reduction of area		%		60		
	Impact energy	- 196°C	J		50		
	Hardness cap/mid		HV		190/215		
Operating parameters	DC +ve						£ î
	ø mm	2.5	3.2		4.0		
	min A	60	75		100		
	max A	90	120		155		

## 20.25.4.Cu

Solid TIG and MIG wire matching alloy 904L

Product description	Solid wire	for TIG a	and MIG.							
Specifications	AWS A5. BS EN IS BS EN IS BS 2901: DIN 8556	O 14343 O 14343 Pt2	<b>B-B</b> SS38 904S	5 5 Cu L 35 392	X2CrNil	MoCu 20	25 / 1.45	519)		
ASME IX Qualification	QW432 I	F-No 6								
Composition (wire wt %)	min max 0.0	C M 1. 025 2. .01 1.	0 0.25 5 0.65	S  0.015 0.001	P  0.025 0.015	Cr 19.5 21.5 20	Ni 24.0 26.0 25	Mo 4.2 5.2 4.5	Cu 1.2 2.0 1.5	
All-weld mechanical properties	Typical val Tensile stro 0.2% Proof Elongation Elongation Impact ene Hardness of	ength f stress on 4d on 5d ergy	elded + 20°C	N	IPa IPa % J HV	TIG 650 490 35 32 210 175/195				
Typical operating parameters		required	TIG Argon DC- 2.4m 100A, 1 as a purge fe oprietary mi	n 2V or root ru	23 Ins.	MIG +2%O <sub>2</sub> ** DC+ 1.2mm 80A, 30V	8			
Packaging data	1.2 1.6 2.4				15	MIG 5kg spool  				
Fume data	MIG fume	Fe 28	tion (wt %) ( Mn 13	(TIG fum Cr <sup>3</sup> 16	e neglig N 2	li N	Мо 3	Cu 2.5	OES (mg/m <sup>3</sup> ) 2.5	



# **CONSUMABLES FOR ALLOY 825**

### DATA SHEET **B-42**

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#### Alloy type

Cr-Ni-Mo-Cu alloy of the generic 825 type.

#### Materials to be welded

Matching 825 materials:

ASTM/UNS	N08825
DIN	2.4858
BS	1501 & 3072 Grade NA16
Proprietary	Incoloy 825 (Special Metals)
	Incoloy 825CP, cast (Special Metals)
	Nicrofer 4221 (Krupp VDM)

The E825L-15 MMA electrode is also suitable for the 28%Cr alloy 28 materials:

ASTM UNS	N08028
DIN	1.4563
Proprietary	Nicrofer 3127LC (Krupp VDM)
	Sanicro 28 (Sandvik)

Also suitable for lower nickel materials of the alloy 20 type.

#### Applications

The consumables deposit Cr-Ni-Mo-Cu weld metal with a high corrosion resistance to organic acids and hot sulphuric acid. The high nickel content gives good resistance to stress corrosion cracking in chloride and  $\rm H_2S$  environments.

Applications include **tanks** and **process vessels**, **pipework systems**, **heat exchangers**, **agitators** and **rotors**, and **cast pumps** and **valves** for use in the **chemical processing** and increasingly **offshore oil** and **gas industries**. Also suitable for corrosion resistant **overlays** and for welding **dissimilar** materials.

#### Microstructure

In the as-welded condition the weld metal microstructure is fully austenitic.

#### Welding guidelines

No preheat required, interpass should be restricted to 150°C maximum and the heat input should be controlled particularly with 4mm and 5mm diameter electrodes.

#### **Additional information**

Some authorities accept or prefer overmatching type 625 weld metal (data sheet D-20) but 825 is the conventional type for welding alloy 825. Both the E825L-15 electrode and 82-50 wire are also suitable for welding the leaner alloy 20 type materials. The MMA electrode E825L-15 (but not the 82-50 wire) can also be used for welding the 28% Cr, alloy 28 type, materials.

#### **Related alloy groups**

The 625 alloy (data sheet D-20) is sometimes used for welding 825 and alloy 28 materials.

Process	Product	Specification
MMA	E825L-15	DIN EL-NiCr28Mo
TIG/MIG	82-50	AWS ERNiFeCr-1



E825L-15								MMA e	electro	ode for	aust	enitic alloy 82	
Product description	flux or ASME resista multip PRE =	MMA electrode for welding 825, alloy 28 and alloy 20 type materials. Specially balanced basic-fluoride-ruti flux on high purity 825 core wire. The electrodes are designed for fixed pipework welds including the demandin ASME 5G/6G positions. Careful control of carbon, manganese, silicon and nitrogen to maximise corrosic resistance in the as-welded condition and to ensure high resistance to solidification cracking and microfissuring multipass welds. The composition is controlled to give a Pitting Resistance Equivalent (PRE) of about 40, whe PRE = $%$ Cr + 3.3%Mo. Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.											
Specifications		AWS A5.4(E383-15)Does not strictly conform; Ni & Cu are higher in E825L-15 compared to the E383-15 classification.DIN 8556EL-NiCr28Mo (2.4653)											
ASME IX Qualification		<b>QW432</b> F-No 5 (This is nearest because the electrode does not strictly conform to AWS)											
Composition (weld metal wt %)	min max typ	C  0.03 0.02	Mn 1.0 3.0 2	Si  0.5 0.3	S  0.015 0.01	P  0.030 0.01	Cr 27.0 31.0 28	Ni 35.0 40.0 38	Mo 3.2 4.5 3.5	Cu 1.5 3.0 2	Nb  1.0 0.3	Fe  30 27	
All-weld mechanical properties	0.2% F Elonga Elonga Reduc Impact	e strength Proof stres ation on 40 ation on 50 tion of are t energy t energy	ss d d ea + 20°C		M M - 20°C 196°C F		min 550 240 30 25   	$\begin{array}{cccccccccccccccccccccccccccccccccccc$					
Operating parameters	DC +v ø mm min A max A			2.5 60 80		3.2 70 110		4.0 90 150		5.0 120 190	••••••••••••••••••••••••••••••••••••••		
Packaging data	ø mm length kg/cart			2.5 275 10.8 612		3.2 325 13.8 387		4.0 325 14.1 261		5.0 325 14.1 168			
Storage	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direction for longer than a working shift of 8h. Excessive exposure of electrodes to humid moisture pick-up and increase the risk of porosity. For electrodes that have been exposed:</li> <li>Redry 150 – 250°C/1-2h to restore to as-packed condition. Maximum 300° C, 3 cy Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no litre recommended. Recommended ambient storage conditions for opened tins (using place)</li> </ul>									• humid c • C, 3 cyc ver: no lin	cles, 10 nit, but	ons will cause som h total. maximum 6 week	
Fume data	Fume	compositi	on, wt	% typical:									
			Fe 4	Mn 5	Ni 3	C 7			Cu 1	F 20	OES	6 (mg/m <sup>3</sup> ) 0.7	



82-50			So	lid TIG	and M	IG wire	for wel	ding h	nigh all	oy aus <sup>.</sup>	tenitic	825 ma	ateria
Product description		Solid wire for TIG and MIG welding of 825 and alloy 20 type 21%Cr and so is not suitable for alloy 28. Note MIG wire is to								he 82-50	wire on	ly has a n	iominal
Specifications	BS 29 BS EI DIN 1		8274	ERNiF NA41 SNi800 (SG-Ni y as filler	65 iCr27Mo		) nearest						
ASME IX Qualification	QW43	32 F-No	45										
Composition (wire wt %)	min max typ	C  0.05 0.02	Mn  1.0 0.5	Si  0.50 0.3	S  0.015 0.005	P  0.020 0.015	Cr 19.5 23.5 22	Ni 38.0 46.0 40	Mo 2.5 3.5 3	Cu 1.5 3.0 2	Al  0.20 0.1	Ti 0.60 1.2 0.8	Fe 22.0 bal 30
All-weld mechanical properties	Tensile 0.2% F Elonga Elonga Reduc	l values a e strength Proof stre ation on 4 ation of ar ess cap/n	n ss Id id ea	ed	М	Pa Pa % % % 1V	TIG (Ar) 475 350 18 16 35 165/180		TIG (Ar- 58 35 3 3 3 3 190/	80 50 9 5 5 5			
Typical operating parameters	Shieldi Curren Diame Param *	ter eters Also re			2V for root	A Do 1 220 runs. Ar-	MIG Argon C+ ** .2mm 0A, 30V +1-5%H <sub>2</sub> c			cial see n	nechanica	al propert	ies.
Packaging data	ø mm 1.2 1.6 2.4 3.2			TIG  2.5kg tu 2.5kg tu 2.5kg tu	ıbe	(to	MIG order) cg spool  						
Fume data	MIG f	ume com	positio	n (wt %) (	TIG fum	e negligił	ole)						
			Fe 23	Mn 2	Cr <sup>3</sup>	Ni 29	Мс 2	)	Cu 3	OES (mg			



**B-45** 

# **Stainless Steels**

## **CONSUMABLES FOR 310L**

#### Alloy type

Low carbon 25%Cr-20%Ni (310L) for corrosion resisting applications.

#### Materials to be welded

**BS EN / DIN** X1CrNi25 21 (1.4335)

AFNOR Z1 CN 25 20 Z2 CN 25 20 M (cast)

#### Proprietary

2RE10 (Sandvik) Uranus 65 (Usinor Industeel)) Cronifer 2521LC (Krupp VDM)

#### Applications

310L consumables are designed for welding special low-carbon 25%Cr-20%Ni alloys which are used for their excellent resistance to oxidising media, e.g. **nitric acid**. Applications range from the **chemical process plant** used in **fertiliser production** to the **waste nuclear fuel reprocessing industries**. It is not intended for welding standard type 310 used for heat resisting applications (see data sheet C-30).

The electrode can also be used for **surfacing** steels to give a deposit with properties similar to the bulk weld metal, but care should be taken to deposit sufficient layers to eliminate any effects of dilution.

The low carbon fully austenitic deposit has excellent **cryogenic toughness** and it can be used as an alternative to 308L/316L types for welding conventional austenitic materials where superior impact values are required at temperatures at or below -196°C.

DATA SHEET

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#### **Microstructure**

Fully austenitic.

#### Welding guidelines

No preheat is required. Owing to the inherent hot cracking susceptibility of fully austenitic weld metal it is desirable to keep interpass temperature below 150°C and heat input below 1.5kJ/mm.

#### **Related alloy groups**

The standard 310 alloy, with 0.1%C (data sheet C-30) is related but is used for entirely different high temperature applications and the two alloys cannot be interchanged.

The 316NF consumables (data sheet B-33) and the Ultramet B310MoLN electrode can be used for similar corrosion resisting applications.

Process	Product	Specification
MMA	25.20.L.R	None



Product description	Special low silica basic rutile flux on low carbon stainless steel core wire. Detrimental residual elements including silicon are kept to low levels for optimum corrosion performance. Coupled with raised manganese, these features also ensure excellent resistance to microfissuring hot cracking. Suitable for all-positional welding up to 3.2mm diameter.										
	Recov	ery is abc	out 1409	% with re	spect to a	core wire	, 65% wi	th respec	et to whe	ole electro	de.
Specifications	There Appro	are no na ovals:		-				ent mate	rial Urar	us 65 by	independent tests.
ASME IX Qualification	QW43	32 F-No	, QV	<b>V442</b> A-	No						
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	Cu
(weld metal wt %)	min max typ	 0.040 0.03	4.0 7.0 5	0.4 0.3	 0.020 0.008	 0.025 0.01	24.0 26.0 25	19.0 22.0 21	 0.2 0.1	0.3 <0.1	0.3 0.08
All-weld mechanical	As wel	Ided					typical				
properties	Tensile 0.2% F Elonga Elonga Reduc	e strength Proof stres ation on 40 ation on 50 stion of are t energy	ss d d	- 196°(	M	1Pa 1Pa % % % J HV	520 350 37 30 55 90 170				
All-weld corrosion properties		eld metal The corro					t (ASTM )	A262 pra	ictice C:	5 x 48hr p	eriods in boiling 65% nitr
	Condit			0					<u> </u>		the eld
	Condit As-wel				ion rate m/48hr (=	= 0.07mn	n or 3 mi	ls/year)		elective a	ittack
	As-wel		nrs	0.40 µ	m/48hr (=	= 0.07mn = 0.13mn			<		
Operating parameters	As-wel PWHT	Ided		0.40 μι 0.73 μι	m/48hr (= m/48hr (=				<	< 0.01mm	
Operating parameters	As-wel PWHT	lded 815°C/2h		0.40 μι 0.73 μι	m/48hr (= m/48hr (=				<	< 0.01mm	
Operating parameters	As-well PWHT DC +v	lded 815°C/2f ve or AC (		0.40 μn 0.73 μn 70V min) <u>3.2</u> 75	m/48hr (= m/48hr (=	= 0.13mn 4.0 100			<	< 0.01mm	
	As-well PWHT DC +v ø mm min A max A	lded 815°C/2f ve or AC (		0.40 μπ 0.73 μπ 70V min) 3.2 75 120	m/48hr (= m/48hr (=	4.0 100 155			<	< 0.01mm	
Operating parameters Packaging data	As-well PWHT DC +v ø mm min A max A ø mm	lded <sup>-</sup> 815°C/2h ve or AC (		0.40 μn 0.73 μn 70V min) <u>3.2</u> 75	m/48hr (= m/48hr (=	= 0.13mn 4.0 100			<	< 0.01mm	
	As-well PWHT DC +v ø mm min A max A ø mm length kg/cart	Ided 815°C/2P ve or AC ( mm ton		0.40 µm 0.73 µm 70V min) 3.2 75 120 3.2 3.2 3.2 3.50 13.5	m/48hr (= m/48hr (=	4.0 100 155 4.0 350 15.0			<	< 0.01mm	
	As-well PWHT DC +v ø mm min A max A ø mm length kg/cart	Ided 815°C/2h ve or AC (		0.40 µ 0.73 µ 70V min) 3.2 75 120 3.2 3.2 350	m/48hr (= m/48hr (=	4.0 100 155 4.0 350			<	< 0.01mm	
Packaging data	As-well PWHT DC +v ø mm min A max A ø mm length kg/cart pieces <b>3 herm</b> for lor moistu For ele <b>Redry</b> <b>Storag</b>	mm ton //carton metically : nger than ure pick-u ectrodes ti / 150 – 20 ge of redr	Sealed I a work: p and in hat have 0°C/1-2 ied elect	0.40 µm 0.73 µm 70V min) 3.2 75 120 3.2 350 13.5 318 ring-pull ing shift of the been ex 2h to resto throase at	m/48hr (= m/48hr (= m/48hr (= metal tin of 8h. E te risk of posed: ore to as- 50 – 200	<ul> <li>4.0</li> <li>4.0</li> <li>100</li> <li>155</li> <li>4.0</li> <li>350</li> <li>15.0</li> <li>258</li> <li>as per cart xcessive</li> <li>porosity</li> <li>packed c</li> <li>o°C in ho</li> </ul>	ton, with exposure ondition. Iding ove	unlimited of elect . Maximen or hea	d shelf lin rodes to num 250° ted quiv	fe. Direct humid co c, 3 cyc er: no lim	Use from tin is satisfactor onditions will cause som les, 10h total. it, but maximum 6 week
Packaging data Storage	As-well PWHT DC +v ø mm min A max A ø mm length kg/cart pieces <b>3 herm</b> for lor moistu For ele <b>Redry</b> <b>Storag</b> recom	mm ton //carton metically : nger than ire pick-u ectrodes ti / 150 – 20 ge of redr mended.	Sealed I sealed I a work p and in hat have 0°C/1-2 ied elec Recomm	0.40 µm 0.73 µm 70V min) 3.2 75 120 3.2 350 13.5 318 ring-pull ing shift of the been ex 2h to resto throase at mended a	m/48hr (= m/48hr	<ul> <li>4.0</li> <li>4.0</li> <li>100</li> <li>155</li> <li>4.0</li> <li>350</li> <li>15.0</li> <li>258</li> <li>as per cart xcessive</li> <li>porosity</li> <li>packed c</li> <li>o°C in ho</li> </ul>	ton, with exposure ondition. Iding ove	unlimited of elect . Maximen or hea	d shelf lin rodes to num 250° ted quiv	fe. Direct humid co c, 3 cyc er: no lim	use from tin is satisfactor onditions will cause som les, 10h total. it, but maximum 6 week
Packaging data	As-well PWHT DC +v ø mm min A max A ø mm length kg/cart pieces <b>3 herm</b> for lor moistu For ele <b>Redry</b> <b>Storag</b> recom	mm ton //carton metically : nger than ure pick-u ectrodes ti / 150 – 20 ge of redr	Sealed I sealed I a work p and in hat have 0°C/1-2 ied elec Recomm	0.40 µm 0.73 µm 70V min) 3.2 75 120 3.2 350 13.5 318 ring-pull ing shift of the been ex 2h to resto throase at mended a	m/48hr (= m/48hr	<ul> <li>4.0</li> <li>4.0</li> <li>100</li> <li>155</li> <li>4.0</li> <li>350</li> <li>15.0</li> <li>258</li> <li>as per cart xcessive</li> <li>porosity</li> <li>packed c</li> <li>o°C in ho</li> </ul>	ton, with exposure ondition. Iding ove	unlimited of elect . Maximen or hea	d shelf lin rodes to num 250° ted quiv	fe. Direct humid co c, 3 cyc er: no lim	Use from tin is satisfactor onditions will cause som les, 10h total. it, but maximum 6 week ic lid): < 60% RH, > 18°C



# **ELECTRODE FOR 310MoLN**

#### Alloy type

25%Cr-22%Ni-2.5%Mo-0.15%N (alloy 310MoLN) austenitic corrosion resistant alloy.

#### Materials to be welded

AISI	310MoLN
AFNOR	Z1 CND 25.22.Az
DIN / EN	1.4465 (X2CrNiMoN 25-25-2)
	1.4466 (X1CrNiMoN 25-22-2)
UNS	S31050
Proprietary	Uranus 25 22 2 (Usinor Industeel)
	2RE69, 3R60U.G (Sandvik)
	Cronifer 25.25.LCN (VDM)
	HR3ELM (Sumitomo)

#### **Applications**

Ultramet B310MoLN is used primarily for welding similar wrought or cast 310MoLN parent alloys. It is particularly suited to positional welding, including fixed pipework qualified in the ASME 6G position, in material thickness from 3mm up to the heaviest sections.

The 310MoLN alloy has very good resistance to pitting, intergranular corrosion, chloride bearing media and nitric acid. The main applications of the alloy are in the production and processing of **urea** and **sulphuric acid**.

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Applications are mainly for joining matching steels although it can also be used for **surfacing**.

#### **Microstructure**

In the as-welded condition the microstructure is fully austenitic. Typical magnetic permeability is <1.01.

#### Welding guidelines

No preheat required and interpass should be controlled to 150°C maximum. It is also desirable for heat input to be limited to a maximum of 1.5kJ/mm, particularly with 4mm diameter electrodes.

#### **Additional information**

The alloy has excellent resistance to the ASTM A262 practice C corrosion test (Huey test). Typically required to meet  $<0.16g/m^2/h$  (0.18mm/year), and selective attack <0.07mm.

Process	Product	Specification
MMA	Ultramet B310MoLN	BS EN E 25 22 2 NLB



Product description	MMA electrode with a specially balanced basic carbonate-fluoride flux on high purity stainless steel core wire. Low silicon and high manganese levels ensure freedom from microfissuring.											
	Low silicon and high manganese levels ensure freedom from microfissuring. Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.											
Specifications	BS EN BS 292				22 2 N L 1.2 L Mn							
ASME IX Qualification	QW43	<b>2</b> F-No	5, <b>QW4</b>	<b>42</b> A-No	o 9.							
Composition (weld metal wt %)	min Max typ	C  0.04 0.03	Mn 3.0 5.0 4	Si  1.0 0.4	S  0.025 0.005	P  0.030 0.02	Cr 24.0 27.0 25	Ni 20.0 23.0 22	Mo 2.0 3.0 2.2	N 0.10 0.20 0.15	Cu  0.50 0.05	
All-weld mechanical properties	0.2% P Elongat Elongat Reducti Impact	strength roof streation on 4 tion on 5 tion of are	ss d d ea	-50°C	MPa MPa % % J HV	5	nin 10 20  25  	typica 640 430 39 38 50 75 185/20				
Operating parameters	DC +ve	e										
	ø mm min A max A			2.5 60 90		3.2 75 120		4.0 100 155				
Packaging data	ø mm length r kg/carto	on		2.5 300 11.4 501		3.2 340 13.8 408		4.0 340 13.8 270				
Storage	for long moistur For eler <b>Redry</b> Storag	ger than re pick-u ctrodes t 200 – 30 <b>e</b> of redr	a worki p and in hat have 0°C/1-2 ied elec	ng shift crease th been ex th to rest trodes at	of 8h. Ex ne risk of posed: ore to as- 50 - 200	xcessive porosity. packed c °C in ho	exposure condition lding over	e of electr . Maximu en or heat	odes to um 300 ed quiv	humid c ° C, 3 cyc er: no lir	conditions cles, 10h nit, but n	n tin is satisfactory s will cause some total. naximum 6 weeks 60% RH, > 18°C
Fume data	Fume c	omposit	ion, wt	% typica					_			. 3.
			_	Fe 9	Mn 10	Ni 2			Cu (0.2	F 18		mg/m <sup>3</sup> ) .6

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#### **Product description**

MMA electrode with basic-rutile flux system, including alloying, made on high purity stainless steel core wire. Recovery is about 130% with respect to core wire and 65% with respect to the whole electrode.

#### **Specifications**

There are no national specifications for this electrode.

#### Materials to be welded

A351 CK3MCuN (cast).
A182 F44.
S31254
1.4547
254SMO (Outokumpu)

#### Applications

This electrode deposits weld metal that closely matches the composition of equivalent 6%Mo superaustenitic parent material, usually castings, and is used only when post weld solution annealing is applied.

As deposited weld metal of this type has inherent Mo segregation and it is essential that welds are fully solution annealed to obtain the excellent pitting resistance this alloy is capable of. When solution annealing is not possible the use of over-matching nickel base electrodes (Nimrod 625KS, Nimrod C22KS or Nimrod C59KS) is normal practice.

The main applications for this electrode are in foundry repair or fabrication of castings for use in process plant where high resistance to chloride pitting and crevice corrosion is required. Applications include: heat exchangers and pipework for seawater contaminated oil and gas plant, equipment for pulp bleaching, gas cleaning systems (FGD), and components handling acid solutions with halides.

#### Microstructure

Fully austenitic.

#### Welding guidelines

Preheat not required. Interpass temperature is restricted to minimise the possibility of hot cracking in the parent HAZ. In susceptible castings, buttering with 100°C maximum interpass temperature and <1.0kJ/mm heat input may be required prior to filling the joint using more relaxed parameters.

#### Heat treatment

To eliminate segregation this weld metal must be solution annealed. High Mo austenitic alloys are prone to intermetallic phase formation (sigma, chi) at 600-1000°C. This damage could occur in the HAZ and weld metal during welding but will certainly occur as the temperature rises slowly during PWHT. A minimum temperature of 1200°C is required to dissolve these intermetallic phases and some



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authorities require >1230°C. This is followed by water quenching to prevent further intermetallic formation on cooling.

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	Ν	PRE
min		0.2	0.2			19.5	17.5	6.0	0.5	0.15	40
max	0.03	1.0	0.8	0.02	0.03	21.0	20.0	7.0	1.0	0.28	
typ	0.02	0.8	0.3	0.01	0.02	20.5	18.5	6.5	0.7	0.2	44
PRE :	= Cr +	· 3.3N	/lo +	16N							

#### All-weld mechanical properties

Solution annealed 1200-1250°C/2h + WQ			min *	typical
Tensile strength		MPa	550	716
0.2% Proof stress		MPa	260	380
Elongation on 4d		%	35	50
Elongation on 5d		%		47
Reduction of area		%		54
Impact energy	-50°C	J		>120
Hardness		HV		200

\* Minimum properties for CK3MCuN castings.

#### Parameters

DC +ve or AC (OCV: 70V min)

ø mm	3.2	4.0
min A	80	130
max A	110	160

#### Packaging data

		0	0
ø mm	3.2	4.0	
length mm	350	350	
kg/carton	15.0	14.1	
pieces/carton	378	201	

#### Storage

**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.

For electrodes that have been exposed:

**Redry**  $150 - 250^{\circ}$ C/1-2h to restore to as-packed condition. Maximum 250° C, 3 cycles, 10h total.

**Storage** of redried electrodes at 50-200°C in holding oven or 50-150°C in heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, >18°C.

#### Fume data

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Мо	Cu	F	OES (mg/m <sup>3</sup> )
8	8	7	2	1.5	1	18	0.7



## **309L STAINLESS STEELS**

#### Alloy type

24% Cr-13% Ni (309L) austenitic stainless for dissimilar joint buffer layers etc.

#### Materials to be welded

Mainly used under high dilution conditions, particularly dissimilar welds between stainless and CMn steels.

#### **Applications**

There are 3 main areas of application:

**Buffer layers** and **clad steels**: Overlays on CMn, mild steel or low alloy steels and for joining 304L/321 clad plate. Subsequent layers are deposited with an electrode chosen to match the cladding, eg 308L, 347.

**Dissimilar joints**: Tolerance to dilution is exploited in joining stainless types 410, 304L, 321 and 316L to mild and low alloy steels such as stiffeners, brackets and other attachments. Service temperatures above 400°C are normally avoided. It is also used for welding 12%Cr 'utility ferritics' such as Cromweld 3CR12, to itself and other steels.

**Similar metal joints**: Wrought and cast steels of 23Cr-12Ni type (eg ASTM 309 and CH8, BS 309S24 and 309C30) can be welded if the service requirement is corrosion resistance below 400°C. However, for high temperature structural service, weld metal with controlled higher carbon and lower ferrite should be used (**Thermet 309CF** – data sheet C-21).

#### **Microstructure**

Austenite with ferrite in the range 8-20FN. The solid wires tend to have lower ferrite than the MMA and FCW consumables, the ferrite falling in the range 8-15FN for the solid wires.

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#### Welding guidelines

Preheat and interpass temperatures depend on base material hardenability. For guidance, no preheat on mild steels; up to 250°C on hardenable steels.

#### **Additional information**

There is a Technical Profile on sub-arc welding with 309S92 and also additional information covering the Supercore flux cored wires.

#### **Related alloy groups**

The 309Mo consumables (B-51), 307 (E-21) and 29.9 types (E-22) cover similar applications. For high temperature applications refer to the controlled ferrite 309 types (C-21) and high carbon 309H (C-22) for matching high carbon cast alloys.

Process	Product	Specification
MMA	Supermet 309L	AWS E309L-17
	Ultramet 309L	AWS E309L-16
	Ultramet B309L	AWS E309L-15
	Ultramet 309LP	AWS E309L-16
TIG	309892	AWS ER309L
MIG	Supermig 309LSi	AWS ER309LSi
SAW	309892	AWS ER309L
	SSB	BS EN SA AF2
	SSCr	BS EN SA FB2
	LA491	BS EN SAFB255
FCW	Supercore 309L	AWS E309LT0-4
	Supercore 309LP	AWS E309LT1-4



## General Data for all 309L MMA Electrodes

Storage	satisfactory for loc cause some moist For electrodes tha <b>Redry</b> 200 – 300° <b>Storage</b> of redried	nger than a wo are pick-up an t have been ex C/1-2h to rest l electrodes at	orking shif d increase posed: ore to as-p 50 – 200°	t of 8h. E the risk o backed con C in holdi	Excessive f porosity ndition. N ng oven o	exposure of /aximum 40 r heated qui	electrod 00° C, 3 c iver: no li	Te. Direct use from the set to humid conditions we be	will eeks			
Fume data	Fume composition	n, wt % typical	l:									
	Fe	e Mn	Cr	Ni	Мо	Cu	F*	OES (mg/m <sup>3</sup> )				
	9	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$										
	* F=28% for basic coated Ultramet B309L but this does not affect the OES.											

SUPERMET 309L								neral	purpose	e rutile	e 309l	_ MMA	electr	rode
Product description	'Low h gives a Desigr	MMA electrode – rutile aluminosilicate flux on l 'Low hydrogen' manufacturing technology ensur gives acid rutile operability combined with contr Designed for ease of use, exceptional weld bea downhand and HV positions; smaller sizes offer Pacovary is about 115% with respect to core with							te to weld n ntent for m and high v	metal po aximun weld me	orosity. 1 crackir	'Superme	et Techno ion resist	ology' tance.
	Recov	covery is about 115% with respect to core wire, 65% with respect to whole electrode.												
Specifications	AWS A5.4         E309L-           BS EN 1600         E 23 12           BS 2926         23.12.1           DIN 8556         E 23 12					R 32 AR								
ASME IX Qualification	QW43	<b>32</b> F-No	5, <b>Q</b>	W442	A-No 8									
Composition (weld metal wt %)	min max typ	C  0.04 0.02	Mn 0.5 2.5 0.8	Si  0.90 0.6	S  0.025 0.01	P  0.030 0.02	Cr 22.0 25.0 24	Ni 12.0 14.0 13	Mo  0.5 0.05	Cu  0.5 0.1	FN 8 20 15			
All-weld mechanical	As-we	Ided					min		typical					
properties	As-welded Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Impact energy			+ 20	)°C	MPa MPa % % % J	560 320 30 30 		620 500 40 36 50 55					
Operating parameters	Hardness H DC +ve or AC (OCV: 50V min)								220	Ū	$\checkmark$		Ê	Î
	ø mm 2.5 min A 60				3.2 75		4.0 100	1	5.0 30					
	max A 90				120		155	2	10					
Packaging data	ø mm					3.2		4.0		5.0				
	length mm300kg/carton11.4pieces/carton579				350 13.5 354		450 18.3 258	1	50 8.0 56					



ULTRAMET 3	ULTRAMET 309L										All-positional rutile MMA electrode for 309L							
Product description	of an a finish pipewo	dvanced and weld ork. The	rutile flu metal 2.5mm	integrity; a electrodes	this inclu and all-po are also d	des opti ositional esigned	mum ver welding for open	urity 304L of resatility for g with the 2 butt root w a respect to	downhand 2.5/3.2mm velding.	d weldin n electi	ng with rodes i	high co	osmetic					
Specifications	AWS BS EN BS 29 DIN 8 Appro	N 1600 26 556		E309L-1 E 23 12 1 23.12.LF E 23 12 1 Germania	L R 32 R	yd												
ASME IX Qualification	QW43	32 F-No	5, <b>QW</b>	442 A-No	8													
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN							
(weld metal wt %)	min		0.5				22.0	12.0			8							
	max	0.04	2.5	0.90	0.025	0.030		14.0	0.50	0.5	20							
	typ	0.03	0.8	0.6	0.01	0.02	23.5	13	0.1	0.1	15							
All-weld mechanical	As wel	ded					min	typical										
properties	Tensile	e strength			M	Pa	560	595										
		Proof stres			M	Pa	320	495										
	-	tion on 40				%	30	41										
	0	ition on 50				%	30	38										
		tion of are		- 20°C		% J		59 45										
	Hardne	energy		- 20°C	н	IV		45 230										
Operating parameters		re or AC (	OCV: 5	OV min)	1			230	Ų.			Ê	Î					
	ø mm			2.5	3	3.2	2	4.0	5.0									
	min A			60	-	75	1	00	130									
	max A			90	1	20	1	55	210									
Packaging data	ø mm			2.5	3	3.2	2	4.0	5.0									
	length	mm		300	3	50	3	50	450									
	kg/cart	on		12.6		3.5		3.5	18.0									
	pieces	/carton		687	3	93	2	.52	165									

### III TRAMET 3091

# **ULTRAMET B309L**

### Basic coated 309L MMA electrode for pipe-welding

Product description	high pr weldin to adve	MMA electrode – designed and manufactured to give high moisture resistance using a basic flux system and high purity 304L core wire. <b>Ultramet B309L</b> 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 BS EI BS 29 DIN 8	N 1600 26		E309L-15 E 23 12 L B 42 23.12.LB E 23 12 L B 20+								
ASME IX Qualification	QW43	32 F-No	5, <b>QW</b>	442 A-No	0 8							
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN	
(weld metal wt %)	min		0.5				22.0	12.0			8	
	max	0.04	2.5	0.90	0.025	0.030	25.0	14.0	0.50	0.5	20	
	typ	0.03	1.2	0.3	0.01	0.02	23.5	13	0.1	0.1	15	



## **ULTRAMET B309L (continued)**

All-weld mechanical	As welded			min	typical		
properties	Tensile strength		MPa	560	630		
	0.2% Proof stress		MPa	320	490		
	Elongation on 4d		%	30	36		
	Elongation on 5d		%	30	34		
	Reduction of area		%		45		
	Impact energy	+20°C	J		75		
		-50°C	J		50		
Operating parameters	DC +ve only.						
	ø mm	2.5	3.2	4.0	5.0		
	min A	60	75	100	130		
	max A	90	120	155	210		
Packaging data	ø mm	2.5	3.2	4.0 *	5.0 **		
	length mm	300	350	350/45	0 450		
	kg/carton	12.0	13.8	14.1/17	.4 17.1		
	pieces/carton	678	402	267/26	7 159		
		standard length ter made to orde		ameter; 450mn	n is available to order	r.	

### All-positional pipe welding and root welding electrode

Product description	309LP ASME need fo	is a fully a 5G/6G. T or a gas pu	all-posi he Ulti rge. T	tional elec ramet 3091 he electroc	trode cap P electro le is also	able o de ha suitab	of the s also ble fo	e most de been de r vertica	emandin esigned to 1-down	ery low ty g fixed pip o deposit sin welding on o whole ele	ework a ngle-sid thin sh	pplicatio e root rui	ons inclu 1s witho	uding
Specifications	AWS BS EI	A5.4 N 1600		E309L-1 E 23 12										
ASME IX Qualification	QW43	32 F-No 5	, QW	442 A-No	o 8									
Composition		С	Mn	Si	S	P	)	Cr	Ni	Мо	Cu	FN		
(weld metal wt %)	min		0.5				-	22.0	12.0			8		
, , , , , , , , , , , , , , , , , , ,	max	0.04	2.5	0.90	0.025	0.0	30	25.0	14.0	0.50	0.5	20		
	typ	0.03	0.8	0.6	0.01	0.0	)2	23.5	13	0.1	0.1	15		
All-weld mechanical	As wel	ded					m	in	typical					
properties	Tensile	e strength			М	Pa	56	50	635					
	0.2% F	Proof stress	;		Μ	Pa	32	20	525					
	Elonga	ation on 4d				%	3	0	41					
	0	ation on 5d				%	3	0	38					
		tion of area	l		-	%		-	45					
	Hardne	ess			ł	IV		-	230					
Operating parameters	DC +v	e or AC (C	DCV: 5	0V min)					Ų			Ê	Î	Ŷ
	ø mm			2.5	:	3.2								
	min A			60		75								
	max A			90	1	20								



# 309S92, SUPERMIG 309LSi

309L solid wire

Product description	Solid wires for TIG, MIG and sub-arc welding.												
Specifications	AWS A5.9 BS EN ISO 14343-A BS EN ISO 14343-B BS 2901: Pt2 DIN 8556			309S92 (TIG & sub-arc)           ER309L           23 12 L           SS309L           309S92           SG X2CrNi 24 12 (1.4332)					Supermig 309LSi (MIG)           ER309L Si           G 23 12 L Si           SS309L Si           309S93           SG X2CrNi 24 12 (1.4332)				
ASME IX Qualification	QW43	<b>2</b> F-No 6,	QW4	42 A-No									
Composition (wire wt %)	C         Mn           min          1.0           max         0.03         2.5           typ         0.015         1.7			Si * 0.30 0.65 0.5	S         P         Cr             23.0           0.020         0.030         25.0           0.005         0.015         23.5		23.0 25.0 23.5	Ni         Mo           12.0            14.0         0.3           13         0.1		Cu  0.3 0.15	FN 8 15 12		
All-weld mechanical properties	* Supermig 309LS As welded Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Impact energy			+ 20°C - 20°C				typi TIG 590 450 43 41 55 200 	Cal MIG 560 430 42 39 56 100 80				
Fypical operating	Hardne	ss cap/mid		- 75°C TIG	]	J HV		-150 5/225 G					
parameters	Shieldir Current Diamete Voltage * ** **	er er Also requ	uired as prietary	Argon * DC- 2.4mm 100A, 12V s a purge for Ar and A	or root ru	2 uns.	$\begin{array}{ccc} Ar+2\%O_2^{**} & SSB^*\\ DC+ & DC- \end{array}$			SB*** DC+ .4mm			
Packaging data	ø mm 0.8 1.0 1.2 1.6 2.4 3.2	2.5 2.5	TIG 09S92  kg tube kg tube kg tube	e			ool ool	pol pol					
Fume data	MIG fu	time composition (wt %) (TIC $ \frac{Fe \qquad Mn}{32 \qquad 12} $			G and SA Cr <sup>3</sup> 20		ume n Ni 11	egligible) Mo < 0.5	) Cu < 0.5		DES (mg/m 2.5	<sup>3</sup> )	



## SUPERCORE 309L, 309LP

Rutile flux cored wires

Product description	<b>309L</b> co HV wel	lux cored wires – the wires are made with an austenitic stainless steel sheath and rutile flux system. <b>Supercore</b> <b>09L</b> combines easy operability, high deposit quality and exceptional weld bead appearance for downhand and V welding. <b>Supercore 309LP</b> is designed for all-positional welding including fixed pipework. Metal recovery about 90% with respect to the wire.										
Specifications & Approvals	AWS A5.22 BS EN ISO 17633-A BS EN ISO 17633-B Approvals			E309L7 T 23 12 TS309I	LRM	yd	Supercore 309LP E309LT1-4 T 23 12 L P M 2 TS309L-FM1 TÜV, Germanischer Lloyd					
ASME IX Qualification	QW43	<b>2</b> F-No 6,	QW	442 A-No	8							
Composition (weld metal wt %)	min max typ	C  0.04 0.03	Mn 0.5 2.0 1.3	Si  1.0 0.6	S  0.025 0.02	P  0.030 0.02	Cr 22.0 25.0 24	Ni 12.0 14.0 12.5	Mo  0.3 0.1	Cu  0.3 0.1	FN           12           22           15	
All-weld mechanical properties	0.2% Pr Elongat Elongat Reducti Impact Hardne	strength roof stress ion on 4d ion on 5d on of area energy ss		+ 20°C - 20°C Supercore 3	M	Pa Pa % % J J HV Values fe	min 520 320 30 25      Supere	typi 56 44 52 65 55 20 core 309L	60 -5 0 6 2 * *	at +20	°C, 40J at -20°C.	
Operating parameters Packaging data	Superc Current ø mm 1.2 1.2P Spools The as- Resistan possibil	vacuum-se packed sh nce to moi lity of pore	is also ranges ealed in elf life sture a osity, i	suitable for as below f amp-vol 120 - 2 120 - 2 n barrier for is virtually	or use wi for Ar-20 It range 80A, 21 50A, 20 il with c: y indefin is high, l d that pa	th 100% -35V -32V ardboard ite. but to ma rt-used s	CO <sub>2</sub> . Supercor carton: intain th	e 309L wi typical 180A, 28 180A, 26 Supercore e high inte e returned	th 100% V 309L – egrity of to polytl	$CO_2$ re s 1 1 12.5kg the win	on should not exceed 85%. quires approx 3V higher): tickout 5 – 20mm 5 – 20mm c, Supercore 309LP – 15kg re surface and prevent any rappers.	
Fume data		ompositio		_	conditio	iis are 00	,,, <b>XII</b> II	шл, 10 С				
			Fe 14	Mn 11	Ni 2	Cr <sup>3</sup> 5			Cu : 1	F 6	OES (mg/m <sup>3</sup> ) 1.2	



## **309Mo STAINLESS STEELS**

#### Alloy type

23%Cr-13%Ni-2.5%Mo (309Mo) austenitic stainless steel.

#### Materials to be welded

Mainly used under high dilution conditions, particularly dissimilar welds between stainless and CMn steels. There are no comparable base materials.

#### Applications

There are 3 main areas of application:

**Buffer layers** and **clad steels**: Overlays on CMn, mild steel or low alloy steels and for joining 316L clad plate. Subsequent layers are deposited with an electrode chosen to match the cladding, eg 316L, 318. Also as a buffer layer prior to hardsurfacing with chromium carbide types.

**Dissimilar joints**: Tolerance to dilution is exploited in joining stainless types 410, 304L, 321 and 316L to mild and low alloy steels such as stiffeners, brackets and other attachments. Service temperatures above 300°C are normally avoided. For some of these applications a more economic alternative may be suitable, eg 309L, 307.

**Hardenable steels**: The high level of alloying and ferrite level tolerates dilution from a wide range of alloyed and hardenable steels to give crack-free welds.

#### Microstructure

Austenite with ferrite normally in the range 10-30FN.

#### DATA SHEET B-51

METRODE PRODUCTS LTD HANWORTH LANE, CHERTSEY SURREY, KT16 9LL Tel: +44(0)1932 566721 Fax: +44(0)1932 565168 Sales Fax: +44(0)1932 569449 Technical Fax: +44(0)1932 566199 Export Email: info@metrode.com Internet: http//www.metrode.com

#### Welding guidelines

Preheat and interpass temperatures depend on base material hardenability. For guidance, no preheat on mild steels, up to 250°C on hardenable steels.

#### **Additional information**

There is a Technical Profile available on sub-arc welding with 309Mo. There is also additional information available covering the Supercore flux cored wires.

#### **Related Alloy Groups**

The 309L consumables (B-50), 307 consumables (E-21) and 29.9 consumables (E-22) cover a similar range of applications.

#### **Products Available**

Process	Product	Specification
MMA	Supermet 309Mo	AWS E309LMo-17
	Ultramet B309Mo	AWS E309LMo-15
	Vertamet 309Mo	AWS E309LMo-17
TIG/MIG/ SAW	ER309Mo	BS EN 23 12 2 L
SAW flux	SSB	BS EN SAFB2
	LA491	BS EN SAFB255AC
FCW	Supercore 309Mo	AWS E309LMoT0-4

# General Data for all MMA Electrodes

Storage 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. 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  $50 - 200^{\circ}$ 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. Fume data Fume composition, wt % typical: Fe Cr F \* OES (mg/m<sup>3</sup>) Mn Ni Cu 9 6 1 7 < 0.5 17 0.7 \* F=28% for basic coated Ultramet B309Mo but this does not affect the OES.



SUPERMET 309Mo							General purpose rutile 309Mo MMA electrode						
Product description	porosi	Acid rutile electrode made on nearly matching austenitic steel core wire. Moisture resistant coating gives sound porosity-free deposits.											
	Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.												
Specifications	AWS BS EI BS 29 DIN 8	N 1600 26		E309LMo-17 E 23 12 2 L R 32 23.12.2.AR E 23 12 2 R 23									
ASME IX Qualification	QW432 F-No 5, QW442 A-No 8												
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN		
(weld metal wt %)	min		0.5				22.0	12.0	2.0		10		
	max	0.04	2.5	0.9	0.025	0.030	25.0	14.0	3.0	0.5	30		
	typ	0.02	0.8	0.6	0.01	0.02	23.5	12.5	2.5	0.05	25		
All-weld mechanical	As welded					min		typical					
properties	Tensile strength				MPa			680					
	0.2% Proof stress				MPa			510					
	0	tion on 4d			%	-		37					
	-	tion on 5d			%	3	0	35					
		tion of area	a	••••	%	-	-	40					
	•	energy		+ 20°C	J			50					
	Hardne	ess			HV	-	-	220					
Operating parameters	DC +v	e or AC (	OCV: 5	50V min)					Ų	$\checkmark$		€ ∩	
	ø mm			2.5	2.5		3.2			5.0			
	min A			60	60		75			130			
	max A			90		20		155		210			
Packaging data	ø mm			2.5		3.2		4.0		5.0			
	length mm			300		350		450		450			
	kg/carton			12.0			13.2			18.0			
	pieces	/carton		609	-	336	36			162			

## **SUPERMET 309Mo**

## **ULTRAMET B309Mo**

#### 309Mo basic coated MMA pipe-welding electrode

Product description	Basic coated electrode on high purity 304L core wire manufactured to order. Designed to give moisture resistance and hence freedom from weld porosity.											resistance	
	Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.												
Specifications	AWS A5.4 BS EN 1600 BS 2926			E309LMo-15 E 23 12 2 L B 42									
				23.12.2.B									
	DIN 8556			E 23 12 2 B 20+									
ASME IX Qualification	QW432 F-No 5, QW442 A-No 8												
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN		
(weld metal wt %)	min		0.5				22.0	12.0	2.0		12		
	max	0.04	2.5	0.90	0.025	0.030	25.0	14.0	3.0	0.50	36		
	typ	0.03	0.8	0.6	0.01	0.02	23.5	13	2.6	0.1	20		
All-weld mechanical	As wel	ded				min		typical					
properties	Tensile strength				MPa	560		680					
	0.2% Proof stress				MPa	350		510					
	Elongation on 4d				%	30		37					
	Elongation on 5d				%	30		35					
	Reduc	tion of are	а		%			40					



## **ULTRAMET B309Mo (continued)**

Operating parameters	DC +ve			
	ø mm	3.2	4.0	
	min A	75	100	
	max A	120	155	
Packaging data	ø mm	3.2	4.0	
	length mm	350	350	
	kg/carton	15.0	14.1	Note: Product available to order only.
	pieces/carton	420	396	

### **VERTAMET 309Mo**

Rutile vertical-down electrode for dissimilar welds

Product description	manuf positio EN 28 distort down	Rutile-aluminosilicate flux on high purity 309L core wire giving very low typical carbon levels. 'Low h manufacturing technology ensures high resistance to weld metal porosity. The electrode is designed positional use where the emphasis is on fast welding speeds achieved by the vertical-down welding techn EN 287-1 PG position). For fillet and lap joints in thinner sheet material, an added advantage is distortion resulting from the lower heat input of vertical-down welding. Although designed primarily for down it can be successfully used in all other positions. Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.												
Specifications	AWS BS EI BS 29 DIN 8	N 1600 926		E 23	309LMo- 23 12 2 I 3.12.2.AR 23 12 2 I	R 11								
ASME IX Qualification	QW43	QW432 F-No 5, QW442 A-No 8												
Composition (weld metal wt %)	min max typ	C  0.04 0.02	Mn 0.5 2.5 0.8	Si  0.90 0.8	S  0.025 0.01	P  0.030 0.02	Cr 22.0 25.0 23	Ni 12.0 14.0 12	Mo 2.0 3.0 2.4	Cu  0.5 0.1	FN 10 30 15			
All-weld mechanical properties	0.2% F Elonga Elonga	ded e strengt Proof stre ation on 4 ation on 5	ess 1d 5d			MPa MPa % % %	min 560 350 30 30		pical 580 380 42 38 50					
Operating parameters	ø mm min A max A Typica	min A			45V min) 2.5 60 90 ~65 ~85		.2 5 20 80 10		U.				ŧ	
Packaging data	ø mm length kg/cart pieces	on			2.5 300 12.9 837	30 12	.2 00 2.9 50							



ER309Mo

#### Solid 309Mo wire for TIG, MIG and SAW

Product description	Solid	wire for TI	G, MIC	G and SA	W.									
Specifications	BS EI	N ISO 143 N ISO 143 901: Pt2		23 12 (neare (neare	est ER309 2 L est SS309 est 309S9 8 XrNiM	LMo) 5)	1.4459)							
ASME IX Qualification	QW43	QW432 F-No 6, QW442 A-No 8												
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN			
(wire wt %)	min		1.0	0.30			21.0	12.0	2.0		5			
	max	0.03	2.5	0.65	0.02	0.030	25.0	15.0	3.0	0.3	20			
	typ	0.015	1.7	0.5	0.005	0.015	22	14.5	2.7	0.2	10			
All-weld mechanical	Typica	l values as	welded	ł			TIG							
properties	Tensile	e strength			MI	Pa	610							
	0.2% Proof stress				MI	Pa	440							
		ation on 4d				%	35							
	-	ation on 5d				%	31							
		tion of area				% 54								
		Impact energy Hardness cap/mid		+ 20°C			> 90							
	Hardne	ess cap/mic	1		Н	$V \mid 20$	)5/220							
Typical operating				TIG			/IG		SAW					
parameters	Shield	-		Argon			$2\%O_2 *$		SSB *					
	Curren			DC-			PC+		DC+					
	Diame			2.4mm	-		2mm		2.4mi					
	Param			100A, 12			A, 26V		350A, 2	28 V				
		prietary Ar C <b>r</b> (Cr com						o suitable	».					
Packaging data	ø mm			TIG		Ν	٨IG		SAW	/				
	1.2					15kg	g spool							
	1.6			2.5kg tu										
	2.0			2.5kg tu										
	2.4			2.5kg tu					25kg c					
	3.2			2.5kg tu	be				25kg c	oil				
Fume data	MIG f	ume compo	osition	(wt %) (	ΓIG and S	AW fum	e negligi	ble)						
	1	_		Ma	Cr <sup>3</sup>	Ni	Мс	· · ·	Cu	OES (mg/i	m <sup>3</sup> )			
		F	e	Mn	0	INI	IVIC	, C	Ju					



SUPERCORE	3091	No			Do	ownhar	d rutile	e flux co	ored w	ire for	dissimilar weldin		
Product description		Flux cored wire made using an austenitic stainless steel sheath and rutile flux system. The wire combines easy operability, high deposit quality and exceptional weld bead appearance for downhand and HV welding.											
	Metal recovery is about 90% with respect to wire.												
Specifications	BS EI	AWS A5.22       E309LMoT0-4         BS EN ISO 17633-A       T 23 12 2 L R M 3         BS EN ISO 17633-B       TS309LMo-FM0											
ASME IX Qualification	QW43	QW432 F-No 6, QW442 A-No 8											
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN		
(weld metal wt %)	min		0.5				22.0	12.0	2.0		15		
	max	0.04	2.0	1.0	0.025	0.030	25.0	14.0	3.0	0.3	25		
	typ	0.03	1.3	0.7	0.01	0.02	23	12.8	2.3	0.1	20		
All-weld mechanical	As wel	ded				r	nin	typic	al				
properties	Tensile	e strength			MI	Pa 5	50	700	)				
	0.2% Proof stress				MI	Pa 3	350		)				
	Elongation on 4d					%	25	32					
	Elongation on 5d					%	25	30					
	Reduction of area					%		40					
	Impact	Impact energy				J							
	Hardne	ess			Н	V		245	5				
Operating parameters	The w	ire is suit	able for	use on 10 neters as be amp-vol	0%CO <sub>2</sub> . elow (for	100%CC	O₂ increas		by ~3V)	: stick	should not exceed 859 out 0mm		
Packaging data	The as Resista possib	Spools vacuum-sealed in barrier foil with cardboard carton: 12.5kg 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 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	compositi	ion (wt	%)									
		-	Fe	Mn	Ni	Cr <sup>3</sup>	Cr <sup>e</sup>	<sup>3</sup> Cı	J F	- o	ES (mg/m <sup>3</sup> )		
			16	11	3	4	6	<1	1 6	5	0.8		

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#### **Product description**

MMA electrode with rutile flux system made on high purity 304L stainless steel core wire. Deposits a low carbon 309 type weld metal with a minimum niobium level of 0.7%.

Recovery is about 115% with respect to core wire and 65% with respect to the whole electrode.

#### **Specifications**

AWS A5.4E309Nb-16 (previously E309Cb-16)BS EN 1600E 23 12 Nb R 32

**ASME IX Qualification** 

QW432 F-No 5, QW442 A-No 8.

#### Materials to be welded

There are no comparable parent materials; used for overlays only.

#### Applications

Ultramet 309Nb is designed specifically for use where niobium stabilised weld metal is required in overlays, or inlays, on CMn or low alloy steels. A minimum niobium content of 0.7% in undiluted weld metal ensures a fully stabilised deposit of approximately 347 composition is produced in the first layer on mild and medium carbon steels.

It may also be useful for the first run when welding 321 or 347 clad steels, prior to completion with 347 type weld metal. It is not recommended as an alternative to 309L types for dissimilar welded joints.

#### **Microstructure**

In the as-welded condition the microstructure consists of austenite with a ferrite content of 8-20FN.

#### Welding guidelines

Preheat is dependent on the base material hardenability, eg none on mild steel, up to  $200^{\circ}$ C on hardenable (0.4%C) steels.

With a typical dilution of 25-30% on a medium carbon steel, Ultramet 309Nb could produce a fully austenitic weld deposit. It is well known that weld metals containing niobium are especially sensitive to hot cracking when little or no ferrite is present. Therefore it is desirable to minimise dilution in the first layer of overlays by controlling parameters and bead overlap (aim for 50% overlap).



#### DATA SHEET B-53

### **ULTRAMET 309Nb**

If PWHT is applied there will be some weld metal embrittlement, although ductility should remain acceptable after normal times and temperature. However fusion boundary embrittlement can be more severe and acceptability should be established with representative procedure tests.

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	Cu
min		0.5				22.0	12.0		0.70	
max	0.04	2.5	0.9	0.025	0.030	25.0	14.0	0.50	1.00	0.50
typ	0.03	1.5	0.5	0.01	0.02	23	12.5	0.05	0.8	0.1

#### All-weld mechanical properties

As welded		typical	
Tensile strength	MPa	660	
0.2% Proof stress	MPa	470	
Elongation on 4d	%	34	
Elongation on 5d	%	31	
Reduction of area	%	52	

#### Parameters

DC +ve or AC (OCV: 70V min)

ø mm	2.5	3.2	4.0	
min A	60	75	100	
max A	90	120	155	

#### Packaging data

a mm	2.5	32	4.0
ø mm	2.5	3.2	4.0
length mm	300	350	350
kg/carton	13.8	15.6	15.9
pieces/carton	717	441	288

#### Storage

**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.

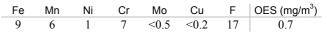
For electrodes that have been exposed:

**Redry**  $150 - 200^{\circ}$ C/1-2h to restore to as-packed condition. Maximum 250° C, 3 cycles, 10h total.

**Storage** of redried electrodes at 100-200°C in holding oven or 50-200°C in heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, >18°C.

#### Fume data

Fume composition, wt % typical:





## **Stainless Steels**

## 22%Cr DUPLEX STAINLESS STEELS

#### Alloy type

22%Cr standard duplex ferritic-austenitic stainless steels.

#### Materials to be welded

**ASTM** A182 Gr F51 A890 Gr 4A (cast) **BS** 318S13

1.4462 X2CrNiMoN22-5-3 **UNS** S31803, S32205 J92205 (cast)

**BS EN & DIN** 

#### Proprietary alloys include:

Sandvik	SAF2205
Avesta Polarit	2205
Creusot Ind	UR 45N
Böhler	A903
VDM	Cronifer 2205LCN
S+C	Maresist F51 (cast)
Sumitomo	SM22Cr
Lean and Mo-free duplex i	including:
(UNS S32304 / DIN 1.4362 /	X2CrNiN23L)
Sandvik	SAF 2304
Creusot Ind	UR35N
LDX 2101	Avesta Polarit

#### **Applications**

Duplex stainless steel pipe, plate, fittings and forgings have an approximate 50:50 microstructure of austenite with a ferrite matrix. This, coupled with general alloying level, confers:

- high strength compared with standard austenitic steels, eg type 316L.
- good general corrosion resistance in a range of environments.
- high resistance to chloride induced stress corrosion cracking (CSCC).
- high resistance to pitting attack in chloride environments, eg seawater.

These alloys are finding widening application in the offshore oil/gas, chemical and petrochemical process industries, eg pipework systems, flowlines, risers, manifolds etc.

#### DATA SHEET **B-60**

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#### Microstructure

Multipass welds in the as-welded condition contain about 25–50% ferrite depending on dilution and heat input/cooling rate conditions.

#### Welding guidelines

Preheat not generally required. Interpass temperature 150°C max. Heat input in the range 1.0–2.5 kJ/mm (depending on material thickness) should be acceptable but some codes restrict the max to 1.75 or 2.0kJ/mm.

#### **PWHT**

Although welds in wrought duplex stainless steels are almost always left in the as-welded condition, major repairs to castings are generally specified in the solution treated condition. Experience has indicated good properties following 1120°C/3-6h + water quench with or without a cooling step to 1060°C before quenching.

#### **Additional information**

A Technical Profile covering duplex and superduplex stainless steels is available.

#### **Related alloy groups**

Superduplex (data sheets B-61, B-62 and B-63) and duplex matching consumables for casting repairs.

Process	Product	Specification
MMA	Supermet 2205	-
	Ultramet 2205	AWS E2209-16
	2205XKS	AWS E2209-15
TIG/SAW	ER329N	AWS ER2209
MIG	ER329N / 2205 MIG	AWS ER2209
SAW flux	SSB	BS EN SA AF2 DC
FCW	Supercore 2205	AWS E2209T0-4
	Supercore 2205P	AWS E2209T1-4



## General Data for all 22%Cr Duplex MMA Electrodes

Storage	for longer t moisture pi For electroc <b>Redry</b> 200 <b>Storage</b> of	<ul> <li>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.</li> <li>For electrodes that have been exposed:</li> <li>Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 380° C, 3 cycles, 10h total.</li> <li>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): &lt; 60% RH, &gt; 18°C.</li> </ul>									
Fume data	Fume comp	osition, v	vt % typic	cal:							
		Fe	Mn	Cr	Ni	Мо	Cu	F *	OES (mg/m <sup>3</sup> )		
		7	6	6	1	0.2	< 0.2	16	0.8		
	* F = 28%		0	-	1 but this c	•			0.8		

SUPERMET 2	205		Rutile electrode for 22%Cr duplex										
Product description	MMA electrode w specification A5.4									the neares	t AWS		
	<b>Supermet 2205</b> is made on high quality stainless steel core wire with a rutile flux system designed to give minimum carbon content coupled with optimum operating characteristics.												
	<b>Supermet 2205</b> is designed for welding wrought, forged or cast "standard" duplex stainless steels for service in the <b>as-welded</b> condition. Good properties are also obtained when <b>solution treated</b> , as frequently required for casting repairs. The electrode has a rutile flux system and is used primarily for downhand and H-V welding applications. Smaller sizes offer excellent all-positional operability.												
	Recovery is about	overy is about 120% with respect to core wire, 65% with respect to whole electrode.											
Specifications	NONE No	earest is AWS A	A5.4 E220	)9-16.									
ASME IX Qualification	QW432 F-No-,	QW442 A-N	o 8										
Composition	C	Mn Si	S	Р	Cr	Ni	Мо	Cu	Ν	$PRE_{N}$			
(weld metal wt %)	min	0.5 0.3			24.0	8.5	3.0		0.14	36			
	0.00	2.0 1.0	0.02	0.03	26.0	10.0	4.0	0.5	0.25	43			
	$\begin{array}{c c} \text{typ} & 0.02 \\ \text{PRE}_{\text{N}} = & \text{Cr} + 3.31 \end{array}$	1 0.7 Mo + 16N	0.01	0.02	25	9.5	3.4	0.1	0.17	38			
All-weld mechanical properties	As welded			min	typical		Pipe butt weld	1120° 3h + V					
	Tensile strength		MPa 690		850		867	800					
	0.2% Proof stress				480	650		752	480 32	)			
	Elongation on 4d		%		20			25 35					
	Reduction of area Impact energy	+20°C		% J		40 60-73	40						
	impact energy	+20°C - 20°C		1		45-55		 45-50					
		- 30°C		J		40-52		42-46	> 90	)			
		- 40°C		J		35-47		38-43	> 70	)			
		- 50°C		J		30-40		35-40	> 3	5			
Operating parameters	DC +ve or AC (O	CV 55V min)											
	ø mm	2.5		3.2		4.0		5.0					
	min A	50		65		100		130					
	max A	90		120		160		190					
Packaging data	ø mm	2.5		3.2		4.0		5.0					
	length mm	300		350		350		450					
	kg/carton	12.0		13.2		13.8		18.6					
	pieces/carton	630		354		255		165					



ULTRAMET 22	205						Rutile	e all-j	oositio	nal el	ectrod	e for 22	2%Cr (	duplex
Product description	carbon	n content	coupl	ed with o	optimun	y stainless n operatin down and	g characte	eristics	. The ele	ectrode l				
	Recov	ery is ab	out 12	20% with	respect	to core w	vire, 65%	with r	espect to	whole	electrod	le.		
Specifications	AWS BS EN	A5.4 N 1600			2209-16 22 9 3 1	5 N L R 3 2								
ASME IX Qualification	QW43	W432 F-No 5, QW442 A-No 8												
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	Ν	$PRE_{N}$		
(weld metal wt %)	min		0.5	0.3			22.0	8.5	2.8		0.14	34		
	max	0.03	2.0	0.90	0.02	0.03	23.5	10.0	3.5	0.5	0.2	38		
	typ	0.02	1	0.7	0.01	0.02	23.2	9	3.2	0.1	0.17	36		
All-weld mechanical	As wel	ded					mir	ı	ty	pical				
properties	Tensile	e strengt	h	Ν			690	)	:	850				
	0.2% F	Proof stre	ess			MPa	480	)		675				
	Elonga	ation on 4	4d				20			27				
	-	ation on $\$$				%	20			25				
		tion of a	rea			%				40				
	Hardne					0 (HRC)				5 (< 24)				
	Impact	energy		+ 20		J (mm)				(> 0.8)				
				- 20 - 50		J (mm) J (mm)				8 (> 0.5 (>0.38	·			
				- 50		J (11111)			32-41	(>0.30	)			
Operating parameters	DC +v	ve or AC	(OCV	7: 50V m	iin).					U			Ê	Û
	ø mm			2.5		3.2	2		4.0		5.0			
	min A			60		75	i		100		130			
	max A			90		12	0		155		190			
Packaging data	ø mm			2.5		3.2	2		4.0		5.0			
	length	mm		300		35	0		350		450			
	kg/cart	ion		12.0		13.			13.5		18.3			
	pieces	/carton		654		37	2		243		177			

2205XKS		Basic pipe-welding electrode for 22%Cr duplex
Product description	MMA electrode ma operability.	de on duplex stainless core wire with a special basic flux to give optimum all-positional
	Recovery is about 10	05% with respect to core wire, 65% with respect to whole electrode.
		basic flux system and is recommended where the highest sub-zero toughness is required, and ding positional welding applications such as fixed pipework qualified in the ASME 6G
Specifications	AWS A5.4	E2209-15
•	BS EN 1600	E 22 9 3 N L B 4 2
ASME IX Qualification	QW432 F-No 5, 0	QW442 A-No 8



## 2205XKS (continued)

Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	Ν	PRE <sub>N</sub>			
(weld metal wt %)	min		0.5				22.0	8.5	3.0		0.15	35			
. ,	max	0.04	2.0	0.90	0.02	0.03	23.5	10.0	3.5	0.75	0.20	38			
	typ	0.03	1	0.6	0.01	0.02	23	9	3.2	0.1	0.17	36			
	PRE <sub>N</sub> =	= Cr + 3	.3Mo +	- 16N											
All-weld mechanical												1120 – 1135°C			
properties	As weld	ded					min		typi	cal		+WQ			
	Tensile	strengt	h			MPa	690		750-	870		790			
	0.2% P	roof stre	ess			MPa	450		630-	700		480			
	Elonga	tion on 4	4d			%	20		28	8		41			
	Elonga	tion on <del>t</del>	5d			%	20	26			37				
	Reduct	ion of a	rea			%			45			64			
	Impact	energy		+ 20		J			> 85						
		1			- 50°C		47		> 60			>75			
				- 75°C		J			> 3						
	Hardne	SS				HV			260-2	290		240			
Operating parameters	DC +ve	e only.								U	$\checkmark$		Î		
	ø mm			2.5		3.2	2		4.0		5.0				
	min A			50		70	)		100		130				
	max A			75		95	5		155		190				
Packaging data	ø mm			2.5		3.2	2		4.0		5.0				
	length i	mm		300		35	00		350		350				
	kg/carte			12.0	)	13.	5		13.5		13.5				
	pieces/	carton		720		40	2		273		171				

### ER329N / 2205 MIG

Solid welding wire for 22%Cr duplex

Product description	Solid	duplex st	ainless	wire for	welding	2205 tyj	pe duple	x stainl	ess stee	ls.					
Specifications	BS E	A5.9 N ISO 14 N ISO 14 901: Pt2	1343-E	22 9 SS2	2209 9 3 N L 209 3.3892										
ASME IX Qualification	QW4	QW432 F-No 6, QW442 A-No 8													
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	Ν				
(wire wt %)	min		1.0	0.25			22.5	8.0	3.0		0.14				
	max	0.03	2.0	0.65	0.020	0.030	23.5	9.5	3.5	0.3	0.20				
	typ	0.015	1.6	0.5	0.001	0.015	23	8.2	3.2	0.1	0.17*				
		329N MI 5%N to 6			-	ed wire is	selected	for sui	tability	for both	MIG and auto-TI	G, with typically			
All-weld mechanical											typical				
properties	Typica	al values a	as welde	ed			min		т	ΊG	MIG	SAW + SSB			
h h	Tensil	e strength	1			MPa	690		8	20	800-835	790			
	0.2%	Proof stre	SS			MPa	450		6	640	560-620	630			
	Elonga	ation on 4	d			%	20			36	28-35	30			
	Elonga	ation on 5	d			%	20			33	30	27			
	Hardn	ess				HV				< 310)	270 (< 310)	275 (< 320)			
						HRC			23 (	< 28)	23 (< 28)	23 (< 28)			
				- 30°	C	J			180 (	> 140)	> 70				
	Impac	t energy				3				·		75 (>55)			
	Impac	t energy		- 50° - 75°	C	J J			180 (	> 120) (>70)	> 60	75 (>55) 55 (>35)			



## ER329N / 2205 MIG (continued)

			/					
Typical operating		TIG		MIG	3	SA	W	
parameters	Shielding	Argor	ı	Ar / He	/ CO <sub>2</sub>	SSB	lux *	
	Current	DC -		pulse	ed	DC	2 +	
	Diameter	1.6 / 2.41	nm	1.2m	m	1.6	nm	
	Parameters	100A, 1	2V	180A, 1	28V	350A	, 30V	
	* LA491 flux also	o suitable.						
Packaging data	ø mm	TIG		MIG	3	SA	W	
	0.8			15kg sj	pool	-	-	
	1.0			15kg sj	pool	-	-	
	1.2	2.5kg tu	be	15kg sj	pool	-	-	
	1.6	2.5kg tu	be			25kg	coil	
	2.0	2.5kg tu	be			to o	rder	
	2.4	2.5kg tu	be			25kg	coil	
	3.2	2.5kg tu	be			-	-	
Fume data	MIG fume compo	sition (wt %) (	TIG and S	AW fume r	negligible)			
	Fe	e Mn	Cr <sup>3</sup>	Ni	Мо	Cu	OES (mg/m <sup>3</sup> )	
	28	3 10	20	8	1.5	< 0.5	2.5	

Flat and positional FCAW for 22%Cr duplex

Product description	to weld positio	High performance rutile flux cored wires produced in the most versatile size of 1.2mm. <b>Supercore 2205</b> is suited to welding in the flat and horizontal-vertical positions (material > 6mm). <b>Supercore 2205P</b> is optimised for positional welding, both vertical up and for fixed pipework qualified in the ASME 5G or 6G welding positions (pipe typically > 150mm diameter, > 15mm wall). Made with an austenitic stainless steel sheath and rutile flux system. Weld metal carbon content is typically													
				c stainless recomme						l metal c	arbon co	ntent is ty	pically		
	Metal	recovery	about 9	0% with r	espect to	the wire	e.								
Specifications		A5.22 N ISO 17 N ISO 17		E2 T	upercoi 2209T0-4 22 9 3 N \$2209-F	4 I L R M		E2 T	209T1-	NLPM					
ASME IX Qualification	QW43	QW432 F-No 6, QW442 A-No 8													
Composition (weld metal wt %)	min max typ * PRI	C  0.04 0.03 E (pitting	Mn 0.5 2.0 1.2 resistar	Si  1.00 0.7 nce equiva	$\frac{S}{0.02} = 0.01$ lent) = C	P  0.030 0.02 Cr + 3.3N	Cr 21.5 24.0 23 Mo + 16N	Ni 8.5 10.0 9.2	Mo 2.8 4.0 3.1	Cu  0.3 0.1	N 0.08 0.20 0.12	PRE* 34 38 35			
All-weld mechanical properties	0.2% F Elonga Elonga Reduct Impact Hardne	e strength Proof stres ation on 4 ation on 5 tion of are energy	ss d d ea s are for	- 20°C - 50°C - 75°C Supercor	H	Pa % % J J J V	min 690 480 20 20      y energy va	typical 800 630 32 29 45 65 * 55 * 30 * 270 alues for <b>S</b>		re 2205 a	are typica	ılly 40J at -	-20°C,		



## SUPERCORE 2205, 2205P (continued)

Operating parameters	Gas mixtures withou suitable for use with	t oxygen add 100% CO <sub>2</sub> .	litions can	be helpful i	for optimu	im weld me	etal tough	rgon should not exceed iness. <b>Supercore 2205</b> requires approx 3V hig	is also							
	ø mm	amp-vo	lt range		typic	al		stickout								
	1.2							15-20mm								
	1.2 P	130A-2	20V to 250	A-34V	140A	A-23V		15-20mm								
Packaging data	The as-packed shelf Resistance to moistu possibility of porosi	life is virtua ire absorptio ty, it is advis	lly indefin n is high, l ed that pa	<ul> <li>Spools vacuum-sealed in barrier foil with cardboard carton: 15kg</li> <li>The as-packed shelf life is virtually indefinite.</li> <li>Resistance to moisture absorption is high, but to maintain the high integrity of the wire surface and prevent possibility of porosity, it is advised that part-used spools are returned to polythene wrappers.</li> <li>Where possible, preferred storage conditions are 60% RH max, 18°C min.</li> </ul>												
Fume data	Fume composition (	wt %)														
Fume data	Fume composition (	wt %) Mn	Ni	Cr <sup>3</sup>	Cr <sup>6</sup>	Cu	F	OES (mg/m <sup>3</sup> )								

SSB FLUX											Sub-arc flux
Product description	Agglomerated b	asic non	-alloying	flux for	submerg	ed arc we	elding.				
Specifications	DIN 32522 BS EN 760		BFB6 63 SA AF2		C8M						
ASME IX Qualification	QW432 F-No	-, QW4	142 A-No	) -							
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	N
(typical)	ER329N wire	0.015	1.6	0.5	0.001	0.015	23	8.5	3.2	0.1	0.17
	deposit	0.02	1.3	0.5			22.5	8.5	3.1	0.1	0.15
All-weld mechanical	As welded										
properties with	Tensile strength		М	Pa	790						
ER329N wire	0.2% Proof stres		Μ	Pa	630						
	Elongation on 40	t			%	30					
	Hardness			H	IV	275 (< 32	20)				
				H	RC	23 (< 28	,				
	Impact energy		- 30°C		J	75 (>55	5)				
			- 50°C		J	55 (>35	j)				
Operating parameters	Current: DC +	ve range	s as below	•							
	ømm	Ũ	amp-volt	range		ť	vpical		stic	kout	
	1.6		200-350		1V		300A, 28	V	20-	25mm	
	2.4		250-450			3	350A, 29	V	20-	25mm	
Packaging data		< 60% R	H, > 18°C	If the			0				age conditions for eriod, it should be



## **Stainless Steels**

## 25%Cr SUPERDUPLEX - ZERON<sup>®</sup> 100

#### Alloy type

25%Cr superduplex ferritic-austenitic stainless steels matching the proprietary Zeron<sup>®</sup> 100 alloy.

#### Materials to be welded

#### Matching

wrought: cast: UNS J93380, DIN 1.4508 UNS S32760 DIN 1.4501 ASTM A890 6A, ASTM A182 F55 ACI CD3MWCuN

### Other superduplex, including

wrought: UNS S32750, 2507 (Sandvik/Avesta), UR47N (CLI) UNS S32550, S32520, UR52N+ (CLI), Ferralium SD40 (Meighs) UNS S39274, DP3W (Sumitomo), UNS S32950, 7-Mo Plus (Carpenter) cast: UNS J93404, DIN 1.4469 ASTM A890 5A, ACI CE3MN

#### **Applications**

Zeron<sup>®</sup> 100 has an exceptional combination of strength and resistance to corrosion and erosion in a wide range of aggressive media. The presence of Cu+W provides superior resistance to sulphuric and hydrochloric acids when compared to similar alloys without these Offshore applications exploit the high additions. resistance to pitting and stress-corrosion cracking in seawater. It is also highly resistant to caustic alkalis and phosphoric acid. Service temperature range is usually limited to -50°C to 280°C, the upper limit owing to thermal instability ("450°C" and sigma embrittlement).

It is widely used in oil and gas production and process pipework, risers, manifolds, pressure vessels, valves, pumps, desalination plant, systems for flue-gas desulphurisation (FGD) and also in the mining, chemical and pharmaceutical industries. Zeron<sup>®</sup> 100 wires are also used for joining supermartensitic stainless steels.

#### **B-61** DATA SHEET

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#### **Microstructure**

Multipass welds in the as-welded condition consist of a duplex austenite-ferrite microstructure with an approximate 30-60% ferrite level, depending on heat input/cooling conditions.

#### Welding guidelines

Preheat not generally required. Interpass temperature 150°C max. Heat input in the range 1.0-2.0 kJ/min (depending on material thickness) should be acceptable but most codes restrict the max to 1.5 or 1.75kJ/mm.

#### **PWHT**

Although welds in wrought duplex stainless steels are almost always left in the as-welded condition, major repairs to castings are generally specified in the solution treated condition. Experience has indicated good properties following 1120°C/3-6h + water quench.

#### Additional information

Further information on the welding of Zeron<sup>®</sup> 100 is available in the Metrode Technical Profile on duplex and superduplex.

#### **Related alloy groups**

2507 superduplex (data sheet B-62) and matching consumables for casting repair (solution annealed) applications.

Process	Product	Specification
MMA	Zeron <sup>®</sup> 100XKS	BS EN E25 9 4 NLB
TIG/MIG/SAW	Zeron <sup>®</sup> 100X	BS EN 25 9 4 NL
SAW flux	SSB	BS EN SA AF2 DC
	LA491	BS EN SA FB 255AC
FCW	Supercore Z100XP	



## General Data for all Zeron<sup>®</sup> 100 MMA Electrodes

Storage	for longer th moisture pick For electrode <b>Redry</b> 200 – <b>Storage</b> of re	an a work-up and k-up and es that hat - 300°C/1 edried el-	king shift increase we been e l-2h to res ectrodes a	t of 8h. the risk o exposed: store to a at 50 – 20	Excessive f porosity s-packed 00°C in h	e exposure y. condition olding ov	e of elect a. Maxim en or hea	rodes to h hum 400° ( ted quiver	umid co C, 3 cycle : no limi	use from tin is satisfa nditions will cause s es, 10h total. it, but maximum 6 w c lid): < 60% RH, > 1	some
Fume data	Fume compo	osition, w	rt % typic	al:							
		Fe	Mn	Ni	Cr	Cu	Мо	V	F	OES (mg/m <sup>3</sup> )	
		7	6	1	7	0.5	0.2	< 0.1	28	0.7	

ZERON <sup>®</sup> 100	KS			Bas	sic pi	be-w	elding	g ele	ectro	de fo	or sup	berdu	plex
Product description	Basic coated all as-welded cond ferrite microstr positions such a Fully alloyed m Recovery is abo	ition. 7 uctural as fixed atching	This ele phase pipewo g Zeron	ectrode is balance. ork qualif <sup>®</sup> 100 cor	overmato It is des ied in the e wire in	ching wi signed for e ASME cluding	th respector the model or the model 6G position W and C	et to nic ost den tion. Cu. Mo	kel cont nanding	ent to a vertica	chieve c al and ov flux tech	orrect au verhead	stenite-
Specifications	AWS A5.4 BS EN 1600 Weir Material Approvals	S	1	E2595-15 E 25 9 4 1 MDS 128 ABS, DN	NLB42 809/08	2							
ASME IX Qualification	QW432 F-No	-, QV	<b>1442</b> A	A-No -									
Composition (weld metal wt %)	C           min            max         0.040           typ         0.03	Mn  1.0 0.9	Si  1.0 0.5	S  0.01 0.005	P  0.03 0.02	Cr 24.0 26.0 25	Ni 9.0 10.0 9.3	Mo 3.5 4.0 3.6	W 0.5 1.0 0.7	Cu 0.5 1.0 0.7	N 0.2 0.3 0.23	PRE <sub>N</sub> 40  41	PRE <sub>w</sub> 40  42
	Pitting resistand Pitting resistand							N					
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stres Elongation on 5 Reduction of are Impact energy Hardness	ss d	- 20' - 50'		MPa MPa % J J HV	min 750 550 20    	80 65 2 4	vpical 0-950 0-750 2-25 0-45 > 55 > 40 0-320					
Operating parameters	DC +ve								U	$\swarrow$		Ê	Î
	ø mm min A max A		2.5 50 75		3.2 70 95		4. 10 15	)0		5.0 130 210			
Packaging data	ø mm length mm kg/carton pieces/carton		2.5 300 12.0 696		3.2 350 14.1 360		4. 35 13 27	50 .5		5.0 350 13.5 172			



ZERON <sup>®</sup> 100X							So	olid v	weldir	ng wir	e fo	or sup	erdu	plex		
Product description	Solid wire for TIG, MIG and SAW. For applications where Zeron <sup>®</sup> 100X wire is to be used for welding supermartensitic stainless steels it is possible for wire to be supplied with a total hydrogen content of 3ppm maximum.													ossible		
													1			
Specifications	-	N ISO 14 Materia		25 M	ER2594 25 9 4 N L (prefix W=TIG, G=MIG, S=SAW) MDS 12809/07 ABS, DNV (TIG and SAW in conjunction with SSB flux)											
ASME IX Qualification	QW4	<b>32</b> F-No	-, QV	<b>/442</b> /	A-No -											
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	W	Cu	Ν	PRE <sub>N</sub>	PREw		
(wire wt %)	min						24.0	9.0	3.5	0.5	0.5	0.2	40	40		
	max	0.03	1.0	1.0	0.01	0.03	26.0	10.0	4.0	1.0	1.0	0.3				
	typ	0.015	0.7	0.4	0.002	0.02	25	9.3	3.7	0.6	0.7	0.23	41	42		
All-weld mechanical	Туріса	al values a	as welde	ed			min		TIG	MIG		SAW	TIG +	-160°C		
properties	Tensil	e strength	า			MPa	750		870	860		885	7	69		
	0.2%	Proof stre	SS	MPa			550		695	645		700	5	23		
	Elonga	ation on 4	d			%			36			26		39		
	Elonga	ation on 5	d			%	20		32	23		24		34		
	Reduc	tion of ar	ea			%			68	28		48		72		
	Impac	t energy		-50°	°C	J			130	60		40				
				-75°	°C	J			>100							
	Hardn	ess cap/n	nid			HV			290	290		290				
Typical operating				Т	IG		MIG			SAW						
parameters	Shield	ling		Ar	gon		Ar/He/C	$O_2$	,	SSB flux						
	Currer	nt		D	C-		pulsec	1		DC+						
	Diame	eter		1.6/2	.4mm		1.2mn			1.6mm						
	Voltag	le		100A	, 12V		180A, 2	8V	3:	50A, 30V	r					
Packaging data	ø mm			Т	IG		MIG			SAW						
	0.8			-			To ord	er								
	1.0			-			To ord	er								
	1.2			-			To ord	er								
	1.6				g tube				2	5kg coil						
	2.4			2.5kg	g tube				2	25kg coil						
	3.2			2.5kg	g tube											
Fume data	MIG f	fume com	positio	n (wt %	5) (TIG :	and SAV	V fume ne	gligibl	e)							
			Fe	Mn	(	Cr <sup>3</sup>	Ni	Мо	Cu	0	DES (n	ng/m³)				
			28	10		22	8	2	1.3		2.	3				



SSB FLUX										Sub	o-arc	flux
Product description	Agglomerated basi	c non-all	oying fl	ux for su	bmerged	arc weld	ling.					
Specifications	DIN 32522 BS EN 760		FB6 633 A AF2 E	53 DC8N DC	M							
ASME IX Qualification	QW432 F-No-,	QW442	A-No -									
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	W	Ν
(typical)	Zeron <sup>®</sup> 100X wire Deposit	0.015 0.02	0.7 0.6	0.4 0.4	0.002 0.002	0.023 0.02	25 24.5	9.3 9.3	3.7 3.6	0.7 0.7	0.7 0.7	0.23 0.21
All-weld mechanical	Typical values as w	elded			mi	n		SAW	1			
properties with	Tensile strength			MPa	75	0		890				
Zeron <sup>®</sup> 100X wire	0.2% Proof stress			MPa	55	0		700				
	Elongation on 4d			%				25				
	Elongation on 5d			%	20	)		24				
	Reduction of area			%				>40				
	Impact energy	- 4	50°C	J				40				
	Hardness			HV				290				
Operating parameters	Current: DC +ve ra	anges as	below:									
	ø mm	an	np-volt ra	ange		typ	oical		sticko	out		
	1.6	20	00-350A	, 27-31V		30	0A, 28V		20-25	5mm		
	2.4	25	50-450A	, 28-32V		35	0A, 29V		20-25	5mm		
Packaging data	Metrode <b>SSB Flux</b> opened drums: <6 redried in the range	0%RH,>	>18°C.	If the flux			0			U		

### LA491 FLUX

Sub-arc flux

Product description	Agglomerated flue	oride-ba	sic non-al	loying flu	ıx for suł	omerged	l arc weld	ling.				
Specifications	DIN 32522 BS EN 760		B FB 6 55 SA FB 25		8							
ASME IX Qualification	QW432 F-No -,	QW44	2 A-No -									
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	W	Ν
(typical)	Zeron <sup>®</sup> 100X wire	0.015	0.7	0.4	0.002	0.02	25	9.3	3.7	0.7	0.7	0.23
	Deposit	0.02	0.6	0.4	0.002	0.02	24.5	9.3	3.6	0.7	0.7	0.21
All-weld mechanical	Typical values as v	velded			min			SAW				
properties with	Tensile strength			MPa	750	)		890				
Zeron <sup>®</sup> 100X wire	0.2% Proof stress			MPa	550	)		700				
	Elongation on 4d			%				25				
	Elongation on 5d			%	20			24				
	Reduction of area			%				>40				
	Impact energy		- 50°C	J				40				
	Hardness			HV				290				
Operating parameters	Current: DC +ve a	ranges a	s below:									
	ø mm		amp-volt ra	ange		typ	oical		sticko	ut		
	1.6		200-350A	, 27-31V		30	0A, 28V		20-25	mm		
	2.4		250-450A	, 28-32V		35	0A, 29V		20-25	mm		
Packaging data	Metrode <b>LA491 F</b> opened drums: < 0 redried in the range	50%RH	,>18°C.	If the flux								



## SUPERCORE Z100XP

Rutile flux cored wire for superduplex stainless steel

Product description	easy o	lux cored wire made with an alloyed stainless steel sheath and rutile flux system. <b>Supercore Z100XP</b> combin asy operability, high deposit quality for both positional pipework and downhand welding. Metal recovery bout 90% with respect to the wire.												
Specifications	There	are no n	ational	specific	ations fo	or this w	rire.							
ASME IX Qualification	QW4	32 F-No	o, Q	W442	A-No									
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	W	Ν	$PRE_{N}$	PREw
(weld metal wt %)	min						24.0	8.5	3.5	0.5	0.5	0.2	40	40
	max	0.04	1.5	1.0	0.01	0.03	26.0	10.0	4.0	1.0	1.0	0.3		
	typ	0.03	1.0	0.5	0.005	0.02	24.5	9.1	3.7	0.6	0.6	0.22	41	41
							Mo + 16N Mo + 1.6		6N					
All-weld mechanical	As we	lded					min		typica	I				
properties	Tensil	e strengt	h			MPa	750		880					
• •	0.2%	Proof stre	ess			MPa	550		690					
	Elonga	ation on	4d			%			27					
	Elonga	ation on	5d			%	20		25					
	Reduc	ction of a	rea			%			33					
	Impac	t energy		-20°	°C	J			40					
				-50°	°C	J			32					
	Hardn	ess				HV			280					
						HRC			26					
Operating parameters					CO2 at 20- clow for .		n. Proprie CO2:	tary gas	ses may be	e used b	out argo	n should	not excee	ed 85%.
	ø mm			amp	-volt rang	ge		typio	cal		sticl	kout		
	1.2			120	– 250A,	20 - 32	2V	180	A, 26V		15 -	- 20mm		
Packaging data	The as Resist possib	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 propossibility 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.										and prev	vent any	
Fume data	Fume	compos	ition (w	t %)										
			Fe	Mn	١	Ni	Cr <sup>3</sup>	Cr <sup>6</sup>	Cu	F	·   C	DES (mg	/m³)	
			14	10	1	.5	5	5	< 1	5		1.0		



## **Stainless Steels**

## 25%Cr SUPERDUPLEX - 2507

#### Alloy type

25% Cr superduplex ferritic-austenitic stainless steel.

#### Materials to be welded

#### 25%Cr superduplex:

UNS S32750, S32760 \* ASTM A182 F53, F55 BS EN 10088-2 X2CrNiMoN25-7-4 (1.4410) SAF 2507 (Sandvik/Avesta) Uranus 47N (CLI)

#### **Castings:**

UNS J93404 ASTM A890 Gr5A, 6A \* ACI CE3MN

#### \* Zeron<sup>®</sup> 100 (see DS: B-61)

#### Applications

Superduplex stainless steel pipe, plate, fittings and forgings have an approximate 50:50 microstructure of austenite with a ferrite matrix. This, coupled with general alloying level confers:

- high strength compared with standard austenitic steels eg. type 316L.
- good general corrosion resistance in a range of environments.
- high resistance to chloride induced stress corrosion cracking (CSCC).
- high resistance to pitting attack in chloride environments eg. seawater.

These alloys are finding widening application in the **offshore oil/gas, chemical** and **petrochemical** process industries, eg. **pipework systems, flowlines, risers, manifolds** etc.

#### DATA SHEET B-62

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#### **Microstructure**

Multipass welds in the as-welded condition consist of a duplex austenite-ferrite microstructure with an approximate 30-60% ferrite level, depending on heat input/cooling conditions.

#### Welding guidelines

Preheat not generally required. Interpass temperature 150°C max. Heat input in the range 1.0–2.0 kJ/min (depending on material thickness) should be acceptable but most codes restrict the max to 1.5 or 1.75kJ/mm.

#### **PWHT**

Although welds in wrought duplex stainless steels are almost always left in the as-welded condition, major repairs to castings are generally specified in the solution treated condition. Experience has indicated good properties following  $1120^{\circ}C/3-6h + water quench$ .

#### **Additional information**

Further information on the welding of 2507 superduplex is available in the Metrode Technical Profile on duplex and superduplex.

#### **Related alloy groups**

Zeron<sup>®</sup> 100 superduplex (data sheet B-61) and matching consumables for casting repair (solution annealed) applications.

Process	Product	Specification
MMA	2507XKS	BS EN 25 9 4 NLB
	Ultramet 2507	BS EN 25 9 4 NLR
FCW	Supercore 2507	-
	Supercore 2507P	-



## General Data for all 2507 MMA Electrodes

Storage	for longer moisture p For electro <b>Redry</b> 200 <b>Storage</b> of	<ul> <li>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.</li> <li>For electrodes that have been exposed:</li> <li>Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.</li> <li>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): &lt; 60% RH, &gt; 18°C</li> </ul>										
Fume data	Fume com	position, w	vt % typic	al:								
		Fe	Mn	Ni	Cr	Cu	Мо	V	F *	OES (mg/m <sup>3</sup> )		
		7	6	1	7	0.5	0.2	< 0.1	16	0.7		

2507XKS					Ba	asic pi	be-w	eldir	ng el	ect	rode f	or superduplex
Product description	Basic coated all-positional MMA electrode for welding superduplex alloys for service in the as-welded condition This electrode is overmatching with respect to nickel content to achieve correct austenite-ferrite microstructural phase balance. It is designed for the most demanding vertical and overhead welding positions such as fixed pipework qualified in the ASME 5G/6G position, and for applications requiring the highest toughness.											
	Recov	ery is ab	out 10	5% wit	h respect	to core wi	ire, 65%	with r	espect t	o who	ole electro	ode.
Specifications	AWS BS E	A5.4 N 1600			2594-15 2 25 9 4 N	N L B 4 2						
ASME IX Qualification	QW4	<b>32</b> F-No	o-, Q	W442	A-No -							
Composition (weld metal wt %)	min max typ	C  0.04 0.03	Mn 0.5 2.0 1	Si  1.0 0.5	S  0.02 0.01	P  0.03 0.02	Cr 24.0 26.0 25	Ni 8.5 10.5 9.5	Mo 3.5 4.5 3.8	Cu  0.5 0.1	N 0.20 0.30 0.22	PRE <sub>N</sub> 40 46 41
All-weld mechanical properties		ded e strengt Proof stre				MPa MPa	min 800 550		typical 900 700		trans	/>3h + WQ verse * 760 
	Elonga Reduc	ation on a ation on a tion of a t energy	5d		-20°C	% % J	22 18 		28 25 45 85			
	Hardn				-50°C -75°C	HV			60 35 280-33(	)		  300
			ive pro	perties	for soluti		welds in			- 1		ade 5A. Ferrite >30%.
Operating parameters	DC +v	ve										
	ø mm min A max A			2.5 50 75		3.2 70 95			4.0 100 155		5.0 130 190	
Packaging data	ø mm length kg/cart pieces			2.5 300 12.9 669	) 0	3.2 350 13.5 420			4.0 350 13.5 267		5.0 350 13.5 165	



ULTRAMET 2	507				Ru	utile a	ll-pos	ition	al el	ectr	ode f	or sup	perdupl	ex
Product description	electro		ermat										condition.	
	Recov	ery is at	out 10	)5% with	h respect	to core w	vire, 65%	with re	spect to	o whol	e electro	de.		
Specifications	AWS BS EI	A5.4 N 1600		_	2594-16 225 9 4 1	5 N L R 3 2	,							
ASME IX Qualification	QW43	32 F-No	o-, Q	W442	A-No -									
Composition (weld metal wt %)	min max typ	C  0.04 0.03	Mn 0.5 1.5 1	Si  1.0 0.8	S  0.02 0.01	P  0.03 0.02	Cr 24.0 26.0 25	Ni 8.5 10.5 9.5	Mo 3.5 4.5 4	Cu  0.5 0.1	N 0.20 0.30 0.23	PRE <sub>N</sub> 40 46 42		
All-weld mechanical	As we	lded					min		typical					
properties	Tensile	e strengt	h			MPa	750		890					
	0.2% F	Proof stre	ess			MPa	550		750					
	Elonga	ation on 4	4d			%	22		26					
		ation on				%	20		24					
		tion of a	rea			%			35					
	Impact	t energy			-20°C	J			28					
	Linda			-	-50°C	1117		_	>21					
	Hardne	ess				HV HRC		4	275-315 28					
Operating parameters	DC +v	ve or AC	(OCV	/: 55V n	nin)	- Inte			20	Ū			Ê	Î
	ømm			2.5		3.2			4.0					
	min A			60		75			00					
	max A			90		12	0	-	55					
Packaging data	ø mm			2.5		3.2			4.0					
	length			300		35			350					
	kg/car			11.4		13.			3.8					
	pieces	/carton		609	)	39	3		249					



## SUPERCORE 2507, 2507P

Rutile flux cored wires for superduplex stainless steel

Product description	easy of <b>Super</b>	operabili core 25	ity, higl 0 <b>7P</b> cor	h depos nbines	sit qualit easy oper	ty and rability,	exception	al beac osit qua	d appeara	ance fo	r down	<b>upercore 2507</b> co hand and HV v pipework and do	welding.
Specifications	There	are no n	ational	specific	ations fo	r these	wires.						
ASME IX Qualification	QW4	32 F-No	o, Q	W442	A-No								
Composition (weld metal wt %)	min	C	Mn 	Si 	S 	P 	Cr 24.0	Ni 8.5	Mo 3.5	Cu 	N 0.2	PRE <sub>N</sub> 40	
	typ	0.04 0.03	2.0 1.0	1.0 0.5	0.02 0.010	$\frac{0.03}{0.02}$	$\frac{26.0}{24.5}$	10.5 9.3	4.5 3.8	0.5 0.05	0.3	41	
All-weld mechanical	As we		ice equi	valent	$PKE_N = 0$	JT + 3.3	Mo + 16 min		typica	ıl			
properties	0.2% I Elonga Elonga Reduc Impac Hardn * Va at	alues giv -20°C a	ess 4d 5d rea * /en are f nd 30J a	at -50 <sup>°</sup> C	°C °C ercore 25			) ues for \$	_	re 2507		ically: 45J at +20	
Operating parameters				es as be amp 140	-280A, -250A,	Ar-20% ge 22-35	CO <sub>2</sub> :	typic 180	·	e used t		n should not excer cout - 20mm - 20mm	ea 85%.
Packaging data	The as Resist possib	s-packed ance to poility of p	shelf li moisture porosity	fe is vir e absorp , it is ac	tually ind ption is h lvised the	definite igh, but at part-u		ain the l ls are re	nigh integ turned to	polythe		surface and prev ppers.	vent any
Fume data	Fume	compos		ŕ			0.3	<u> </u>	-				
			Fe 14	Mn 10		Ni .5	Cr <sup>3</sup>	Cr <sup>6</sup> 5	Cu < 1	F 5		DES (mg/m <sup>3</sup> )	



## **Stainless Steels**

## 25%Cr SUPERDUPLEX WITH 2%Cu

#### Alloy type

Superduplex ferritic-austenitic alloy with nominally 25%Cr-8%Ni-3.5%Mo-1.5%Cu-0.2%N.

#### Materials to be welded

	cast
ASTM	A240 UNS S32550 (wrought).
	A351 & A744 grade CD4MCu.
	A890 grade 1A/UNS J93370.
	A890 grade 1B/UNS J93372.
DIN	1.4515 (G-X3CrNiMoCuN 26 6 3).
	1.4517 (G-X3CrNiMoCuN 26 6 3 3).
BS	3100 grade 332C13.
	3146 grade ANC21.
Proprietary	Ferralium 255 and SD40 (Meighs).
	Uranus 50M, 55, 52N, 52N+ (CLI).
	Ferrinox 255 (Advanced Metals).

#### **Applications**

These consumables are designed to match similar alloys, usually supplied as castings. The addition of copper improves corrosion resistance in sulphuric acid media and potentially increases strength and wear resistance, but as-welded toughness and pitting performance in chloride media are reduced in comparison to alloys with <1%Cu. Although the composition is controlled to ensure a minimum Pitting Resistance Equivalent (PRE) of 40 to match the superduplex alloys and maximise resistance to pitting consumables with <1%Cu may be preferred for nonsulphuric acid media unless PWHT is applied (see later).

Applications include **pumps** and **valves**, **corrosion/wear resisting parts**, and **process equipment** for use in **offshore oil** and **gas industries**, **pulp**, **paper** and **textile industries**, and **chemical** and **petrochemical plant**.

#### DATA SHEET **B-63**

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#### Microstructure

In the as-welded, or solution annealed condition, the microstructure is duplex with about 25-60% ferrite.

#### Welding guidelines

For general fabrication welds no preheat is generally required and interpass is kept below 150°C. For castings and other highly restrained welds a preheatinterpass range of 100-225°C is helpful in avoiding any risk of hydrogen cracking.

#### **PWHT**

The consumables are designed to be predominantly used in the solution annealed condition. Castings will invariably require solution annealing and both electrode and flux cored wire provide higher toughness and somewhat lower strength after solution annealing. The G48A performance is also better following solution annealing. Typical PWHT is carried out at 1120°C for about 2-3 hours and then water quenched.

#### **Related alloy groups**

Solid filler wire to match these alloys (AWS ER2553) has only 6%Ni, so welds usually have excess ferrite. The best alternative is Zeron<sup>®</sup> 100X with 0.7%Cu (DS B-61). Copper-free 2507 electrodes are also available (DS B-62).

Process	Product	Specification
MMA	Supermet 2506Cu	AWS E2553-16
FCW	Supercore 2507Cu	-



Product description	MMA electrode alloying and de risk of cracking	oxidation	n. Nitroger	n and nic	kel are c	ontrolled					
	Recovery is abo	out 140%	with resp	ect to con	re wire,	65% with	respect to	whole	electrode	<b>.</b>	
Specifications	AWS A5.4 BS EN 1600 BS 2926			-16 3 Cu N I st 25.6.2.							
ASME IX Qualification	QW432 F-No	5, <b>QW</b>	442 A-No	8							
Composition	С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	N	PRE *
(weld metal wt %)	min	0.5				24.0	7.5	2.9	1.5	0.18	40
	max 0.04	1.5	1.0	0.025	0.030	27.0	8.5	3.9	2.5	0.25	
	typ 0.03	1	0.4	0.01	0.02	25.5	8	3.5	1.7	0.22	41
	* PRE (Pitt	ing Resi	stance Equ	ivalent)	= %Cr +	- 3.3%Mo	+ 16%N				
All-weld mechanical	Typical as-welde	ed and P	WHT			1120°C/2h			As-we		
properties						nin *	typical	_	min	typical	
	Tensile strength			MP		590	775		760	925	
	0.2% Proof stres Elongation on 4			MP		185	575 32		550 15	780	
	Elongation on 5			%		16	32		15 15	17 16	
	Reduction of are				6		40			25	
	Impact energy		+ 20°C		J		70			35	
	1		- 30°C		J		60			22	
	Hardness			HV	7		260			340	
			re appropr ooling is ii		ASTM C			lution t	reated fo	r optimun	n corrosion
Operating parameters	DC +ve or AC	(OCV: 7	0V min)					Ų	$\checkmark$		Ê Î
	ø mm		2.5		3.2		4.0		5.0	-	
	min A		60		75		100		130		
	max A		90		120		155		210		
Packaging data	ø mm		2.5		3.2		4.0		5.0		
	length mm		300		350		350		450		
	kg/carton		12.0		15.0		15.0		16.5		
	pieces/carton		513		321		216		111		
Storage	<b>3 hermetically</b> for longer than moisture pick-u	a worki	ng shift of	8h. Exc	essive e						
	For electrodes t Redry 200 – 25 Storage of redr	50°C/1-2 ied elect	h to restor rodes at 50	e to as-pa ) – 200° <b>(</b>	C in hole	ling oven	or heated	quiver:	no limit	, but maxi	imum 6 wee
	recommended.	Recomn	nended am	bient stor	age con	ditions for	opened ti	ns (usin	g plastic	lid): < 609	% RH, >18°
		6 typical:									
Fume data	Fume composit	Fume composition, wt %									
Fume data		Fe	Mn	Ni	Cr	Cu	Мо	V	F	OES	(mg/m <sup>3</sup> )



Product description		Flux cored wire made with an alloyed stainless steel sheath and rutile flux system. The <b>Supercore 2507C</b> combines easy operability, high deposit quality and exceptional bead appearance for downhand and HV welding												
	Metal	Metal recovery is about 90% with respect to wire.												
Specifications	There	There are no national specifications for this wire, the nearest relevant specification is AWS A5.22 E2553T0-4												
ASME IX Qualification	QW4	QW432 F-No, QW442 A-No												
Composition		C Mn Si S P Cr Ni Mo Cu N <b>PRE<sub>N</sub></b>												
(weld metal wt %)	min						24.0	8.5	3.2	1.0	0.2	40		
(	max	0.04	1.5	1.0	0.02	0.03	26.0	10.5	4.2	2.0	0.3			
	typ	0.03	0.8	0.5	0.005	0.02	24.5	9.3	3.7	1.4	0.25	41		
	Pitting	g resistar	nce equi	valent	$PRE_N = 0$	Cr + 3.3	Mo + 16	N						
All-weld mechanical	Туріса		1120°(	C/2h + W	/Q	,								
properties							ty	ypical		min		typical		
•	Tensil	MPa		760		750		780						
	0.2% Proof stress MPa							450		550				
	Elongation on 4d %							40				35		
		ation on				%		39		20		33		
		ction of a	rea		+20°C J							32		
	Impac	ct energy						65				40		
	Hardn	0000		-50	-50°C J HV			45 250			>27 300			
	narun	less				ΠV		230				300		
Operating parameters		dinggas: ent:DC+					-	etary ga	ses may	be used l	but argo	n should not e	exceed 85	
	ømm		ve rung	1	p-volt ran		002	typi	cal		stic	kout		
	1.2				-280A,	-	V		A, 28V			– 20mm		
Packaging data	Spool	ls vacuur	n-sealed	l in bar	rier foil v	with card	lboard ca	arton: 1	5kg					
	-	s-packed							C					
												e surface and	prevent	
	possit	bility of p	porosity	, it is ac	lvised the	at part-u	sed spoc	ols are re	turned to	o polyth	ene wra	ppers.		
	Where	e possibl	e, prefe	rred sto	orage con	ditions a	are 60%	RH max	x, 18°C r	nin.				
	Where possible, preferred storage conditions are 60% RH max, 18°C min. Fume composition (wt %)													
Fume data	Fume	compos	ition (w	t %)										
Fume data	Fume	compos	ition (w Fe	t %) Mr	۱ <b>۲</b>	Vi	Cr³	Cr⁵	Cu	F	-   (	DES (mg/m³)		

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SECTION C

### **HIGH TEMPERATURE ALLOYS**

### Consumables for elevated temperature service

The 300H consumables are designed for welding matching high carbon stainless steels typically used at service temperatures of 400-800°C. To ensure optimum performance under these service conditions not only is the carbon controlled (normally 0.04-0.08%C) but the ferrite and total alloying are also carefully regulated to minimize the formation of brittle intermetallic phases.

The 309 consumables in this section should not be confused with the 309L/309Mo types used for dissimilar welding (B-50 and B-51). The 309 consumables in Section C generally have controlled carbon and ferrite and are designed for matching base materials for elevated temperature service.

Consumables in the 330, 800 and HP40 alloy sections are designed to match a wide range of **special austenitic** alloys which are used primarily for resistance to **creep** and **hot corrosion** or **oxidation**. In all types, the presence of a controlled level of carbon is essential for hot strength. Parent alloys with 0.4% carbon or more are produced predominantly in cast form and have quite low room temperature ductility, but in general this does not have an adverse effect on weldability.

Preheat is not normally required for welding these alloys, with the exception of the highest alloy high carbon types containing tungsten which can suffer from cold cracking due to build up of residual stresses and low ductility. Interpass temperature and heat input control is more important for the lower carbon types to minimise any possibility of hot cracking. The presence of a copious primary carbide eutectic tends to suppress hot cracking in the higher carbon types. PWHT is rarely applied to any of the alloys in this section, although service-aged base material may require solution treatment to restore satisfactory ductility prior to welding.

Data	Alloy	Brooss	Broduct	Specifications				
Sheet	Alloy	Process	Product	AWS	BS EN			

300H sta	ainless stee	consumables for ele	evated temperature service		
		N 4 N 4 O	Ultramet 308H	E308H-16	E 19 9 H R
		MMA	Ultramet B308H	E308H-15	E 19 9 H B
C-10	308H	TIG/MIG/SAW	308596	ER308H	19 9 H
		FCW	Supercore 308H	E308HT0-4	
		FCW	Supercore 308HP	E308HT1-4	
		MMA	Ultramet 347H	E347-16	E 19 9 Nb R
C 11	C-11 347H	IVIIVIA	Ultramet B347H	E347-15	E 19 9 Nb B
0-11		TIG/SAW	ER347H	ER347	19 9 Nb
		FCW	Supercore 347HP	E347T1-4	T 19 9 Nb P M 2
		MMA	Supermet 16.8.2	E16.8.2-17	
		IVIIVIA	E16.8.2-15	E16.8.2-15	
C-12	16.8.2	TIG	ER16.8.2	ER16.8.2	W 16 8 2
0-12	10.0.2	SAW	ER16.8.2	ER16.8.2	S 16 8 2
		FCW	Supercore 16.8.2		
		FCW	Supercore 16.8.2P		
		MMA	17.8.2.RCF		BS: 17.8.2.R
C-13	316H		Ultramet 316H	E316H-16	E 19 12 2 R 32
		TIG/MIG/SAW	316\$96	ER316H	19 12 3 H



Data	Alloy	Process	Product	Speci	fications
Sheet	Alloy	FIOCESS	Floadet	AWS	BS EN
High ten	nperature 30	)9 alloys			
C-20	253MA	MMA	Supermet 253MA		
C-21	309	MMA	Thermet 309CF	E309H-16	(E 22 12 R)
6-21	309	TIG/MIG	309\$94	ER309	23 12 H
C-22	309H	MMA	Thermet 309H		
	309W	MMA	Thermet 309W		BS: 23.12.W.R

310 stainless steels for high temperature service											
		MMA	25.20 Super R	(E310-16)	E 25 20 R						
C-30	310	IVIIVIA	Ultramet B310Mn	(E310-15)	E 25 20 B						
		TIG/MIG/SAW	310\$94	ER310	25 20						
C-31	310H	MMA	Thermet 310H	E310H-15	E 25 20 H B						

Consumables for alloys 330 and 800											
C-40	900	MMA	Thermet 800Nb								
C-40	800	TIG/MIG	21.33.Mn.Nb								
C-41	330	MMA	Thermet R17.38H	(E330H-16)	BS: 15.35.H.R						
C-45	25.35.Nb	MMA	Thermet 25.35.Nb								

Consum	ables for HF	40 and other high	carbon cast alloys	
C-50	HP40Nb	MMA	Thermet HP40Nb	 BS: 25.35.H.Nb.B
0-50		TIG/MIG	25.35.4C.Nb	 
C-60	35.45	MMA	Thermet 35.45.Nb	 
0-00	55.45	TIG/MIG	35.45.Nb	 
C-70	HP50	MMA	Thermet HP50WCo	 
C-80	22H	MMA	Thermet 22H	 
C-90	657	MMA	Nimrod 657	 



# High Temperature Alloys

## **308H CONSUMABLES**

#### Alloy type

For 304/304H materials used at elevated temperatures.

#### Materials to be welded

	wrought	cast
ASTM / UNS	304H/S30409	CF10, CF8
DIN	1.4948	
BS	304S51	302C25, 304C15

#### **Applications**

The 308H consumables are designed to match unstabilised 18Cr-10Ni austenitic stainless steels for elevated temperature strength and oxidation resistance. These steels and the weld metal have carbon content controlled to 0.04-0.08%.

Composition limits of the MMA electrodes and FCAW wires are tightened above those of BS/AWS specifications in order to meet requirements of *Shell* and other operators of refinery equipment. Weld metal Cr and Ni are kept low and ferrite is controlled to minimise embrittlement by sigma phase. Beneficial and detrimental minor elements and residuals are also controlled to optimise high temperature properties. No bismuth-bearing constituents are allowed in these consumables, to ensure <0.002%Bi as required by API 582.

The 308H consumables should also be considered for welding thick (>12mm) stabilised grades 321H or 347H to avoid in-service HAZ cracking and low creep rupture ductility associated with 347 weld metal. Note that some authorities recommend the use of type 16-8-2 types for these steels, including 304H.

308H is widely used in **petrochemical** and **chemical process plant**, particularly for the fabrication of **cyclones**, **transfer lines** used to re-circulate the catalyst in **catalytic crackers** (cat crackers) operating in the range 400-815°C.

#### DATA SHEET C-10

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#### **Microstructure**

Austenite with delta ferrite controlled 2-8FN.

#### Welding guidelines

Preheat not required; maximum interpass temperature 250°C. No PWHT required.

#### **Additional information**

Farrar J.C.M. and Marshall A.W.: 'Type '300H' austenitic stainless steel weld metals for high temperature service'

Marshall A.W. and Farrar J.C.M.: 'Influence of residuals on properties of austenitic stainless steel weld metal, with particular reference to energy industries' (Conference) Stainless Steels '84, pp 271-285, Metals Society, London 1985.

There is also a Metrode Technical Profile covering the use of these products in the petrochemical industry on cat crackers.

#### **Related alloy groups**

See also the consumables in the related alloy groups of 347H (C-11), 16.8.2 (C-12) and 316H (C-13).

Process	Product	Specification
MMA	Ultramet 308H	AWS E308H-16
	Ultramet B308H	AWS E308H-15
TIG/MIG	308896	AWS ER308H
SAW	308596	AWS ER308H
	SSB	BS EN SA AF2 DC
FCW	Supercore 308H	AWS E308HT0-4
	Supercore 308HP	AWS E308HT1-4



ULTRAMET 3			Rutile	e elect	trode f	for 30	4H stainl	ess steel							
Product description	MMA	electrod	le with	rutile f	lux on ma	atching c	ore wire.								
	Recov	ery is ab	out 11	0% with	n respect	to core v	vire, 65%	with res	pect to v	whole el	lectrode	<b>.</b>			
	feature	es includ	le optir	num ve		or downl							sign. These smetic finish		
	The smaller sizes are particularly suited to vertical and overhead welding applications including fixed pipework. In addition, the 2.5mm diameter is specifically designed to enable the root pass to be deposited in single side butt welds using standard MMA equipment without a gas purge.														
Specifications	BS EI BS 29	AWS A5.4E308H-16BS EN 1600E 19 9 H R 3 2BS 292619.9.RDIN 8556E 19 9 R 23													
ASME IX Qualification	QW43	QW432 F-No 5, QW442 A-No 8													
Composition		C	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN				
(weld metal wt %)	min max	0.04 0.08	0.5 1.5	0.9	0.025	0.030	18.0 21.0	9.0 11.0	0.25	0.5	2 8				
	typ	0.03	1.5	0.6	0.025	0.030	18.5	9.5	0.25	0.05	3				
	-	Mo + Nb + Ti = 0.25% max Note: Cr content of 2.5mm is typically 19.5%.													
All-weld mechanical											Hig	h Temperat	ure		
properties	As wel		L-			MD	min	typical		650°C		732°C	816°C		
		e strengt Proof stre				MPa MPa	560 350	610 445		29		231 187	181 156		
	Elonga	ation on 4	4d			%	35	45		-	-				
	•	ation on { tion of a				% %	30		43 35	2		51 63	53 64		
		t energy	lea	+ 20°C		J			80	-	-				
	Hardne	ess		Н				19	0-210	-	-				
Operating parameters	DC +v	DC +ve or AC (OCV: 50V min)											€ 1		
	ø mm			2.5	5	3.	2	4.	0		5.0				
	min A max A			60 90		75 120		10 15			130 210				
Packaging data	ømm			2.5		3.2		4.			5.0				
r ackaging data	length	mm		300		35		35			450				
	kg/car			12.		13		13			17.1				
	pieces	carton		726	)	41	4	26	01		171				
Storage	for mu moistu For ele <b>Redry</b> Storag	ich longe ire pick- ectrodes v 200 – 3 ge of red	er than up and that ha 600°C/2 Iried el	a worki increas we beer 1-2h to ectrode	ng shift o the risk n exposed restore to s at 50 –	f 8h. Exo c of poro l: o as-pack 200°C in	cessive ex sity. ed conditi 1 holding	posure o ion. Max oven or 1	f electro cimum 4 heated c	odes to h 400° C, quiver: 1	umid co 3 cycles no limit	onditions wil s, 10h total. , but maxim	s satisfactory l cause some um 6 weeks RH, > 18°C.		
Fume data	Fume	composi	ition, w	rt % typ	ical:										
			Fe	Mr	n l	Ni	Cr	Cu	F	O	ES (mg/	m <sup>3</sup> )			
			8	5	C	).8	5	< 0.2	16		1				



Product description	MMA electrode with basic carbonate-fluoride flux on matching core wire.													
								-		ole electr	ode			
		-			-			-						
	<b>Ultramet B308H</b> is particularly suited to positional welding, including fixed pipework qualified in the ASME 60 position, in materials thickness from 3mm up to the heaviest sections.													
Specifications	AWS	-			H-15									
	-	N 1600		E 19 9 H B 4 2										
	BS 29	-		19.9. E 10										
		<b>DIN 8556</b> E 19 9 B 20+												
ASME IX Qualification	QW43	QW432 F-No 5, QW442 A-No 8												
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN			
(weld metal wt %)	min	0.04	0.5				18.0				2			
	max typ	0.08	2.0	0.9	0.025	0.03			0.25	0.5	8 3			
		Nb + Ti :	-		0.01	0.02	10.5	).5	0.1	0.05	5			
All-weld mechanical									1		High Temperat	ure		
properties	As wel	ded					min	typ	bical	650°C	732°C	816°C		
•	Tensile	strength	1			MPa	560	6	650		225	154		
		Proof stre				MPa			460		168	111		
	0	tion on 4				%			41					
	-	tion on 5				%	30		38		48	47		
		tion of ar energy	ea	$+20^{\circ}$	°C	% J			48 100		63	54		
	Hardne	•••		1 20	C	HV			10					
Operating parameters	DC +v	e.							Γ			î Î Î		
	ø mm		I	2.5		3.2		4.0		5.0				
	min A			60		75		4.0		13				
	max A			90		120		15:		21				
Packaging data	ø mm			2.5		3.2		4.0	)	5.	0			
	length	mm		300		35		35		45				
	kg/cart			12.0		13.		13.		16				
	pieces	carton		726		414		26		15	9			
Storage	3 hern	netically	sealed	ring-pu	ll metal	tins per	arton, wi	th unlimi	ted shelf	life. Dire	ect use from tin i	s satisfactor		
								osure of	electrode	es to humi	d conditions wi	ll cause som		
		re pick-ı					ity.							
		ectrodes			-		d conditi	on Max	mum 400	$1^{\circ}$ C 3 a	cles, 10h total			
											imit, but maxin			
											stic lid): < 60%			
Fume data	Fume	composi	tion, wt	% typic	al:									
			Fe	Mn	Ν	i	Cr	Cu	F	OES (	mg/m³)			
	1		8	5	0.		5	< 0.2	28		1			



308S96

Solid wire for 304H stainless steel

Product description	Solid w	ire for '	TIG, N	IIG and	SAW.									
Specifications	AWS A BS EN BS EN BS 290 DIN 85	ISO 1 ISO 1 01: Pt2	4343-	A 19 B SS 30	R308H ( 9 H S308H 08S96 G X5CrN	ER19-1( Ni 19 9	)H on rec (1.430	-						
ASME IX Qualification	QW432	QW432 F-No 6, QW442 A-No 8												
Composition (wire wt %)	• •					0.015 d metal is	-			Cu  0.25 0.1				
All-weld mechanical properties	Typical Tensile 0.2% Pr Elongati Impact e Hardnes	strengtl roof stre ion on 4 energy	h ess Id	M] M] + 20°C			$\begin{array}{c cccc} a & 450 \\ 5 & 43 \\ J & > 100 \end{array}$							
Typical operating parameters	Shieldin Diamete Current Voltage	er		Th Arg 2.4r 100A, 12	gon nm , DC-	A	MIG r/2%O <sub>2</sub> c 3%C0 1.2m 260A, I 28V	or Ar/1- O <sub>2</sub> m DC+			SAW or SSCr flux 1.6mm 50A, DC+ 30V			
Packaging data	ø mm 0.8 1.0 1.2 1.6 2.0 2.4 3.2			TIG  To order 2.5kg tube To order 2.5kg tube 2.5kg tube			MIG To ord To ord 15 kg sj   	der der		2	SAW   25kg coil 25kg coil To order			
Fume data	MIG fu	me con	npositi Fe 32	-	6) (TIG	fume neg Cr <sup>3</sup> 16	gligible): Ni 8		Cu 0.5	OES (mg/m <sup>3</sup> ) 3.1				



## SUPERCORE 308H / 308HP

Downhand and positional FCW for 304H stainless steel

Product description	Flux c	ored win	es mad	e with a	an auster	nitic stain	less steel	sheath	n and rut	ile flu	x system	L <b>.</b>		
	primar	<b>Supercore 308H</b> is designed for ease of use, exceptional weld bead appearance and high weld metal integrity primarily in downhand and H-V welding situations with plate and material of a 6mm thickness or greater <b>Supercore 308HP</b> designed for all-positional welding from 1G/2G up to 5G/6G pipework.												
	Metal recovery is about 90% with respect to wire.													
Specifications	AWS BS EN	A5.22 N ISO 1	7633-	E	upercor 308HT0 S308H-I	-4	E30	ercore 8HT1- 08H-F	4	(1 <b>.2</b> m	ım only)			
ASME IX Qualification	QW43	QW432 F-No 6, QW442 A-No 8												
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN			
weld metal wt %)	min	0.04	1.0				18.0	9.0			3			
	max	0.08	2.0	1.0	0.03	0.04	20.0	11.0	0.5	0.5	8			
	typ	0.05	1.3	0.5	0.01	0.02	18.8	9.5	0.1	0.1	5			
All-weld mechanical properties	As welded								typical		650°C	High Temperatu 732°C	ire 816°C	
	Tonsile	estrengt	'n			MPa	550		620		287	222	163	
		Proof stre				MPa			420		213	177	103	
		tion on				%	35		40					
	U	tion on				%	30		36		30	46	40	
	Reduct	tion of a	rea			%			50		58	69	74	
	Impact	energy		+ 2	+ 20°C J				100					
	Aged a	at 730°C	/1000h			J			90					
Operating parameters						)-251/min	. Proprie	etary ga	ises may	be use	ed but arg	gon should not e	exceed 809	
		nt: DC+	-ve rang	-							- 1			
	ø mm 1.2				p-volt rar	nge to 250A-1	321		ical 0A-29V			ickout 2 – 20mm		
		sitional)		-		to 250A			5A-24V			2 - 20mm 2 - 20mm		
	1.2 (po	onorial)				to 330A			0A-30V			5 - 25mm		
Packaging data	The as Resista spools	-packed ance to a are retu	shelf l moistur rned to	ife is vir e absor polythe	rtually in ption is l ene wrap		to preve	nt any	possibil			it is advised th 1.	at part-us	
Fume data	Fume	compos	ition (w	vt %):										
			Fe	Mr	า	Ni	Cr <sup>3</sup>	Cr <sup>6</sup>	С	r	F	OES (mg/m <sup>3</sup> )		
			17	11		2	4	5	<1		5	1		



# High Temperature Alloys

## **347H STAINLESS STEEL**

#### Alloy type

Controlled, high carbon Nb stabilised stainless steel for elevated temperature service.

#### Materials to be welded

<b>ASTM-ASME</b>	<b>BS EN &amp; DIN</b>
321H	1.4941
347H	1.4961
<b>BS</b>	UNS
321S51	S32109
347S51	S34709

#### **Applications**

Used to weld titanium and niobium stabilised 18/8 high carbon stainless steel types 321H and 347H.

Applications include catalytic crackers (cat crackers), cyclones, transfer lines, furnace parts, steam piping, superheater headers, some gas and steam turbine components, used in petrochemical, chemical process plants and in power generation industries.

Note that the alloy 16.8.2 (data sheet C-12) was developed as a more ductile alternative to 347H consumables to avoid in-service HAZ failure in 347H base material of >12mm thickness. For this reason when joining thicker section 321H/347H the 16.8.2 consumables are considered a preferable alternative.

#### DATA SHEET C-11

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For welding 321/347 for general corrosion resisting applications at temperatures up to about 400°C use 347 (data sheet B-31) or 308L (data sheet B-30) consumables.

For cryogenic applications requiring >0.38mm (15mils) charpy lateral expansion at -196°C, use unstabilised weld metal with low carbon and controlled ferrite (B-37).

#### Microstructure

Austenite with 2-9FN, typically 4FN (solid wire typically 8FN).

#### Welding guidelines

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

#### **Related alloy groups**

The 308H (data sheet C-10), 16.8.2 (data sheet C-12) and 316H (data sheet C-13) consumables are also relevant for many of the same materials and applications.

Process	Product	Specification
MMA	Ultramet 347H	AWS E347-16
	Ultramet B347H	AWS E347-15
TIG/SAW	ER347H	AWS ER347
FCW	Supercore 347HP	AWS E347T1-4



## General Data for all 347H MMA Electrodes

Storage	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfor longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause moisture pick-up and increase the risk of porosity. For electrodes that have been exposed:</li> <li>Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.</li> <li>Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 recommended. Recommended ambient storage conditions for opened tins (using plastic lid): &lt; 60% RH, &gt;</li> </ul>								cause some um 6 weeks			
Fume data	Fume composi	tion, wt	% typical:									
		Fe	Mn	Ni	Cr	Cu	F *	OES (mg/m <sup>3</sup> )				
		8	5	0.8	5	< 0.2	16	1				
	* F=28% for b	* F=28% for basic coated Ultramet B347 but this does not affect the OES.										

ULTRAMET 3	47H					All-po	ositiona	al rutile l	MMA	electro	de for :	321H/	347H	
Product description	MMA rutile flux coated 347 electrode on high purity 304L core wire. Ultramet 347H has all the benefits of an advanced rutile flux design, including all-positional fixed pipework welding with the 2.5/3.2mm diameter electrodes.													
	Recove	ery is abou	ut 110%	with res	pect to co	re wire,	65% with	n respect to	whole	electrod	e.			
Specifications	AWS BS EN BS 29 DIN 85	N 1600 26		19.9.1	9 Nb R32									
ASME IX Qualification	QW43	32 F-No 5	5, <b>QW</b> 4	<b>142</b> A-N	lo 8									
Composition (weld metal wt %)	min max typ	C 0.04 0.08 0.05	Mn 0.5 2.0 0.7	Si  0.9 0.7	S  0.025 0.01	P  0.030 0.02	Cr 18.0 21.0 19	Ni 9.0 11.0 9.5	Mo  0.50 0.05	Nb * 8xC 1.00 0.5	Cu  0.50 0.07	FN 2 8 4		
	* BS re	equires 10	xC mini	imum.										
All-weld mechanical properties	As welded					R	oom Ten min	nperature typica	ıl 6	Hię 50°C	gh Tempe 732°C		315°C	
properties	0.2% P Elonga Elonga	e strength Proof stres Ition on 4d Ition on 5d			9		560 350 30 25 	650 500 40 37 52		354 283  19 47	308 269  20 38		233 206  7 23	
Operating parameters	DC +v	e or AC (	OCV: 50	OV min)					Ū			Î	Î	
ø mm min A max A				2.5 60 90			3.2 75 120			5.0 130 210				
Packaging data	ømm			2.5		3.2		4.0		5.0				
	length kg/carte pieces/	on		300 12.0 693		350 12.0 354		350 12.9 243		450 16.5 168				



ULTRAMET B	347⊦	1	Ba	sic pip	e-weldir	ng elea	ctrode	for 321	H/347	H whic	h is ma	de to	order	
Product description	resistar fixed p conditi slag do	MMA electrode with basic carbonate-fluoride flux on high purity 304L core wire. Designed to give good moisturesistance and hence freedom from weld porosity. The electrode is particularly suited to positional welding fixed pipework qualified in the ASME 5G/6G position and is tolerant to adverse wind and draughts under sconditions. Compared with rutile types, the basic flux gives a more convex fillet bead profile and although the slag does not self-lift, it is easily removed and gives welds of exceptional appearance and quality. Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.												
Specifications	AWS A BS EN BS 29 DIN 8	1 1600 26		E 19 19.9.1	E347-15 E 19 9 Nb B 42 19.9.Nb.B E 19 9 Nb B 20+									
ASME IX Qualification	QW43	<b>2</b> F-No 5	5, <b>QW</b> 4	<b>42</b> A-N	lo 8									
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Nb *	Cu	FN		
(weld metal wt %)	min	0.04	0.5				18.0	9.0		8xC		2		
	max	0.08	2.0	0.9	0.025	0.030	21.0	11.0	0.50	1.00	0.50	8		
	typ	0.05	1.5	0.3	0.01	0.02	19	9.5	0.05	0.6	0.07	5		
	* BS re	equires 10	xC mini	mum.										
All-weld mechanical	As weld	ded						nperature			gh Temper			
properties	Topoilo	strength			MPa		min Ko	typical 650		350°C	732°C 311	č	315°C 248	
		roof stres	s		MP			500		263	265		248 223	
		tion on 4d					30	40						
	Elonga	tion on 5d			9	6	25	37		18	14		5	
	Reduct	ion of are	а		9	6		52		43	30		19	
Operating parameters	DC +ve	e							U			Î	Î	
	ø mm			2.5		3.2		4.0		5.0				
	min A			60		75		100		130				
	max A			90		120		155		210				
Packaging data	ø mm			2.5		3.2		4.0		5.0				
	length i	mm		300		350		350 450		450				
	kg/carte			11.4		13.5		13.5		16.8				
	pieces/	carton		627		396		258		159				



ER347H								Solid	weldir	ng wire t	for 32	1H/347
Product description	Solid v	vire for TIC	and S	AW.								
Specifications	BS EN	A5.9 N ISO 1434 N ISO 1434 O1: Pt2		ER347 19 9 Nb SS347 347S96								
ASME IX Qualification	QW432 F-No 6, QW442 A-No 8											
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	Cu	FN
(wire wt %)	min	0.04	1.0	0.30			19.0	9.0		10xC		3
	max	0.08	2.5	0.65	0.020	0.030	20.0	11.0	0.3	1.0	0.3	9
	typ	0.055	1.7	0.4	0.005	0.02	19.5	9.2	0.1	0.6	0.1	8
All-weld mechanical	As wel	ded				Турі	cal	High Temperature				
properties						TIC		650°C	9	732°C		815°C
	Tensile	strength			MPa	66	0	398		312		235
		Proof stress			MPa	45	0	318		244		184
	Elonga	tion on 4d			%	42	2	23		22		22
	Elonga	tion on 5d			%	40	)	21		20		21
		tion of area			%	67		55		53		52
	Impact Energy			+20°C	J							
	Hardne	ess cap/mid			HV	190/2	230					
Typical operating				TIG		SAV	/					
parameters	Shieldi	ng		Argon *		SSE	}					
	Curren	t		DC-		DC-	F					
	Diamet	er		2.4mm	2.4mm 2.4mm							
	Parame	eters	1	100A, 12V		350A, 2	28V					
	*	Also requi	red as	a purge for	root runs	3.						
Packaging data	ø mm			TIG	TIG SAW							
	2.4	2.4 2.5kg tube					oil					
Fume data	Fume o	composition	n (wt %	) (TIG and	SAW fu	me neolic	rible)					
	i unic c	Fe		Mn	Cr <sup>3</sup>	Ni	Mo	Cu	OES	S (mg/m³)		
		32	,	12	16	8	< 0.5	< 0.5		3.1	_	



#### **SUPERCORE 347HP** All-positional rutile flux cored wire for 321H/347H **Product description** Flux cored wire made with an austenitic stainless steel sheath and rutile flux system. Supercore 347HP is designed for all-positional welding from 1G/2G up to 5G/6G fixed pipework. Metal recovery is about 90% with respect to the wire. **AWS A5.22** E347T1-4 **Specifications BS EN ISO 17633-A** T 19 9 Nb P M 2 **BS EN ISO 17633-B** TS347-FM1 **ASME IX Qualification** QW432 F-No 6, QW442 A-No 8 С Mn Si S Ρ Cr Ni Мо Nb Cu FN Composition (weld metal wt %) min 0.04 0.5 9.0 8xC ------18.0 ----4 max 0.08 2.0 1.0 0.025 0.030 21.0 11.0 0.5 1.0 0.3 9 5 typ 0.05 1.4 0.6 0.01 0.02 19.5 10.2 0.1 0.5 0.1 All-weld mechanical As welded Room Temperature **High Temperature** properties min typical 732°C Tensile strength MPa 550 310 630 0.2% Proof stress MPa 350 470 265 Elongation on 4d % 30 43 24 22 Elongation on 5d % 25 40 43 Reduction of area % 46 --Impact energy $+20^{\circ}C$ J 70 ----**Operating parameters** Shielding gas: 80% Ar-20% CO, at 20-251/min. Proprietary gases may be used but argon should not exceed 85% argon. Current: DC+ve ranges as below: ø mm amp-volt range typical stickout 180A, 29V (down-hand) 15-20mm 120-280A, 22-34V 1.2 160A, 25V (positional) 15-20mm 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 %) Cr<sup>3</sup> Cr<sup>6</sup> Cu Fe Ni F OES (mg/m<sup>3</sup>) Mn 2 17 4 5 <1 5 1 11



**C-12** 

# High Temperature Alloys

## 16.8.2 FOR HIGH TEMPERATURE 3XXH STAINLESS STEELS

#### Alloy type

16.8.2 for high temperature 3XXH stainless steels.

#### Materials to be welded

ASTM/UNS	DIN	BS
304H / S30409	1.4948	304S51
321H / S32109	1.4941	321851
347H / S34709	1.4961	347851
316H / S31609	-	316851, 316853

#### Applications

The 16.8.2 consumables have a controlled composition, optimised for performance in structural service at temperatures up to about 800°C. With molybdenum specifically at the lower limit for AWS 16.8.2, it is essentially a dilute hybrid between E308H and E316H. Rather than matching any single parent material, it has applications for welding all the '3XXH' series of stainless steels with 0.04-0.10% carbon, which combine creep, oxidation and general corrosion resistance.

A low total Cr+Mo with controlled carbon and ferrite content ensures high resistance to thermal embrittlement by intermetallic phases (and also excellent toughness at low temperatures). A strictly limited level of Mo provides valuable effects on creep ductility and thermal fatigue, balanced against control of oxidation under stagnant conditions above 650°C, and sigma or chi phase formation in service. No bismuth-bearing constituents are allowed in these consumables, to ensure <0.00 2% Bi as required by API 582.

For 304H, some authorities now choose 16.8.2 specifically to avoid hot ductility and creep-fatigue problems in thick sections which traditionally would have been welded with 308H. Historically, this weld metal was initially developed to avoid in-service HAZ failure in 347H of >12mm thickness. For the same reasons it is also a candidate for 321H, although HAZ failures here are not so well documented. For thermal stability, it is equally suitable for 316H in preference to matching weld metal.

In some applications, the chromium in 16.8.2 weld metal may be considered too low for satisfactory resistance to corrosion (possibly under dew-point conditions during plant shutdown). However, the weld root is normally on the process side, and is conventionally deposited by TIG using higher chromium weld metal. Similar electrodes for capping runs are available

#### DATA SHEET

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#### if required.

Applications include **catalytic crackers** (cat crackers), **cyclones, transfer lines, furnace parts, thick wall steam piping, superheater headers**, some **gas** and **steam turbine** components used in **petrochemical, chemical process plants** and in **power generation industries**.

Owing to the lean composition and controlled ferrite content, the 16.8.2 consumables also show useful cryogenic toughness down to  $-196^{\circ}$ C.

#### **Microstructure**

Austenite with delta ferrite of 1-6FN typically. Hot cracking is not reported at low FN.

#### Welding guidelines

Preheat is not required; maximum interpass temperature 250°C. Welds are left as-welded, no PWHT required.

#### **Additional information**

O R Carpenter and R D Wylie: "16-8-2 Cr-Ni-Mo for welding electrodes" Met. Prog. 1956, 70, (5), 65-73. This paper describes the original development (by Babcock and Wilcox) of E16-8-2 to weld 347 for power plant applications.

R D Thomas: "HAZ cracking in thick sections of austenitic stainless steels" Part 1, Weld J 1984, 63, 12, 24-32; Part 2 idem 355s-368s. This detailed review covers all standard stainless steels, in particular for high temperature structural applications.

There is also a Metrode Technical Profile available on the use of 16.8.2 consumables in cat crackers.

#### **Related alloy groups**

See also the consumables in the related alloy groups of 308H (C-10), 347H (C-11), 316H (C-13).

Process	Product	Specification
MMA	Supermet 16.8.2	AWS E16.8.2-17
	E16.8.2-15	AWS E16.8.2-15
TIG/SAW	ER16.8.2	AWS ER16.8.2
FCW	Supercore 16.8.2/P	None relevant



Product description	General purpose, all-positional MMA electrode with rutile-aluminosilicate flux on high purity 304L core wire.														
	Manufactured with 'controlled hydrogen' and moisture resistant flux covering technology to ensure high resistanc to weld porosity.														
	Recovery is about 115% with respect to core wire, 65% with respect to whole electrode.														
Specifications	AWS BS EN BS 29	N 1600		(E	16-8-2-1 E 16 8 2 H 7.8.2.AR	R)									
ASME IX Qualification	QW43	<b>32</b> F-No	5, <b>Q</b>	W442	A-No 8										
Composition		С	Mn	Si	S	Р	Cr	Ni	Mo*	Cu	FN				
(weld metal wt %)	min	0.04	0.5				14.5	7.5	1.0		1				
	max	0.08	2.5	0.60	0.03	0.03	16.5	9.5	2.0	0.75	6				
					0.01 0 – 1.3% o 1.50 – 2		15.5 equested	8.5 d other	1.2 wise.	0.1	3				
All-weld mechanical	As welded							min	typ	ical	High Temperature				
properties											650°C	732°C	816°		
	Tensile	e strengt	h			MF	MPa 550			> 620		232	161		
		Proof str				MF			> 410		225	179	126		
	-	tion on						35	42						
	-	tion on						25		2	28	47	43		
		tion of a		-+\	. 2000		%		45 > 70 (>1.3)		52	59	55		
	-	energy			+ 20°C - 50°C	J (mn	<pre>/</pre>								
	-	Impact energy (and LE*) $-50^{\circ}$ CJ (mm) $$ $>50$ (>0.9) $$ $$ *LE = Charpy lateral expansion, mm (0.38mm = 15 mils)													
Operating parameters	DC +ve or AC (OCV: 55V min)										]	l 🗧 i	2 n		
	ø mm		I	2.5		3.2 4.0					5.0				
	min A			60							130				
	max A			90			75 100 120 155				210				
Packaging data	ø mm			2.5		3.2	2		4.0		5.0				
	length	mm		300	)	35	0		350		450				
	kg/cart	on		12.0	)	13.	5		13.5		18.0				
	pieces	/carton		648		38	1		249		165				
Storage	for mu moistu For ele <b>Redry</b> Storag	ch longe re pick- ectrodes 200 – 3 ge of rec	er than up and that ha 300°C/2 Iried el	a workir increase we been 1-2h to r ectrodes	ng shift of e the risk exposed restore to s at 50 – 2	8h. Exc of poros as-packo 200°C ir	essive e sity. ed cond holdin	exposur ition. I g oven	re of elec Maximu or heate	etrodes to m 400° ( ed quiver	o humid c C, 3 cycle r: no limi	use from tin is conditions will es, 10h total. it, but maximu c lid): < 60% F	cause som		
Fume data	Fume	compos	ition, w	/t % typi	ical:										
i une uala															
i une uata			Fe	Mn	N	li	Cr	Мо	ſ	u	F	OES (mg/m <sup>3</sup> )	)		



E16.8.2-15						Basi	c pipe	weldi	ng eleo	ctrode f	for 32	XXH stain	less stee
Product description		tional ele	ectroc	le suited	to the 1	nost dema						<b>6.8.2-15</b> is a plications, in	
	Recover	ry is abo	out 11	5% with	respec	t to core v	wire, 659	% with	respect to	o whole e	lectro	de.	
Specifications	AWS A BS EN BS 292	1600		(E	16-8-2- E16 8 2 7.8.2.E	B)							
ASME IX Qualification	QW432	2 F-No	5, <b>Q</b>	W442	A-No 8	5							
Composition (weld metal wt %)	max typ	C 0.04 0.08 0.05 EN E16	Mn 0.5 2.5 1.8	Si  0.60 0.3 3 has Mo	S  0.03 0.01	P  0.03 0.02 - 2 50%	Cr 14.5 16.5 15.5	Ni 7.5 9.5 8.5	Mo* 1.0 2.0 1.2	Cu  0.75 0.06	FN 1 6 3		
	Mo	control				% unless 1	•			1			
All-weld mechanical properties	ed					min		typical	650°	°C	gh Temperatu 732°C	816°C	
	Tensile : 0.2% Pr Elongati Elongati Reductio Impact e	oof stres ion on 40 ion on 50 on of are	ss d d	-10	00°C	MPa MPa % % y J	550  35  		> 620 > 410 42 40 45 > 50	294 216  27 61	5	230 187  36 70	165 132  57 75 
Operating parameters	DC + ve		itable			- 1							i i
	ø mm			2.5		3.	2		4.0				
	min A max A			60 90		7: 12			100 155				
Packaging data	ø mm			2.5		3.	2		4.0				
	length m			300		35			350				
	kg/carto pieces/c			12.0 684		13 39			13.5 255				
Storage	for much moisture For elec <b>Redry</b> 2 <b>Storage</b>	h longer e pick-u etrodes th 200 – 30 e of redr	than p and hat ha 00°C/1 ied el	a workin increase we been 1-2h to r ectrodes	ig shift e the ris expose estore to at 50 -	of 8h. Ex sk of poro ed: to as-pack - 200°C in	cessive e sity. ed cond n holdin	exposu ition. 1 g oven	re of elect Maximun or heated	rodes to h n 400° C, l quiver: 1	umid 3 cycl no lim	use from tin i conditions wi les, 10h total it, but maxin ic lid): < 60%	ll cause sor num 6 wee
Fume data	Fume co	ompositi	ion, w	vt % typi	cal:								
			Fe	Mn		Ni	Cr	Мо	Cı		F	OES (mg/m	1 <sup>3</sup> )
			8	5		0.7	5	0.1	0.2	2 1	6	1	



ER16.8.2				S	olid w	ire TI	G and	SA	N for 3X	XH stainl	ess steel
Product description	Solid wire for TIC	6 welding	and sub-a	rc weldin	g of 300	)H stair	nless stee	el.			
Specifications	AWS A5.9 BS EN ISO 143 BS EN ISO 143	43-A	ER16-8-2 16 8 2 SS16-8-2								
ASME IX Qualification	QW432 F-No 6,	QW442	A-No 8								
Composition (wire wt %)	min 0.04 1 max 0.10 2		S 0.02 0.01 st.	P  0.03 0.01	Cr 14.5 16.5 15.5	Ni 7.5 9.5 8.5	Mo* 1.0 2.0 1.3	Cu  0.3 0.1			
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Impact energy –19	96°C	MPa MPa % % J	TIC 62 45 35 	0	al SAW 630 360 29 29 30 30		High 650°C 315 221  31 67 	Temperature 732°C 241 178  36 69 	(TIG) <u>816°C</u> 173 147  42 65 	
Typical operating parameters	Shielding Diameter Current Voltage	TIGShieldingArgonDiameter2.4Current100A				ux DC+					
Packaging data	ø mm 1.6 2.4	2.5	TIG kg tube kg tube		SAW to orde to orde	er					
Fume data	F	Fume composition (wt %) (TIG & SAV Fe Mn C 40 10 12					C < (		OES (m 4.2		



## SUPERCORE 16.8.2 / 16.8.2P

Rutile FCW for 3XXH stainless steel

Product description	maxin only a 6mm t positio	nise high nd is des thickness ons from	tempe igned f and al ASM	rature st for appli pove. <b>S</b> E 1G/20	rength and cations p upercor G up to 2	nd resistar orimarily i e <b>16.8.2P</b>	nce to se n the de is made bework,	ervice en ownhan e in 1.2r , and al	mbrittle d and H nm only	ment. V pos and i	Superce sitions on sdesigne	with alloying c ore 16.8.2 isma- plate and mate d for welding in l operability in	de in 1.6mn rial of abou all welding
Specifications	-	A5.22 N ISO 1	7633-		lone app nearest T	licable S16-8-2-I	FM1)						
ASME IX Qualification	QW4	QW432 F-No 6, QW442 A-No 8											
Composition (weld metal wt %)	min max typ * M	C 0.04 0.08 0.05 0 contro	Mn 0.5 2.0 1.2 Iled are	Si  0.70 0.5 ound 1.0	S  0.03 0.01 0 - 1.3%	P  0.04 0.02 unless rec	Cr 14.5 17.0 16.2 quested	Ni 7.5 10.0 9.2 otherw	Mo 1.0 2.0 1.1* ise.	Cu  0.5 0.1	FN 1 8 4		
All-weld mechanical properties		As welded Tensile strength					r	nin	typica	ıl	650°C	High Temperatu 732°C	ure 816°C
	0.2% I Elonga Elonga	e strengt Proof stre ation on 4 ation on 4 ction of a	ess 4d 5d			MP MP 9 9	a ó	560  35 25 	620 410 42 42 50		290 207  30 66	224 180  44 68	160 134  39 79
All-weld mechanical properties (continued)	-	t energy		, -	+ 20°C -130°C - 196°C nsion, mi	J (mm J (mm J (mm n (0.38mi	) ) )	min   mils)	tyr 100 50 45	(0.	.8)		
Operating parameters	exceed Curre ø mm 1.2 1.6	d 80%. nt: DC+	ve ran	ges as b am 130 200	elow: p-volt rar )A-25V t )A-28V t		2V 4V	typ 18 30	ical 0A-29V 0A-30V		s 1 1	used but argor tickout* 2 – 20mm 5 – 25mm	ı should no
Packaging data	The as Resist spools	Spools vacuum-sealed in barrier foil with cardboard carton: 15kg (1.2mm), 12.5kg (1.6mm) The as-packed shelf life is virtually indefinite. Resistance to moisture absorption is high, but to 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 maximum, 18°C minimum.											
Fume data	Fume	composi	tion (v Fe	vt %): Mr 11		Ni	Cr <sup>3</sup>	Cr <sup>6</sup>	С	u 1	F	OES (mg/m <sup>3</sup> ) 1.2	



## **316H TYPE CONSUMABLES**

#### Alloy type

For 316/316H materials used at elevated temperatures.

	Materials to be welded
ASTM	316/316H
	CF10M
BS	316S51
	316S52
	316S53
	316C16
	316C71
UNS	S31609

#### Applications

These consumables are designed for welding 316/316H austenitic stainless steels operating at high temperatures (500-800°C) under long term creep conditions. The 17.8.2.RCF MMA electrode is a modified 316H weld metal of lean composition to resist thermal embrittlement.

The consumables can also be used for welding 321/321H and 347/347H grades in high temperature structural service. This is particularly important in thick highly restrained weldments, since the possibility of premature service failure by intergranular HAZ cracking is reduced by using more ductile weld metal rather than 347H.

Used for welding steam piping, superheater headers, furnace parts, some gas and steam engine turbine components, in the petro-chemical industry, in fossil and nuclear fuelled power stations.

#### DATA SHEET C-13

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#### Microstructure

Austenite with delta ferrite typically controlled in the range 2-8FN.

#### Welding guidelines

Preheat not required, maximum interpass temperature 250°C. PWHT not required.

#### **Additional information**

There is a Metrode Technical Profile available covering 3XXH consumables and their use in refinery cat crackers.

#### **Related alloy groups**

See also the consumables in the related alloy groups of 308H (C-10), 347H (C-11) and 16.8.2 (C-12).

Process	Product	Specification
MMA	17.8.2.RCF	BS 17.8.2.R
	Ultramet 316H	AWS E316H-16
TIG/MIG/SAW	316896	AWS ER316H
SAW flux	SSB	BS EN SA AF2 DC



### **General Data for all MMA Electrodes**

Storage	for longer th moisture pic For electrod <b>Redry</b> 150 - <b>Storage</b> of n	han a work ek-up and i les that hav - 200°C/1- redried ele	cing shift of increase the ve been exp -2h to restor ctrodes at	of 8h. Exc e risk of poposed: posed: $50 - 200^{\circ}$	essive exp prosity. acked cond C in holdin	dition. M	electrodes aximum 25 r heated qu	to humio 50° C, 3 iver: no	rect use from tin is sati d conditions will caus cycles, 10h total. limit, but maximum ( lastic lid): < 60% RH,	se some 6 weeks	
Fume data	Fume comp	osition, wt	% typical	:							
		Fe Mn Ni Cr Mo Cu F OES (mg/m³)									
		8	5	0.7	5	0.1	< 0.2	16			

17.8.2.RCF	_	Rutile electrode for 316 at elevated temperatu										mperature	
Product description												ightly contr ) during ser	olled level of rvice.
	Design	ned prim	arily f	or down	hand and	l HV weld	ling alth	ough fo	or struct	ural app	olications	it is usable	positionally.
	Recov	covery is about 120% with respect to core wire, 65% with respect to whole electrode.											
Specifications	AWS BS 29			· · · ·	E16.8.2-1 7.8.2.R	16) neare	st						
ASME IX Qualification	QW4	<b>32</b> F-No	o-, Q	W442	A-No -								
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN		
(weld metal wt %)	min	0.06	0.5				16.5	8.0	1.5		3		
. , ,	max	0.10	2.5	0.50	0.030	0.040	18.5	9.5	2.5	0.50	8		
	typ	0.08	1.6	0.25	0.008	0.02	17	8.5	2	< 0.1	5		
All-weld mechanical	As we	lded				Room	Tempe	erature		Hię	gh Tempera	ture	
properties							min		typical	6	50°C	732°C	815°C
	Tensil	e strengt	h			MPa	560		> 630		369	274	191
		Proof stre				MPa			>460		287	197	147
	-	ation on 4				%			> 30				
	-	ation on \$				%	25		> 30		28	44	53
		tion of a	rea	10	000	%			>45		55	61	75
	Impac	t energy		-10	0°C	J			> 50				
Operating parameters	DC +v	ve or AC	(OCV	7: 70V n	nin)					U			£ î
	ø mm			2.5		3.2			4.0		5.0		
	min A			60		75			100		130		
	max A			90		120	)		155		210		
Packaging data	ø mm			2.5		3.2			4.0		5.0		
	length	mm		300	)	350	)		350		450		
	kg/car	ton		12.0	5	14.4	14.4 14.7 18.6						
	pieces	/carton		684	Ļ	411			267		165		
	1												



### **ULTRAMET 316H**

#### Rutile coated MMA electrode for 316H stainless steel

Product description	alloy o	Rutile coated electrode made on high purity 304 core wire, previously called <b>Metrode E316H-16</b> . The higher alloy content compared to 17.8.2.RCF does increase the risk of intermetallic formation during service at elevated emperatures (500-800°C).											
Specifications	AWS BS E BS 29	N 1600		E	316H-16 19 12 2 9.12.3.R								
ASME IX Qualification	QW4	<b>32</b> F-No	5, <b>Q</b>	W442	A-No 8								
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN		
(weld metal wt %)	min	0.04	0.5				17.0	11.0	2.0		3		
	max	0.08	2.0	0.90	0.025	0.030	20.0	13.0	3.0	0.5	8		
	typ	0.05	1	0.6	0.01	0.02	18	12	2.2	0.1	5		
All-weld mechanical properties	As we	lded					Room Temperature min typical			65	Hig 0°C	h Temperat 732°C	ture 815°C
proportioo	Tensil	e strengt	th			MPa	550		570	352		268	197
		Proof str				MPa	350	450		264		204	152
	Elonga	ation on	4d			%	30		35	-			
	Elonga	ation on	5d			%	25		33	3	2	43	54
	Reduc	ction of a	rea			%			50		8	53	60
Operating parameters	DC +v	ve or AC	C (OCV	: 50V n	nin)					Ų	$\swarrow$		î Î
	ø mm			2.5		3.2		4	.0				
	min A			60		75		10	)0				
	max A	۱.		90		120		15	55				
Packaging data	ø mm			2.5		3.2		4	.0				
	length	mm		300	)	350		35	50				
	kg/car	ton		11.4	1	13.5		13	.5				
	pieces	s/carton		633	;	393		20	51				

### 316S96

#### Solid wire for TIG/MIG and SAW of 316H

Product description		olid wire for TIG, MIG and SAW which can not only be used in conjunction with E316H-16, but also wire 7.8.2.RCF and other 300H consumables.											with	
Specifications	BS E	N ISO 1 N ISO 1 901: Pt	4343	-A 19 -B SS 31	R316H 0 12 3 H S316H 6S96 Jearest S	SG X5Cr	NiMo 19 I	11 1.440	03)					
ASME IX Qualification	QW4	<b>432</b> F-No 6, <b>QW442</b> A-No 8												
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN			
(wire wt %)	min	0.04	1.0	0.30			18.0	11.0	2.0		3			
	max	0.08	2.5	0.65	0.02	0.025	20.0	14.0	3.0	0.3	8			
	typ	0.05	1.8	0.5	0.01	0.02	19	13	2.2	0.15	4			
All-weld mechanical	Typica	al values	as wel	ded			typical							
properties	Tensil	e strengt	h			MPa	650							
	0.2% F	Proof stre	ess			MPa	460							
	Elonga	ation on	4d			%	35							
Typical operating				Т	ĪG		MIG			SAW				
parameters	Shield	ing			Ar	А	$r + 2\%O_{2}$	$/CO_2$	S	SB flux				
	Diame	eter		2	2.4		1.2			2.4				
	Currer	nt		Ľ	DC-		DC+		DC+					
	Param	neters		100A	A, 12V	220A, 26V			35	50A, 30V	T			



## 316S96 (continued)

Packaging data	ø mm		TIG		MIG	G	S	SAW				
	1.2				15kg	reel						
	1.6		2.5kg tu	be								
	2.4		2.5kg tu	be			25kg spool					
Fume data	MIG fume	compositio	on (wt %) (*	ΓIG & SA	W fume ne	egligible):						
		Fe	Mn	Cr <sup>3</sup>	Ni	Мо	Cu	OES (mg/m <sup>3</sup> )				
		30	12	15	11	1.5	< 0.5	3.3				

SSB FLUX											Sub-arc flux
Product description	Agglomerated b losses. Approxi										l low Mn and Cr
Specifications	DIN 32522 BS EN 760		BFB6 SA AF	63353 D 2 DC	C8M						
ASME IX Qualification	QW432 F-No	-, QW	442 A-N	No -							
Composition (weld metal wt %)	wire (316S96) deposit	C 0.05 0.04	Mn 1.8 1.6	Si 0.5 0.6	S 0.01 0.01	P 0.02 0.02	Cr 19 18	Ni 13 13	Mo 2.2 2.2	Cu 0.15 0.15	
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stres Elongation on 4	SS		MPa MPa %	6 4	bical 550 160 35					
Operating parameters	Current: DC+v ø mm 2.4	w: olt range 50A, 28-3	82V		typic 3504	al 4, 30V		stickout 20-25mm			
Packaging data		<60%RI	H, >18°C	C. If the f	lux has	become	damp	0			age conditions of stored for a long



**C-20** 

## **High Temperature Alloys**

### **OXIDATION RESISTANT 253MA ALLOY**

#### Alloy type

Iron based 22%Cr-10%Ni alloy with controlled additions of C, Si, N and rare earths (RE), predominantly cerium, with excellent resistance to oxidation resistance.

#### Materials to be welded

	wrought
ASTM/UNS	S30815.
	1.4818 X6CrNiSiNCe 19-10
	1.4828 X15CrNiSi 20-12
BS EN 10095	1.4835 (X9CrNiSiNCe 21-11-2).
DIN	1.4893 (X8CrNiSiN 21 11).
	1.4891 (X4CrNiSiN 18 10)).
Proprietary	Avesta 253MA

Also suitable for similar material:

ASTM UNS S30415 Avesta 153MA

#### Applications

Designed to match equivalent alloys with good hot strength coupled with excellent resistance to oxidation up to about 1100°C. Resistance to sulphidation under oxidising conditions is superior to many higher nickel heat-resistant alloys. Resistance to nitriding and carburisation is satisfactory except under reducing conditions where higher nickel alloys are superior.

Also satisfactory for **dissimilar** combinations of materials with related levels of alloying. However,

control of hot cracking in this high silicon weld metal is dependent on some ferrite being present during solidification. Caution is therefore required when considering dilution by dissimilar materials which could promote fully austenitic solidification, such as type 310 and other high nickel alloys. Combinations with alloys stabilised with Ti and especially Nb should be avoided, due to the possibility of embrittlement by Si-rich eutectics with these elements.

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Applications include **furnaces** and **furnace parts**, high temperature **flues**, **exhaust** and **heat recuperator systems**, combustion nozzles.

#### **Microstructure**

Austenite with controlled ferrite of about 5FN.

#### Welding guidelines

No preheat required, it is desirable to keep interpass below 150°C.

#### **Related alloy groups**

There are other consumables that also provide excellent oxidation resistance but they are generally more highly alloyed than the 253MA alloy.

Process	Product	Specification
MMA	Supermet 253MA	



Product description	(RE) a	All-positional MMA electrode with an acid rutile flux system on alloyed core wire. Controlled Si and rare earth (RE) additions (mainly cerium) provide excellent oxidation resistance. Recovery is about 115% with respect to core wire, 65% with respect to whole electrode.											
Specifications	There	are no aj	pplicab	e natior	nal standa	rds.							
ASME IX Qualification	QW43	32 F-No	, Q	<b>W442</b>	A-No								
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Ν	Cu	Ce *	FN
(weld metal wt %)	min	0.04		1.4			21.0	9.0		0.14			3
	max	0.10	1.0	2.0	0.020	0.035	23.0	11.0	0.50	0.20	0.50	trace	10
	typ	0.06	0.8	1.5	0.01	0.02	22	10.3	0.1	0.16	0.1	0.005	5
	* Ceriu	um is pro	esent bu	it actual	value not	t reported	on test c	ertificate	e.				
All-weld mechanical	As wel	ded					typical						
properties	Tensile	e strengt	h		Μ	Pa	705						
		Proof stre			Μ	Pa	550						
	Ű	ation on 4				%	40						
	•	ation on 5				%	38						
	Reduct	tion of ar	ea			%	50						
Operating parameters	DC +ve or AC (OCV: 50V min)									Û.			
	ø mm			2.5		3.2		4.0	_		.0		
	min A			50		75		100	)	1	30		
	max A			75		120		155		2	10		
Packaging data	ø mm			2.5		3.2		4.0		5	.0		
	length			300		350		350			50		
	kg/cart			11.4		13.5		14.4			7.7		
	pieces	/carton		594		366		261		1	68		
Storage	<ul> <li>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.</li> <li>For electrodes that have been exposed:</li> <li>Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.</li> <li>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): &lt;60% RH, &gt;18°C.</li> </ul>												
Fume data	Fume	composi	tion, w	% typio	cal:								
			Fe	Mn	Ni	С	r	Cu	F	OES	(mg/m <sup>3</sup> )		
	1									-			

Rutile electrode for matching alloy 253MA



**C-21** 

## High Temperature Alloys

## **CONTROLLED FERRITE 309**

#### Alloy type

23%Cr-12%Ni (309) alloy with a controlled ferrite and carbon content to match similar heat resistant alloys.

#### Materials to be welded

	wrought	cast
ASTM/UNS	S30900 (309)	A351 Grades CH8,
	S30908 (309S)	CH10, CH20.
	S30909 (309H)	
DIN	1.4829	1.4832
	(X12CrNi 22 12)	(G-X25CrNiSi2014)
BS	309S24	309C30
EN	1.4833	
	(X12CrNi23-12)	

#### **Applications**

These consumables deposit 309 type weld metal with a controlled carbon of about 0.08% and low ferrite content. These controls are designed to increase the high temperature strength and microstructural stability for service applications above 400°C. The widely used 309L dissimilar weld metal has lower hot strength and is more prone to embrittlement during long term high temperature service for which it is not intended.

The main application for this electrode is for welding steels of similar composition although some high temperature steels of dissimilar composition, such as ferritic CrAl and CrSiAl alloys are applicable. It is also a candidate for welding 'utility ferritic' stainless steels for elevated temperature service.

Tel:

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309 steels have useful oxidation resistance up to about 1000°C and the lower nickel content gives better sulphidation resistance than 310 types.

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They are normally used in **furnace** or **flue-gas systems** and **ducting** where the structural creep requirements are modest.

#### Microstructure

Austenite with up to 8% ferrite and some carbides.

#### Welding guidelines

Preheat not required for most applications.

#### **Related alloy groups**

The 309L consumables (data sheet B-50) typically used for dissimilar joints are related but are not used for the same high temperature applications. The 309H alloy (data sheet C-22) is also related but is generally used for the higher carbon (0.35%C) cast alloys.

Process	Product	Specification
MMA	Thermet 309CF	AWS E309H-16
TIG/MIG	309894	AWS ER309



Product description         MMA electrode with a nutile flux coating on high purity 304L core wire. Recovery is about 120% with respect to ore wire, 65% with respect to whole electrode.           Specifications         AWS A5.4 BS EN 1600 BS EN 1600 BS 2926 23.12.R DIN 8556         E309H-16 (E 22 12 R 26)           ASME IX Qualification         QW432 F-No 5, 0W442 A-No 8         V         N         Mo         Cu         FN           Composition (weld metal wt %) $C$ Mm         Si         P         Cr         N         Mo         Cu         FN           All-weld mechanical properties         C         Mm         Si         S         P         Cr         N         Mo         Cu         FN           All-weld mechanical properties         As welded         min         typical 560         mo         DC         Si         S         P         Cr         N         Mo         Cu         FN           Operating parameters         DC +ve or AC (OCV: 70V min)         Im         typical 75         DIO         130         DIO         Si0         350         350         350           Packaging data         gram         2.5         3.2         4.0         5.0         Im         Engle and frame         Engle and frame           Bordiation on 5d         % </th <th>THERMET 30</th> <th>9CF</th> <th></th> <th></th> <th></th> <th>309</th> <th>elect</th> <th>rode wi</th> <th>ith cont</th> <th>rollec</th> <th>l carbor</th> <th>n and fe</th> <th>errite content</th>	THERMET 30	9CF				309	elect	rode wi	ith cont	rollec	l carbor	n and fe	errite content
Specifications         AVS A5 40 BS EN 160 BS EN 160 BS 2026 23.12.R DN 8556         C U 2 12 R 32 23.12.R E2 12 R 220           ASME IX Qualification         CW432 F-No 5. CW442 A-No 8           Composition (weld metal wt %)         C         Mn         Si         S         P         Cr         Ni         Mo         Cu         FN           ASME IX Qualification         CW432 F-No 5. CW442 A-No 8         Composition (weld metal wt %)         Mo         Cu         FN           Metal metal wt %)         A swelded         min         0.06         0.5         0.2        2         2.0         1.0         0.1         5           All-weld mechanical properties         As welded         min         MPa         550         600         600         25         3.1         Reduction of area         %         2.5         3.1         Reduction of area         %         2.5         3.1         EI           Operating parameters         DC + vor AC (OCV: 70V min)         EI         EI         EI         EI         EI         EI	Product description	MMA	electrode	e with a	rutile flu	x coating	on high	purity 30	)4L core v	vire.			
BS       EN 1600 BS 2926       (E 22 12 R 32) 23.12.R (E 22 12 R 26)         ASME IX Qualification       QW432 F-No 5.       QW442 A-No 8         Composition (weld metal wt %) $\overline{C}$ Mn       SI       S       P       Cr       Ni       Mo       Cu       FN         ASME IX Qualification       QW432 F-No 5.       QW442 A-No 8       Cu       FN       Mo       Cu       FN         Composition (weld metal wt %) $\overline{C}$ Mn       SI       S       P       Cr       Ni       Mo       Cu       FN         All-weld mechanical properties       As welded       min       Vol       0.02       0.02       22.7       12.8       0.1       0.1       5         All-weld mechanical properties       As welded       MPa       550       600       600       50         Q28.Proof stress       MPa       550       600       31       Elongation on 4d       %       25       31         Bigging data       DC +ve or AC (OCV: 70 V min)       IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII		Recov	ery is abo	out 1209	% with re	spect to c	core wire	e, 65% wi	th respect	to who	ole electro	de.	
Composition (weld metal wt %)         C         Mn         Si         S         P         Cr         Ni         Mo         Cu         FN           min         0.06         0.5         0.2           22.0         12.0           2           MI         0.06         1.5         0.0         0.01         0.02         22.7         12.0           2           All-weld mechanical properties         As welded         min         MPa         560         605         0.1         5           2% Proof stress         MPa         350         460         14.0         0.1         5           2% Proof stress         MPa         350         460         14.0         1	Specifications	BS EN BS 29	BS EN 1600         (E 22 12 R 32)           BS 2926         23.12.R										
(weld metal wt %)       min max       0.06       0.5       0.2         22.0       12.0        2         All-weld mechanical properties       Ms       0.08       1.5       0.3       0.01       0.02       22.7       12.8       0.1       0.1       5         All-weld mechanical properties       As welded       min       typical        30.01       0.02       22.7       12.8       0.1       0.1       5         All-weld mechanical properties       As welded       MPa       350       460         30         30         210         210         210          210          220       12.0         2         2         2         2         2         2         2        2         2         2        2         2         2 <th>ASME IX Qualification</th> <th>QW43</th> <th>32 F-No</th> <th>5, <b>QN</b></th> <th><b>/442</b> A-2</th> <th>No 8</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th>	ASME IX Qualification	QW43	32 F-No	5, <b>QN</b>	<b>/442</b> A-2	No 8							
max       0.15       2.0       0.8       0.025       0.03       24.0       14.0       0.5       0.50       8         All-weld mechanical properties       As welded       0.08       1.5       0.3       0.01       0.02       22.7       12.8       0.1       0.1       5         All-weld mechanical properties       As welded       MPa       560       605       5       5       5       3       460       5       31       7       7       12.8       0.1       0.1       5       5       5       7	Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	FN	
typ0.081.50.30.010.0222.712.80.10.15All-weld mechanical propertiespropertiesAs weldedMPa5606050.2% Proof stressMPa350460Elongation on 4d%3034Elongation on 5d%2531Reduction of area%30HardnessHV210Operating parametersDC +ve or AC (OCV: 70V min)Image: Colspan="4">Image: Colspan="4">Image: Colspan="4">Image: Colspan="4">Colspan="4"Colspa	(weld metal wt %)	min										2	
All-weld mechanical propertiesAll-weld mechanical propertiesAs weldedmin MPatypical 560Tensile strength 0.2% Proof stress Elongation on 4dMPa % 30330 34 25Deresting parametersDC +ve or AC (OCV: 70V min)Image: Construct on the strength on the st													
Tensile strengthMPa5606050.2% Proof stressMPa350460Elongation on 4d%3034Elongation on 5d%2531Reduction of area%30HardnessHV210Operating parametersDC +ve or AC (OCV: 70V min)Image: a stress of the stress o		typ	0.08	1.5	0.3	0.01	0.02	22.7	12.8	0.1	0.1	5	
propertiesTensile strength 0.2% Proof stressMPa MPa560605 460 400 25Defention on 4d% 83034 25Elongation on 5d% 82531 Reduction of areaMPaDC +ve or AC (OCV: 70V min)Image: StressImage: StressOperating parametersDC +ve or AC (OCV: 70V min)Image: StressImage: Stress $a mm$ 2.53.24.05.0min A6075100130max A90120155210Packaging data $a$ mm2.53.24.0kg/carton13.515.016.515.9pieces/carton899432285183StorageStorageGrid colspan="4">Storage of relicied extra that have been exposed: Redry 200 - 250°C/1-2h to restore to as-packed condition. Maximum 250° C, 3 cycles, 10h total. Storage of relicied 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.Fume dataFeMnCrNiCuFOES (mg/m <sup>3</sup> )	All-weld mechanical	As wel	ded					min	typica	ıl			
0.2% Proof stressMPa350460Elongation on 4d%3034Elongation on 5d%2531Reduction of area%30HardnessHV210Operating parametersDC +ve or AC (OCV: 70V min)Image: Colspan="4">Image: Colspan="4">Image: Colspan="4">Image: Colspan="4">Colspan="4">Image: Colspan="4">Image: Colspan="4">Colspan="4">Image: Colspan="4">Colspan="4"Colspan="4">Colspan="4"Colspan="4"Colspan="4"Colspan="4"Colspan="4"Colspan="4"Colspan="4"						M	IPa	560					
Elongation on 5d Reduction of area Hardness% %25  30 HV31  210Operating parametersDC + ve or AC (OCV: 70V min)Image: Comparing the second						M	IPa	350	460				
Reduction of area Hardness $\frac{9}{HV}$ $$ $30$ $-210$ Operating parametersDC +ve or AC (OCV: 70V min)Image: Constraint of the		-					%	30	34				
HardnessHV210Operating parametersDC +ve or AC (OCV: 70V min)Image: Constraint of the constra		-						25					
Operating parametersDC +ve or AC (OCV: 70V min)Image: boot of the second				ea		1							
	Operating parameters	DC +ve or AC (OCV: 70V min) $\square$											
min A max A6075100130Packaging data													
max A90120155210Packaging dataø mm2.53.24.05.0length mm300350350350kg/carton13.515.016.515.9pieces/carton899432285183Storage3 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. For electrodes that have been exposed: Redry 200 - 250°C/1-2h to restore to as-packed condition. Maximum 250° 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.Fume dataFume composition, wt % typical:Image: Storage in the storage i		ø mm			2.5		3.2		4.0		5.0		
Packaging data       ømm       2.5       3.2       4.0       5.0         length mm       300       350       350       350         kg/carton       13.5       15.0       16.5       15.9         pieces/carton       899       432       285       183         Storage       A 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. For electrodes that have been exposed:       Redry 200 – 250°C/1-2h to restore to as-packed condition. Maximum 250° 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.         Fume data       Fume composition, wt % typical:       Fe       Mn       Cr       Ni       Cu       F       OES (mg/m <sup>3</sup> )		min A			60		75		100		130		
length mm       300       350       350       350         kg/carton       13.5       15.0       16.5       15.9         pieces/carton       899       432       285       183         Storage       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. For electrodes that have been exposed:         Redry 200 – 250°C/1-2h to restore to as-packed condition. Maximum 250° 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.         Fume data       Fume composition, wt % typical:		max A			90		120		155		210		
length mm       300       350       350       350         kg/carton       13.5       15.0       16.5       15.9         pieces/carton       899       432       285       183         Storage       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. For electrodes that have been exposed:         Redry 200 – 250°C/1-2h to restore to as-packed condition. Maximum 250° 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.         Fume data       Fume composition, wt % typical:	Packaging data	ø mm			2.5		3.2		4.0		5.0		
pieces/carton899432285183Storage3 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. For electrodes that have been exposed: Redry 200 – 250°C/1-2h to restore to as-packed condition. Maximum 250° 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.Fume dataFume composition, wt % typical: FeMnCrNiCuFOES (mg/m³)		length	mm		300		350		350		350		
Storage       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. For electrodes that have been exposed:         Redry 200 – 250°C/1-2h to restore to as-packed condition. Maximum 250° 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.         Fume data       Fume composition, wt % typical:         Fe       Mn       Cr       Ni       Cu       F       OES (mg/m³)		0											
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. For electrodes that have been exposed:         Redry 200 – 250°C/1-2h to restore to as-packed condition. Maximum 250° 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.         Fume data       Fume composition, wt % typical:         Fe       Mn       Cr       Ni       Cu       F       OES (mg/m <sup>3</sup> )		pieces	/carton		899		432		285		183		
Fe Mn Cr Ni Cu F OES (mg/m <sup>3</sup> )	Storage	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. For electrodes that have been exposed: <b>Redry</b> 200 – 250°C/1-2h to restore to as-packed condition. Maximum 250° C, 3 cycles, 10h total. <b>Storage</b> of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks											
	Fume data	Fume	composit	ion, wt	% typical	:							
9 6 7 1 <0.2 17 0.7				Fe	Mn	Cr	Ν	i C	Cu	F	OES (m	ng/m³)	
				9	6	7	1	<	0.2	17	0.2	7	



309S94						3	09 solio	d wire	with co	ontrolle	d carbo	n and ferr
Product description	Solid v	vire for T	'IG and	MIG.								
Specifications	BS EN	A5.9 N ISO 14 N ISO 14 01: Pt2		ER30 22 12 SS309 30989 S3098	H 9 94							
ASME IX Qualification	QW43	2 F-No	6, <b>QN</b>	<b>/442</b> A-N	No 8							
Composition	min	C 0.04	Mn 1.0	Si 0.30	S 	P 	Cr	Ni	Mo	Cu	FN 3	
(wire wt %)	min max typ	0.04 0.12 0.07	1.0 2.5 1.7	0.30 0.65 0.5	0.02	0.030	23.0 24.0 23.5	12.0 14.0 13	0.3	0.3	3 12 6	
All-weld mechanical properties	Tensile 0.2% P Elonga Elonga Reduct	values a strength Proof strest tion on 4 tion on 4 tion of are ess cap/m	ss d d ea	d	Ν	APa APa % % % HV 1	TIG 580 415 42 39 56 75/215					
Typical operating parameters	Shieldi Curren Diamet Parame * *	t ter eters Also rec		TIG Argon DC- 2.4mn 120A, 1 s a purge and Ar-H	n 4V for root	26 runs.	MIG -2%O <sub>2</sub> ** DC+ 1.2mm 0A, 26V <3%CO <sub>2</sub>		suitable			
Packaging data	ø mm 1.0 1.2 1.6 2.4			TIG  2.5kg tu 2.5kg tu			MIG kg spool kg spool  					
Fume data	MIG fu	ume com	positior Fe	ı (wt %) ( Mn	TIG fun Cr <sup>3</sup>	ne neglig N		Ло	Cu	OES (r	ng/m <sup>3</sup> )	
			32	12	20	1		0.5	<0.5	2.		

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### DATA SHEET C-22

### THERMET 309H

#### Product description

MMA electrode with basic-rutile flux system made on high purity 304L stainless steel core wire. Deposits a high carbon (0.3%) 309 type weld metal to match cast base materials. Has a controlled nitrogen addition to optimise as-deposited ductility and high temperature strength.

Recovery is about 120% with respect to core wire and 65% with respect to the whole electrode.

#### **Specifications**

There are no national specifications for this electrode.

#### **ASME IX Qualification**

QW432 F-No-, QW442 A-No-.

#### Materials to be welded

ASTM	A297 grade HH (cast). A447 grades I & II (cast).
BS	3100 grades 309C30/32/35/40 (cast).
DIN	1.4837, 1.4809, 1.4832 (cast).
Proprietary	Paralloy H11, H12, H12N.
	Thermalloy T40.

#### Applications

Thermet 309H is designed for welding similar austenitic high carbon 309 castings; lower carbon cast and wrought alloys are matched by Thermet 309CF (data sheet C-21). Depending on the balance of Cr and Ni the high carbon castings may be fully austenitic or may contain a small percentage of ferrite.

These alloys have good resistance to oxidation, sulphidation and abrasion at temperatures up to about 1050°C, with applications in **furnace parts**, **petrochemical** and **cement plants**. They are generally not used for critical load bearing structures.

#### Microstructure

In the as-welded condition the microstructure consists of austenite with primary and secondary carbides and possible traces of ferrite.

#### Welding guidelines

Preheat and PWHT are generally not required.

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	Ν	FN
max	0.45	2.5	1.0	0.03	0.04	28.0	14.0	0.5	0.5		
typ	0.3	1.7	0.4	0.01	0.02	26	13	0.05	0.1	0.12	<2

#### All-weld mechanical properties

As welded		typical
Tensile strength	MPa	780-840
14-25	MPa	550-600
Elongation on 4d	%	14-25
Reduction of area	%	14-23
Hardness	HV	250

#### Parameters

DC +ve or AC (OCV: 70V min)



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	350
kg/carton	12.9	15.0	14.4
pieces/carton	615	402	249

#### Storage

**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.

For electrodes that have been exposed:

**Redry**  $200 - 300^{\circ}$ C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

**Storage** of redried electrodes at 100-200°C in holding oven or 50-150°C in heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, >18°C.

#### Fume data

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Мо	Cu	F	OES (mg/m <sup>3</sup> )
8	6	1	8	< 0.1	< 0.2	16	0.6



## **310 STAINLESS STEEL**

#### Alloy type

25%Cr-20%Ni (310) stainless steel.

#### Materials to be welded

	wrought	cast
ASTM/UNS	310 / S31000 310S / S31008	CK20
DIN	1.4841, 1.4842, 1.4845	1.4840
BS	310S24, 310S31	310C45
Proprietary	Immaculate 5 (Firt Sirius 3 (CLI) 15RE10 (Sandvik)	,

#### **Applications**

These consumables are used primarily for welding similar wrought or cast 25%Cr-20%Ni (310) parent alloys with up to 0.25% carbon. Parent metal and weld metal are fully austenitic, unlike the other common 300 series stainless steels. For maximum resistance to solidification cracking and microfissuring, the MMA weld metal manganese range is raised to 2-5% in accordance with European practice.

The high alloy content of type 310 gives useful oxidation resistance up to peak temperatures of about 1200°C for **heat shields**, **furnace parts** and **ducting**.

These consumables can also be used for **mixed welding** and **dissimilar joints** including those where PWHT is applied, but it should be noted that the relatively high thermal expansion coefficient may promote thermal fatigue in transition joints which are subject to thermal cycling. In such cases, nickel base consumables are usually preferred (eg. D-10, D-11).

#### DATA SHEET C-30

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Other uses include **buffer layers** and for **surfacing**. The fully austenitic weld metal can be useful for specialised applications requiring **low magnetic permeability** (typically <1.01). 310 weld metals are also inherently tough down to  $-196^{\circ}$ C and therefore suitable for **cryogenic installations** involving any of the standard 300 series austenitic stainless steels.

#### Microstructure

Fully austenitic. Typical magnetic permeability <1.01.

#### Welding guidelines

No preheat required. Preferably keep interpass temperature below 150°C and heat input below 1.5kJ/mm; this is particularly important for high heat input processes eg. SAW.

#### **Related alloy groups**

These standard 310 alloy should not be confused with 0.4% carbon 310H cast alloys of the HK40 type (see data sheet C-31), or the very low carbon 310L alloys which are used in severely corrosive conditions (see data sheet B-45).

Process	Product	Specification
MMA	25.20 Super R	(E310-16)
	Ultramet B310Mn	(E310-15)
TIG/MIG	310894	AWS ER310



Product description	are desi	irable to e	ensure	<ul> <li>h low silica rutile flux on high purity 310 core wire. Low silicon and high manganese level are freedom from microfissuring.</li> <li>20% with respect to core wire, 65% with respect to whole electrode.</li> </ul>								
Specifications	AWS A BS EN BS 292 DIN 85	l 1600 26		25.20	20 R 32	cification	has Mn	range of 1.0	D-2.5%.			
ASME IX Qualification	QW43	<b>2</b> F-No 5	, QV	<b>/442</b> A-N	o 9							
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu		
(weld metal wt %)	min	0.08	2.0				25.0	20.0				
	max	0.15	5.0	0.70	0.025	0.030	27.0	22.0	0.50	0.50		
	typ	0.12	3.5	0.4	0.008	0.02	26	21	0.2	0.1		
All-weld mechanical	As weld	led					min	typica	al			
properties		strength			Μ	Pa	560	575				
	0.2% P	roof stres	5		Μ	Pa	350	400				
	-	tion on 4d				%	30	38				
	-	tion on 5d				%	25	37				
		ion of area	a	. 2000		%		50				
	Impact Impact	0,		+ 20°C - 196°C		J J		100 60				
	Hardne			- 190 C		IV		200				
Operating parameters	DC +ve	e or AC (	OCV:	70V min)								
	ø mm			2.5		3.2		4.0		5.0		
	min A			60		75		100		130		
	max A			90		120		155		210		
Packaging data	ø mm			2.5		3.2		4.0		5.0		
	length r	nm		300		350		350		450		
	kg/carto			12.0		13.5		14.7		20.1		
	pieces/o	carton		675		405		282		198		
Storage	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use fro for longer than a working shift of 8h. Excessive exposure of electrodes to humid condition moisture pick-up and increase the risk of porosity.</li> <li>For electrodes that have been exposed:</li> <li>Redry 150 – 200°C/1-2h to restore to as-packed condition. Maximum 250° C, 3 cycles, 10h Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but recommended. Recommended ambient storage conditions for opened tins (using plastic lid):</li> </ul>									litions will cause so , 10h total. but maximum 6 wea		
Fume data	Fume c	ompositio	on, wt	% typical:								
		I	Fe	Mn	Ni	Сг	· (	Cu	F	OES (mg/n	n <sup>3</sup> )	
	1		9	10	2	7.5		0.2	18	0.6		



Product description	MMA electrode with basic carbonate-fluoride flux on high purity 310 core wire. Low silicon and high manganese levels are desirable to ensure freedom from microfissuring. The electrode is particularly suited to positional welding, including fixed pipework in the ASME 5G/6G positions.											
	Recov	Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.										
Specifications	BS EI BS 29	WS A5.4       (E310-15)       AWS specification has Mn range of 1.0-2.5%.         SS EN 1600       E 25 20 B 42         SS 2926       25.20.B         DIN 8556       E 25 20 B 20+										
ASME IX Qualification	QW43	QW432 F-No 5, QW442 A-No 9										
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu		
(weld metal wt %)	min	0.08	2.0				25.0	20.0				
	max	0.15	5.0	0.70	0.025	0.030	27.0	22.0	0.50	0.50		
	typ	0.1	3.8	0.4	0.008	0.018	26	21	0.2	0.1		
All-weld mechanical	As wel	ded					min	typica	al			
properties	Tensile	e strength			Μ	Pa	560	615				
		Proof stres			Μ	Pa	350	435				
	-	ation on 40				%	30	36				
	-	ation on 50				%	25	34				
		tion of are energy	а	+ 20°C		% J		50 105				
		energy		+ 20 C - 196°C	•	J		103 75				
	Hardne			170 0		IV		220				
Operating parameters	DC +v	ve										
	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				
r uonuging uutu	length	mm		300		350		350				
	kg/cart			12.0		13.5		13.5				
	pieces	/carton		669		384		255				
Storage	for lor moistu For ele <b>Redry</b> Storag	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions moisture pick-up and increase the risk of porosity. For electrodes that have been exposed:</li> <li>Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h t Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but ma recommended. Recommended ambient storage conditions for opened tins (using plastic lid): &lt; 0</li> </ul>									ons will cause sor Dh total. t maximum 6 wee	
Fume data	Fume	compositi	on, wt	% typical:								
		-	Fe	Mn	Ni	Cr	. (	Cu	F	OES (mg/m <sup>3</sup> )		
			9	10	2				28	0.6		



31	<b>0S94</b>
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Solid wire for TIG, MIG and SAW of 310 stainless steel

Product description	Solid wire for TIC	Solid wire for TIG, MIG and SAW.									
Specifications	AWS A5.9 BS EN ISO 143 BS EN ISO 143 BS 2901: Pt2 DIN 8556 UNS	43-A 25 43-B St 31 St	R310 5 20 5310 0S94 G X12CrNi 81080	25 20							
ASME IX Qualification	QW432 F-No 6, QW442 A-No 9										
Composition (wire wt %)	C           min         0.08           max         0.15           typ         0.11	Mn         S           1.0         0.3           2.5         0.6           1.8         0.5	30 55 0.02	P  0.030 0.02	Cr 25.0 27.0 26	Ni 20.0 22.0 21	Mo  0.3 0.1	Cu  0.3 0.1			
All-weld mechanical properties	Typical values as Tensile strength 0.2% Proof stress Elongation on 4d Impact energy Hardness cap/mic	- 19	N 96°C	MPa APa % J HV	IG Ar+2% 540 355 27 70 185	0O <sub>2</sub>					
Typical operating parameters	** Proprieta	Ar, I 2.4 1002 iired as a pu ry Ar and A	r-He mixtu	22 runs. res with <		also suit	SAW *** SSB DC+ 2.4mm 325A, 30V so suitable. se the risk of solidification cracking				
Packaging data	ø mm 0.8 1.2 1.6 2.4 3.2	2.5k 2.5k	TIG  g tube g tube g tube		MIG kg spool kg spool  		- 25kg 25kg	W - g coil g coil -			
Fume data		osition (wt 9 Fe Mr 0 13	ı Cr <sup>3</sup>	SAW fum N	i N	ble) No 0.5	Cu <0.5	OES (mg/m <sup>3</sup> ) 2.3			



**C-31** 

## High Temperature Alloys

## **310H ELECTRODE TO MATCH HK40**

#### Alloy type

0.4%C-25%Cr-20%Ni (310H) austenitic cast alloy for heat resisting service.

#### Materials to be welded

ASTM	A351, A608 Grade HK40.
	A297 Grade HK
DIN	1.4846 (X40CrNi 25 21)
	1.4848 (G-X40CrNiSi 25 20)
BS	3100 Grade 310C40
	1504 Grade 310C40
Proprietary	H20 (Doncasters Paralloy)
	Thermalloy 47 (Duraloy)
	Lloyds T47 (LBA)
	HR6 (Cronite)

#### Applications

Thermet 310H is designed to weld HK40 which is one of the standard materials for centrifugally cast tubes operating at around 1000°C.

These alloys are used in **reformer** and **steam cracker coils** in **chemical** and **petrochemical plants**. Also for components such as **billet skids**, **calinating tubes**, **kiln nose segments**, **conveyor rolls**, and **furnace**  structural items in the cement, ceramic and steel industries.

**DATA SHEET** 

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#### Microstructure

In the as-welded condition the weld metal microstructure consists of austenite with eutectic and secondary carbides.

#### Welding guidelines

Generally no preheat or PWHT are required.

#### **Related alloy groups**

There are two other 310 alloy groups: the 310L (data sheet B-45) which is used for corrosion resistant applications not high temperature service, and the standard 310 alloys (data sheet C-30) which are used for the standard (0.1%C) base materials.

Process	Product	Specification
MMA	Thermet 310H	AWS E310H-15



Product description	MMA electrode with basic flux coating made on 310 core wire to give low residual levels. The electrode is optimised for DC+ welding in all positions including fixed pipework in ASME 5G/6G positions. Moistur resistant coating giving sound porosity free deposits.													
	Recove	Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.												
Specifications	BS EN	AWS A5.4       E310H-15         BS EN 1600       E 25 20 H B 42         BS 2926       25.20.H.B												
ASME IX Qualification	QW43	<b>2</b> F-No	5											
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu				
(weld metal wt %)	min	0.35	1.0				25.0	20.0						
	max	0.45	2.0	0.7	0.025	0.030	28.0	22.0	0.5	0.50				
	typ	0.41	1.7	0.5	0.01	0.02	26	21	0.1	0.03				
All-weld mechanical	As weld	led					min	typica						
properties	Tensile	strength			Ν	IPa	620	760						
		roof stres			Ν	IPa	350	550						
	-	tion on 4				%	10	20						
	-	tion on 50 ion of are				%	10	17 25						
	Hardne		a		1	% HV		25 230						
Operating parameters		ge 10-20												
			I	<u> </u>										
	ø mm min A			2.5		3.2		4.0						
	max A			60 90		75 120		100 155		210	5.0 450			
Deckering data	ø mm			2.5		3.2		4.0		5.0				
Packaging data	length r	nm		300		350		350						
	kg/carto			11.4		13.5		14.4		18.0				
	pieces/			546		384		258		165				
Storage		ger than	a worki	ng shift crease th	of 8h. E ie risk of	xcessive	exposure	e of electr	odes to	humid co	use from tin is satisfacto onditions will cause sor			
Clotage	moistur For ele <b>Redry</b> Storag	ctrodes ti 200 – 25 <b>e</b> of redr	hat have 0°C/1-2 ied elec	h to rest trodes at	ore to as- 50 – 200	°C in ho	olding ove	en or heate	ed quiv	er: no lim	les, 10h total. hit, but maximum 6 wee ic lid): < 60% RH, > 18°			
Fume data	moistur For ele Redry Storag recomm	ctrodes the ctrodes the ctrodes the ctrodes the ctrodes the ctrode term $200 - 25$ of red	hat have 0°C/1-2 ied elec Recomr	trodes at nended a	ore to as- 50 - 200 mbient st	°C in ho	olding ove	en or heate	ed quiv	er: no lim	nit, but maximum 6 wee			
	moistur For ele Redry Storag recomm	ctrodes the ctrodes the ctrodes the ctrodes the ctrode $200 - 25$ error of redrinended.	hat have 0°C/1-2 ied elec Recomr	h to rest trodes at	ore to as- 50 - 200 mbient st	°C in ho	olding over onditions	en or heate for opened	ed quiv	er: no lim	nit, but maximum 6 wee			



### CONSUMABLES TO MATCH CAST & WROUGHT ALLOY 800

#### Alloy type

Austenitic heat resisting consumables to match alloy 800.

#### Materials to be welded

ASTM	BS EN & DIN
A351 CT15C	1.4850 1.4859 1.4876
BS	UNS
NA15	N08800
NA15H	N08810
	N08811

#### Proprietary alloys include:

cast:wrought:Paralloy CR32WIncoloy 800, 800H, 800HTManaurite 900 (Manoir)(Special Metals)Thermalloy T52Sanicro 31 (Sandvik)(Lloyds)Nicrofer 3220 (VDM)Vicro 8 (Firth Vickers)RA330 (Rolled Alloys)MORE 21 (Duraloy)Centralloy 4859 (Centracero)

#### Applications

The consumables are designed to deposit weld metal with composition and properties closely matching type 800 alloys in cast and wrought forms. The weld metals are based on the composition of castings, with controlled carbon and niobium for optimum corrosion resistance and creep performance. Most wrought materials have Ti and Al instead of Nb. Weld metal Mn and Si levels are modified to give high resistance to hot cracking in highly restrained welds. For optimum resistance to ageing embrittlement, the composition will generally meet the Chiyoda parameter:

 $P \le 9$  where P = (7C + 5Si + 8Nb - 3Mn).

#### DATA SHEET C-40

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These alloys are used for their resistance to corrosion, thermal fatigue and shock at temperatures up to about 1000°C, for the fabrication of **muffles** and **radiant tubes**, **heat treatment trays** and **baskets**, **reformer furnace outlet manifolds** and **ethylene plant transfer lines**, in the **furnace**, **petrochemical** and **nuclear engineering industries**.

These consumables are used as alternatives to various nickel base consumables up to 1000°C, with the added benefit of expansion coefficient and sulphidation resistance similar to parent material.

#### Microstructure

As-welded weld metal microstructure consists of austenite with cellular NbC-rich network.

#### Welding guidelines

No preheat, interpass temperatures below 150°C recommended, no PWHT.

#### **Additional information**

Marshall A.W. & Farrar J.C.M. 'Matching consumables for type 800 alloys', Stainless Steel World, Sept 1999, pp 56-60.

#### **Related alloy groups**

The nickel base alloys AB(data sheet C-11), 625 (data sheet C-20) and 617 (data sheet C-40) are sometimes used as alternatives for the same base materials.

Process	Product	Specification
MMA	Thermet 800Nb	None
TIG/MIG	21.33.MnNb	None



Product description	MMA electrode – Basic moisture resistant coated electrode made on high alloy, high purity core wire.													
	Recov	Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.												
Specifications	There	are no r	national	specifi	cations for	or this ele	ectrode.							
ASME IX Qualification	QW4	QW432 F-No-, QW442 A-No-												
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	Cu			
(weld metal wt %)	min	0.06	1.6				19.0	30.0		0.8				
	max	0.12	4.5	0.6	0.02	0.03	23.0	35.0	0.5	1.5	0.5			
	typ	0.1	2.5	0.3	0.007	0.015	21	32	0.4	1.3	0.15			
All-weld mechanical	As we	lded					min *		typica	al				
properties		e streng				MPa	520		615					
		Proof str				MPa	210		410					
	-	ation on				% %	 25		> 33 > 32					
	-	ation on tion of a				%			2 52 46					
		t energy		+ 2	0°C	J			> 55	i				
	Hardn				0 0	HV			170-2					
			nsile p	ropertie	s based o	n wrougl	nt alloy 8	00H.						
Operating parameters	DC +ve only													
	ø mm			2.5	5	3.2	2		4.0		5.0			
	min A			60		75			100		130			
	max A			90		120	)		155		5.0			
Packaging data	ø mm			2.5	5	3.2	2	4.0			5.0			
	length	mm		300	)	350	)		350	5.0 130 210 5.0 450				
	kg/car			12.		13.			13.5			5.0 130 210 5.0 150 8.0 165 rect use from tin is satisfactory		
	pieces	carton		642	2	354		243		165				
Storage	for mu moistu For ele <b>Redry</b> Storag	ich long ure pick- ectrodes v 150 – 2 ge of rec	er than -up and that ha 250°C/ dried el	a worki increas we been 1-2h to ectrode	ng shift o se the risk n exposed restore to s at 50 –	f 8h. Exc c of poros l: as-packe 200°C in	essive ex ity. ed conditi holding	posure ion. M oven o	of electro aximum r heated	odes to h 350° C, quiver:	numid co , 3 cycle no limit			
Fume data	Fume	compos	ition, w	vt % typ	oical:									
			Fe	Mn	Ci	- N	li N	Ло	Cu	F	OES	S (mg/m <sup>3</sup> )		
			4	6	6	2		0.2	< 0.2	18		0.8		

### **THERMET 800Nb**

MMA electrode to match alloy 800



21.33.MnNb		9	Solid TIG	welding	g wire	for 800	0H ar	nd simila	ar hea	it resist	ing alloys
Product description	Solid wire – This	s is a higl	n Mn, 21%C	Cr-33%Ni-	1%Nb, r	nicro-all	oyed w	vire for TIC	G weldi	ng of 800	type alloys.
Specifications	There are no nati	ional spe	cifications for	or this wir	e.						
ASME IX Qualification	QW432 F-No-,	, <b>QW44</b>	<b>2</b> A-No -								
Composition (wire wt %)	min 0.10 max 0.20	3.5     -       5.0     0.       4.3     0	Si         S           -            70         0.015           .5         0.008           typically a l	P  0.025 0.012 ittle lower	Cr 19.0 23.0 21 than wi	Ni 30.0 35.0 33 re analys	Mo  0.50 0.3 sis.	Nb 0.8 1.5 1	Cu  0.5 0.1	Al  0.35 0.1	Ti 0.30 0.15
All-weld mechanical properties	Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Impact energy	0.2% Proof stress         MPa         210         500           Elongation on 4d         %          18           Elongation on 5d         %          18									
Typical operating parameters	Shielding Current Diameter Parameters	1	TIG Ar DC – 2.4mm 00A, 12V								
Packaging data	ø mm 1.6 2.0 2.4 3.2	2	TIG To order To order .5kg tube .5kg tube								
Fume data	MIG fume comp	Fe 40	wt %) (TIG Mn 15	fume negl Cr <sup>3</sup> 18	igible) Ni 20	Ci <	-	OES (mg/r 2.5	m³)		





## HIGH CARBON 18/37 HEAT RESISTING AUSTENITIC ALLOY

#### Alloy type

0.45%C-17%Cr-38%Ni high carbon austenitic heat resisting steel often called 18/37 or 37/18 alloy.

#### Materials to be welded

ASTM-ASME	DIN	BS
A297 HT & HU	1.4865	3100 Gr 330C11
A351 HT30		3100 Gr 331C40
		4534 Gr 8 & 9

#### Proprietary

Paralloy H38, H40, H33, H35 (Doncasters Paralloy) Cronite HR5, HR17, HR31 (Cronite) Lloyds T50 (LBA) Thermalloy T50, T58 (Duraloy) RA330-HC (Rolled Alloys) Incoloy DS & 330 (Special Metals) (wrought)

#### Applications

Thermet R17.18H is designed to match fully austenitic high alloy heat resisting steels often called 17/38 or 38/17. Alloys of this type are produced as castings with about 0.4%C, or in wrought form with carbon of about 0.08%. Thermet R17.38H matches the composition of castings but experience has also shown it to be compatible wit the wrought alloys, although higher weld metal ductility will be obtained with a nickel base type (data sheet D-11).

The high nickel content and low thermal expansion of the alloys give good resistance to thermal shock. The alloy is also highly resistant to carburisation and DATA SHEET C-41

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oxidation but is not suitable for use in high sulphur bearing atmospheres.

These alloys retain good mechanical strength up to 1050-1100°C and are used for heat treatment trays and containers, retorts furnace rollers, moulds, hearth plates, radiant tubes, and furnace fittings and headers in the heat treatment industries and high temperature process plants.

#### Microstructure

In the as-welded condition the weld metal microstructure consists of austenite with eutectic and secondary carbides. Although fully austenitic the alloy is slightly magnetic with an apparent ferrite of up to 5FN.

#### Welding guidelines

Preheat is not generally required.

#### **Related alloy groups**

The AB type nickel base alloys are often used to weld the wrought versions of this alloy (data sheet D-11).

There is no matching solid wire for this alloy.

Process	Product	Specification
MMA	Thermet R17.38H	BS 15.35.H.R



THERMET R1	7.38	Н		MMA	A electr	ode to	match	high ca	arbon	18/37	heat resisting alloy	ys		
Product description											re resistant coating givin al welding.	ng		
	Recov	ery is abo	out 120%	6 with re	espect to a	core wire	, 65% wi	th respect	to who	le electro	ode.			
Specifications	AWS BS 29	-			30H-16) 5.H.R	Therm	et R17.3	8H has hi	gher C,	Cr & Ni	than AWS specification.			
ASME IX Qualification	QW43	W432 F-No 5												
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо					
(weld metal wt %)	min	0.35	1.0	0.3			17.0	35.0						
	max typ	0.60	2.0 1.5	1.0 0.5	0.030	0.040	20.0 18.5	40.0 38	0.5					
All-weld mechanical	As wel	lded					min	typica	al					
properties	Tensile	e strength			Ν	IPa	620	780						
		Proof stres			Ν	IPa		520						
	0	ation on 4				%	10 5	16						
	0	ation on 50 tion of are				% %	5	14 15						
	Hardne		a		1	TV VI		250						
			designe	ed for on			l tempera			ambient	temperature elongations	in		
		nge 10-20	-	-			1				1			
Operating parameters	DC +v	ve or AC (	(OCV: 7	0V min	)									
	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			300		350		350						
	kg/cart			12.6		15.6		15.6						
Storage	3 hern for lor moistu For ele Redry Storag	nger than ure pick-u ectrodes t v 200 – 25 ge of redr	a worki p and in hat have 0°C/1-2 ied elec	ng shift crease the been ex th to rest trodes at	of 8h. E ne risk of posed: tore to as- 50 - 200	xcessive porosity packed o °C in ho	exposure condition	e of electr . Maximu en or heat	odes to um 250° ed quiv	humid c <sup>o</sup> C, 3 cyc er: no lir	et use from tin is satisfacto conditions will cause son cles, 10h total. nit, but maximum 6 weel tic lid): < 60% RH, > 18°	me		
Fume data	Fume	composit	ion, wt 9	% typica	1:									
			Fe	Mn	Ni	Cr	· N	lo	Cu	F	OES (mg/m <sup>3</sup> )			
			4	7	4	5	<(	).1 <	0.2	16	1			
						2				-	1			



### THERMET 25.35.Nb

#### Alloy type

0.1%C-25%Cr-35%Ni-0.6%Nb (HP10Cb) austenitic cast alloy for heat resisting service.

#### Materials to be welded

#### Similar cast alloys:

Alloy HP10Cb (ACI-ASTM terminology) Paralloy CR39W (Doncasters Paralloy) Lloyds T57 (LBA) Centralloy H101 (Centracero)

#### **Applications**

This electrode is specially designed to deposit weld metal which matches the composition of similar castings. This alloy was developed from 800 type alloys with increased chromium and nickel contents and exhibits improved carburisation and oxidation resistance. It is used at temperatures up to 1100°C and is resistant to thermal shock and fatigue.

Applications include the welding of centrifugally cast **pyrolysis coils**, **reformer tubes**, **return bends** and **tees** 

#### DATA SHEET C-45

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for the **petrochemical industry**.

#### **Microstructure**

In the as-welded condition the weld metal microstructure consists of austenite with some grain boundary carbides.

#### Welding guidelines

Generally no preheat or PWHT are required; interpass temperatures below 150°C are recommended.

#### **Related alloy groups**

There is no directly equivalent solid wire, the nearest available is Metrode 21.33.Nb/21.33.Mn (see data sheet C-40).

Process	Product	Specification
MMA	Thermet 25.35.Nb	



THERMET 25.	35.N	lb		Ва	asic al	I-posit	ional N	1MA e	lectro	de for	'HP10	Cb' type	castings
Product description	weldir		position	s includi									sed for DC+ pating giving
	Recov	very is ab	out 120	% with 1	respect t	o core w	vire, 65%	with re	spect to	whole e	lectrode		
Specifications	There	are no re	elevant r	national	standaro	ls.							
ASME IX Qualification	QW4	<b>32</b>											
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	Cu	Pb	Sn
(weld metal wt %)	min	0.08	2.5	0.2			24.0	34.0		0.50			
	max	0.14	4.0	1.0	0.02	0.03	28.0	39.0	0.5	1.50	0.15	0.01	0.01
	typ	0.12	3.5	0.5	0.01	0.01	26	36	0.2	0.8	0.05	< 0.001	0.005
All-weld mechanical	As we	Ided					min		typical				
properties		e strengt	h			MPa	520		660				
• •		Proof stre				MPa	300		460				
	Elonga	ation on 4	1d			%	20		34				
	Elonga	ation on 5	5d			%	20		32				
	Reduc	tion of ar	ea			%			42				
Operating parameters	DC +v	ve								U			€ Î
	ø mm			2.5		3.2	2	4	4.0				
	min A			60		75		1	.00				
	max A			90		12	)	1	55				
Packaging data	ø mm			2.5		3.2	2	2	4.0				
	length	mm		265		32			320				
	kg/car			10.5		12.			2.0				
	pieces	carton		555		33	)	2	204				
Storage	for lor moistu For ele <b>Redry</b> Storag	nger than ure pick- ectrodes y 150 – 2 ge of red	a work up and i that hav 50°C/1- ried ele	ting shif ncrease we been e 2h to res ctrodes a	t of 8h. the risk exposed store to at 50 – 2	Excess of poros as-packe 200°C in	ive expos ity. ed condit holding	sure of o ion. Ma oven or	electrod aximum • heated	es to hur 350° C, quiver: 1	nid con 3 cycles no limit,	ditions will s, 10h total. but maxim	s satisfactory cause some num 6 weeks RH, > 18°C.
Fume data	Fume	composi	tion, wt	% typic	al:								
		_	Fe	Mn	Ν	li	Cr	Мо	Cu		F	OES (mg/m	<sup>3</sup> )
			4	6	2	2	7	< 0.1	<0.1	2 1	8	0.7	
	1												



## **CONSUMABLES TO MATCH HP40Nb**

#### Alloy type

Consumables to match 0.4% C-25% Cr-35% Ni-Nb heat resistant cast alloys.

#### Materials to be welded

#### **Matching alloys**

ASTM-ASME	DIN
A297 'HP40Cb'	1.4852 (G-X40NiCrNb 35 25)
	1.4853 (wrought)

#### **Proprietary alloys**

Paralloy H39W (Doncasters Paralloy) Lloyds T64 (LBA) MORE 10 & 10-MA (Duraloy) Thermalloy 64 (Duraloy) Manaurite 36X & 36XM (Manoir) Pyrotherm G25/35Nb & NbTZ (Pose Marre) Centralloy 4852 & 4852 Micro (Schmidt + Clemens -Centracero)

#### Nb-free alloys

ASTM-ASME DIN

A297 HP or HP40 1.4857 (G-X40NiCrSi 35 25) 1.4853 (wrought)

#### Proprietary alloys

Paralloy H39 (Doncasters Paralloy) Lloyds T63 (LBA) HR33 (Cronite)

Also suitable for high carbon 18%Cr-37%Ni-Nb alloys eg. DIN 1.4849.

#### Applications

These consumables are designed to match heat resistant cast alloys with 0.4%C-25%Cr-35%Ni-Nb, including those micro-alloyed with Ti to increase creep resistance. They are also suitable for the Nb free alloys and leaner

#### DATA SHEET C-50

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high carbon Cr-Ni alloys such as HK40, HT40 and IN519 where overmatching weld metal will normally be acceptable.

Alloy HP40Nb is not prone to sigma phase embrittlement and the presence of eutectic and secondary carbides provide excellent hot strength and creep resistance in the typical service temperature range 900-1100°C. High levels of Cr and Ni provide good resistance to oxidation and carburisation.

The principal applications are **pyrolysis coils** and **reformer tubes** for **ethylene production** in the **petrochemical industry**.

#### Microstructure

In the as-welded condition the weld metal consists of austenite with eutectic and secondary carbide.

#### Welding guidelines

Generally preheat is not required.

#### **Related alloy groups**

There are a number of related high carbon Cr-Ni alloys which are used in the same type of applications, see other alloys in the Hot Zone. There is also a lower carbon version of the 25% Cr-35% Ni alloy (data sheet C-40) which provides better thermal shock and fatigue, with some reduction in creep strength.

Process	Product	Specification
MMA	Thermet HP40Nb	BS 25.35.H.Nb.B
TIG	25.35.4CNb	



Product description         Basic moisture resistant MMA electrode made on high purity alloy core wire, giving high resistance to microfissaring and provsky in large multi-run deposits.           Recovery is about 120% with respect to cree wire, 65% with respect to twole electrode.           Specifications         BS 2926         25.35.11N.b           ASME IX Qualification         OW432 F.No         Visual and the second seco	THERMET HP	40Nk	)					Ва	sic el	ectrode	e mato	ching I	HP40	)Nb alloys
Specifications         BS 2926         25.35.H.Nb.B           ASME IX Qualification         QW432 F-No-           Composition (weld metal wt %)         C         Mn         Si         S         P         Cr         Ni         Mo         Nb         Ti           Min         0.35         0.5         0.2           23.0         32.0          0.02         min         0.03         0.40         2.5         0.20         0.02         min         0.02         0.02         min         0.50         0.20         0.00         0.010         25         35         0.1         1.1         0.08         Allweld         min         "typical         Transle strength         MPa          740          740          740          75         15         Etergation on 40         %          15         Reduction of area         %          15         Reduction of area         %          13         Rodu State         14         140         Rodu State         Rodu State         15         Reduction of area         %          15         Reduction of area         %         15         Reduction of area <th>Product description</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>purity</th> <th>alloy co</th> <th>re wire</th> <th>, giving</th> <th>high</th> <th>resistance to</th>	Product description								purity	alloy co	re wire	, giving	high	resistance to
ASME IX Qualification         QW432 F-No -           Composition (weld metal wt %)         isotropic isotrop		Recove	ery is abo	ut 1209	% with r	espect to c	ore wire	, 65% witl	h respec	et to who	le elect	rode.		
Composition (weld metal wt %)         C         Mn         Si         S         P         Cr         N         Mo         Nb         T           min         0.35         0.5         0.2          23.0         32.0          0.75         0.02           Mark         0.59         2.0         1.3         0.030         0.040         27.0         35.0         0.5         1.50         0.20           All-weld mechanical properties         As welded         min         typ         0.43         1.7         0.9         0.010         0.010         25         50         1.1         0.08           All-weld mechanical properties         As welded         min         mark         typ         0.43         1.7         0.9         0.010         0.010         25         50         1.5         0.08           As welded         mark         MPa         (600 (450)         740          240          1.5           Reduction of area         %          1.5         1.5         1.6         1.5         1.5         1.5         1.5         1.5         1.5         1.5         1.5         1.5         1.5         1.5         1	Specifications	BS 29	26		25.3	35.H.Nb.B								
(weid metal wt %)         min         0.35         0.5         0.2         -         -         2.0         3.2.0         -         0.7.5         0.02           Max         0.50         2.0         1.3         0.030         0.040         27.0         3.6.0         5         1.50         0.20           All-weld mechanical properties         As welded         min *         typical         typical         0.08           All-weid mechanical properties         As welded         min *         typical         -         1.50         0.20           As welded         min *         typical         -         -         1.50         0.02           As welded         min *         typical         -         -         1.50         0.02           Stores strange         MPa         -         -         -         1.50         0.02         -           Reduction of area         %         -         -         1.5         1.5         1.5         1.5         1.5           Reduction of area         %         -         -         1.60         4.82         7         1.43         6         2.5         1.41         1.6         6         2.5         2.2         2.41	ASME IX Qualification	QW43	<b>2</b> F-No-	-										
max         0.50         2.0         1.3         0.030         0.040         27.0         36.0         0.5         1.50         0.20           MP         0.43         1.7         0.9         0.010         025         35         0.1         1.1         0.08           All-weld mechanical properties         As welded Tansile strength         MPa 0.2% Proof stress         MPa 0.2% Proof stress         Proof stress         MPa 0.2% Proof stress         MPa 0.	Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	Ti		
Vp         0.43         1.7         0.9         0.010         0.10         25         35         0.1         1.1         0.08           All-weld mechanical properties         As welded         MPa         600 (450)         7.40         7.40           O2% Proof stress         MPa         600 (450)         7.40         -         15           Elongation on 4d         %         -         15         -         -           Reduction of area         %         -         17         -<	(weld metal wt %)													
All-weld mechanical properties       As welded       min * typical         All-weld mechanical properties       As welded       min * typical         All-weld mechanical properties       MPa       600 (450)       740         0.2% Proof stress       MPa      (250)       560         Elongation on 5d       %        15         Reduction of area       %        15         Reduction of area       %        17         Hardness       HV        240         * Minimum tensile strength of 600MPa is from BS2926; the values in brackets are minimum values for base material static castings.       Room temperature elongation has little significance for weld metal designed for high temperature service and recepresistance. Values down to 4.5% (on 44) are allowed in ASTM HP40 castings and the ductility of multipass welds may approach this value due to carbide precipitation in successive runs.         Stress rupture/creep data:       Temperature       Stress       Life       Elongation         oc       er       MPa       ksi       Hours       %         871       1600       48.2       7       1431       6         927       700       27.6       4       2398       3         982       1800       17.3       2.5       210														
propertiesTensile strengthMPa 0.2%. Froof stressMPa (-(250)600 (450)740 (-(250)0.2%. Proof stressMPa (-(250)-(250)560Elongation on 3d% (15Reduction of area% (17HardnessHV-240*Minimum tensile strength of 600MPa is from BS2926; the values in brackets are minimum values for base material static castings.Room temperature clongation has little significance for weld metal designed for high temperature service and creep resistance. Values down to 4.5% (on 4d) are allowed in ASTM HP40 castings and the ductility of multipas welds may approach this value due to carbide precipitation in successive runs.Stressrupture/creep data: TemperatureKeiHours (MPa%077.027.6423983982180017.32.524143Operating parametersDC +veImal 60 (27.675100130mm2.53.24.05.0100min A max A90120155210100Packaging datamm2.53.24.05.0iength mm2.653.20320320kgdcarton5193.48228153Storage3hermetically sealed ring-pull metal time per caron, 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 minity in case at 50 - 200°C (-3 cycles, 1		тур	0.43	1.7	0.9	0.010	0.010	25	35	0.1	1.1	0.08		
0.2% proof stressMPa Elongation on 5d (250)560 15 Elongation on 5dReduction of area% (5)15 FlowHardnessHV 240* Minimum tensile strength of 600MPa is from BS2926; the values in brackets are minimum values for base material static castings.Room temperature elongation has little significance for weld metal designed for high temperature service and creep resistance. Values down to 4.5% (on 4d) are allowed in ASTM HP40 castings and the ductility of multipass welds may approach this value due to carbide precipitation in successive runs.Stress rupture/creep data: Temperature***********************************	All-weld mechanical	As weld	ded					min *		typical				
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	properties	Tensile	strength			Μ	IPa	600 (450)	)	740				
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $						Μ		. ,						
Reduction of area% Hardness17 -HardnessHV240*Minimum tensile strength of 600MPa is from BS2926; the values in brackets are minimum values for base material static castings.Room temperature elongation has little significance for weld metal designed for high temperature service and creep resistance. Values down to 4.5% (on 4d) are allowed in ASTM HP40 castings and the ductility of multipass welds may approach this value due to carbide precipitation in successive runs.Stress rupture/creep data:LifeElongation oc% % %0emperature927144316277170027.6423983982180017.32.524143Operating parametersDC + veImage: StressImage: StressImage: Stresse mm2.53.24.05.0min A6075100130max A90120155210Packaging datae mm2.53.24.05.0kg/carton519348228153Storage3 Intermetically 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. For electrodes to tarbid sprosity. For electrodes to tarbid sprosity. For electrodes at 50 – 200°C in holding oven or heated diver: no limit, but maximum 6 weeks recom		-												
HardnessHV- 240* Minimum tensile strength of 600MPa is from BS2926; the values in brackets are minimum values for base material static castings.Room temperature elongation has little significance for weld metal designed for high temperature service and creep resistance. Values down to 4.5% (on 4.0) are allowed in ASTM HP40 castings and the ductility of multipass welds may approach this value due to carbide precipitation in successive runs.Stress rupture/creep data:Image: Stress rupture/creep data:DC +veImage: Image: Stress rupture/creep data:DC +veImage: Image: Image: Stress rupture/creep data:a mm 2.5 3.2 4.0 5.0mm 2.5 3.2 4.0 5.0max A90120130Image: Stress		-												
material static castings.         Room temperature elongation has little significance for weld metal designed for high temperature service and creep resistance. Values down to 4.5% (on 4d) are allowed in ASTM HP40 castings and the ductility of multipass welds may approach this value due to carbide precipitation in successive runs.         Stress rupture/creep data:         Temperature or er       MPa       ksi       Hours       %         97       1600       48.2       7       1431       6         97       1700       27.6       4       3         Operating parameters       DC +ve       Ima       Colspan="4">Colspan="4				iu ii		I								
remperatureStressLifeElongation°C°FMPaksiHours%871160048.2714316927170027.6423983982180017.32.524143Operating parametersDC +veIma6075100130 $mm$ 2.53.24.05.0ImaIma $mm$ 2.53.24.05.0ImaIma $max$ 90120155210ImaImaPackaging dataø mm2.53.24.05.0ImaImax A90120155210ImaImaPackaging dataø mm2.53.24.05.0ImaImax A90120155210ImaImaPackaging dataØ mm2.653.20320320Imax A90348228153ImaStorage331.112.312.012.3Ipices/carton519348228153ImaStorage of redried 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 more storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended ambient storage conditions. Traject or opened tins, but maximum 6 weeks recommended. Recommended ambient stora		Room creep re	temperati esistance	ure elor . Values	ngation 1 s down to	o 4.5% (or	n 4d) are	allowed in	ASTM	HP40 ca	astings a			
°C         °F         MPa         ksi         Hours         %           871         1600         48.2         7         1431         6           927         1700         27.6         4         2398         3           982         1800         17.3         2.5         2414         3           Operating parameters         DC +ve         Image: Constant of the second of the se		Stress	rupture/	creep d	lata:									
			-	peratur				Stress						-
927 9821700 180027.6 17.34 2.52398 24143Operating parametersDC + veImage: Constraint of the second se														
982180017.32.524143Operating parametersDC + ve $\widehat{\baseline}$ </td <td></td>														
		-												
min A max A6075100130 130Packaging dataø mm2.53.24.05.0length mm kg/carton265320320320kg/carton11.112.312.012.3pieces/carton519348228153Storage <b>3 hermetically sealed ring-pull metal tins</b> 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. 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.Fume dataFume composition, wt % typical: FeMnNiCrCuMoVFOES (mg/m³)	Operating parameters	DC +ve	e											Î
max A90120155210Packaging dataømm2.53.24.05.0length mm265320320320kg/carton11.112.312.012.3pieces/carton519348228153Storage3 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. 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.Fume dataFume composition, wt % typical: FeFeMnNiCrCuMoVFOES (mg/m³)		ø mm			2.5		3.2		4.0		5.	0		
Packaging data          ø mm           2.5           3.2           4.0           5.0          length mm           265           320           320           320          kg/carton           11.1         12.3         12.0         12.3           153          Storage          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.         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.          Fume data          Fume composition, wt % typical:		min A			60		75		100		13	0		
length mm       265       320       320       320         kg/carton       11.1       12.3       12.0       12.3         pieces/carton       519       348       228       153         Storage       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. 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.         Fume data       Fume composition, wt % typical:       Fe       Mn       Ni       Cr       Cu       Mo       V       F       OES (mg/m³)		max A			90		120		155		21	0		
length mm       265       320       320       320         kg/carton       11.1       12.3       12.0       12.3         pieces/carton       519       348       228       153         Storage       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. 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.         Fume data       Fume composition, wt % typical:	Packaging data	ø mm			2.5		3.2		4.0		5.	0		
pieces/carton519348228153Storage3 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. 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.Fume dataFume composition, wt % typical: Fe Mn Ni Cr Cu Mo V F OES (mg/m³)		length i	nm		265				320		32	0		
Storage       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. 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.         Fume data       Fume composition, wt % typical:         Fe       Mn       Ni       Cr       Cu       Mo       V       F       OES (mg/m³)		0												
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.         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.         Fume data       Fume composition, wt % typical:         Fe       Mn         Ni       Cr       Cu       Mo       V       F       OES (mg/m³)		pieces/	carton		519		348		228		15	3		
Fe Mn Ni Cr Cu Mo V F OES (mg/m <sup>3</sup> )	Storage	for lon moistur For ele <b>Redry</b> Storag	ger than re pick-up ctrodes the 200 – 30 <b>e</b> of redri	a worki p and ir hat have 0°C/1-2 ied elec	ing shift acrease t been e 2h to res trodes a	of 8h. E he risk of xposed: tore to as- t 50 – 200	xcessive porosity packed c °C in ho	exposure condition. lding over	of elect Maxim n or hea	trodes to num 400° ated quiv	humid C, 3 cy er: no li	conditio vcles, 10 mit, but	ns wil h total maxii	ll cause some l. num 6 weeks
Fe Mn Ni Cr Cu Mo V F OES (mg/m <sup>3</sup> )	Fume data	Fume o	compositi	on wt	% typics	al:								
	i une udla		-				Cr	Cu	Mo	V		F I		ma/m <sup>3</sup> )
$4 \qquad 6 \qquad 7 \qquad 7 \qquad < 0.5 \qquad < 0.1 \qquad < 0.1 \qquad 18 \qquad 0.7$														



25.35.4CNb								Soli	d TIG	wire	for ma	atchin	g HP	40Nb a	alloys
Product description	Solid	wire for	TIG aı	nd auto	o-TIG.										
Specifications	There	are no r	ational	l speci	fications	for this	wire								
ASME IX Qualification	QW4	QW432 F-No -													
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	Ti	Zr	Cu	Sn	Pb
(wire wt %)	min max	0.40 0.50	1.0 2.5	0.5 1.6	0.02	0.02	23.0 27.0	32.0 36.0	 0.50	0.75 1.50	0.05 0.25	0.01 0.15	0.5		
	typ	0.43	1.7	1.1	0.005	0.01	26	35	< 0.3	1.1	0.1	0.03	0.1	< 0.01	< 0.01
All-weld mechanical	Typica	al values	as wel	ded			1	min *	TI	G					
properties		Tensile strengthMPa450809													
		Proof str				MPa %		250 5	55						
	0	ation on				%			1						
	Reduc	ction of a	rea			%			1	5					
	Hardn	ess cap/	mid			HV			211/	/263					
Typical operating parameters	resista may a	nce. Va	lues do	wn to		tle signif 4d) are a side preci	allowe	d in AS							
	Shield Currei	0			TIG Argon DC-		pitatio	on in suc	cessive	runs.					
	Currei Diame	nt eter		2	Argon DC- 2.4mm		pitatio	on in suc	ccessive	runs.					
	Currei	nt eter		2	Argon DC-		pitatio	on in suc	ccessive	runs.					
Packaging data	Currei Diame	nt eter		2	Argon DC- 2.4mm		Spool	led wire	normally	,					
Packaging data	Currer Diame Param	nt eter		2	Argon DC- 2.4mm 0A,12V		Spool used f	led wire	normally natic TIC	,					
Packaging data	Curren Diame Param ø mm 1.2 1.6	nt eter		210	Argon DC- 2.4mm 0A,12V TIG  5kg tube		Spool used f	led wire	normally natic TIC	,					
Packaging data	Curren Diame Param ø mm 1.2 1.6 2.0	nt eter		2 10 2.4 2.4	Argon DC- 2.4mm 0A,12V TIG  5kg tube 5kg tube		Spool used f	led wire or auton 12.5kg r	normally natic TIC	,					
Packaging data	Curren Diame Param Ø mm 1.2 1.6 2.0 2.4	nt eter		2 10 2.4 2.5 2.5	Argon DC- 2.4mm 0A,12V TIG  5kg tube 5kg tube 5kg tube		Spool used f	led wire or auton 12.5kg r 	normally natic TIC	,					
Packaging data	Curren Diame Param 1.2 1.6 2.0 2.4 3.2	nt eter neters	ition (v	2 10 2.4 2.4 2.4 2.4 2.4 2.4	Argon DC- 2.4mm 0A,12V TIG  5kg tube 5kg tube 5kg tube 5kg tube		Spool used f	led wire or auton 12.5kg r  	normally natic TIC	,					
	Curren Diame Param 1.2 1.6 2.0 2.4 3.2	nt eter neters		2 10 2.4 2.4 2.4 2.4 2.4 2.4	Argon DC- 2.4mm 0A,12V TIG  5kg tube 5kg tube 5kg tube 5kg tube	ne neglig	Spool used f	led wire or auton 12.5kg r  	normally hatic TIC eel	,		5 (mg/m			



## HIGH CARBON 35Cr-45Ni-1Nb

#### Alloy type

High carbon 35Cr-45Ni-1Nb to match heat-resisting castings, which are often micro-alloyed with Ti and Zr.

#### Materials to be welded

#### Proprietary alloys include:

Paralloy H46M (Doncasters Paralloy) Manaurite XT/XTM (Manoir Industries) Centralloy ET45 Micro (Schmidt + Clemens-Centracero) Lloyds T80 (LBA) Lloyds T75MA (LBA)

#### Applications

These alloys have superior carburisation and oxidation resistance to alloys based on 25%Cr-35%Ni for service up to 1150°C but with some reduction in creep strength.

Applications include **pyrolysis coils** and **reformer tubes** for the **petrochemical** industry.

#### DATA SHEET C-60

METRODE PRODUCTS LTD HANWORTH LANE, CHERTSEY SURREY, KT16 9LL Tel: +44(0)1932 566721 Fax: +44(0)1932 565168 Sales Fax: +44(0)1932 569449 Technical Fax: +44(0)1932 566199 Export Email: info@metrode.com Internet: http://www.metrode.com

#### Microstructure

In the as-welded condition the multi-pass weld metal microstructure consists of austenite with primary eutectic and secondary precipitated carbides.

#### Welding guidelines

For the thicker section materials a preheat may prove beneficial owing to the low ductility of the material. There would not normally be any requirement for PWHT.

#### **Related alloy groups**

There are a number of other high carbon austenitic alloys for high temperature service e.g.. 25Cr-35Ni-1Nb types (data sheet C-50).

#### **Products available**

Process	Product	Specification
MMA	Thermet 35.45.Nb	-
TIG/MIG	35.45.Nb	-

### THERMET 35.45.Nb

#### MMA electrode

Product description	purity	hermet 35.45.Nb is a basic coated electrode with some alloy additions in the coating and is made on a high urity NiCr core wire. Recovery is approximately 140% with respect to core wire, 65% with respect to whole ectrode.												
Specifications	No rel	evant na	tional	specific	ations.									
ASME IX Qualification	QW43	N432 F-No-, QW442 A-No-												
Composition		С	Mn	Si	S	Р	Cr	Ni	Nb	Мо	Ti	Fe		
(weld metal wt %)	min	0.40	0.5	1.0	-	-	34	44	0.60	-	0.04	-		
. ,	max	0.50	1.5	1.6	0.01	0.01	38	50	1.30	0.25	0.15	bal		
	typ	0.45	0.9	1.2	0.005	< 0.01	35	47	0.8	0.05	0.07	13		
All-weld mechanical	As we	ded					min *		typical					
properties	Tensile	e strengt	h			MPa	450		740					
	0.2% F	Proof str	ess			MPa	245		550					
	Elonga	ation on -	4d			%	3		6					
	Hardn	ess				HV	-		270					
	* Min	imum v	alues a	re for s	tatic casti	ngs.								



MMA electrode

## THERMET 35.45.Nb (continued)

Operating parameters	DC +ve					Ų	$\checkmark$		Ê	Û
	ø mm	2.5		3.2	4	.0				
	min A	70		85	1	10				
	max A	95		120	10	50				
Packaging data	ø mm	2.5		3.2	4	.0				
	length mm	260		350	3:	50				
	kg/carton	9.9		13.5	13	3.5				
	ng/ourton			10.0						
	pieces/carton	450		306	20	01				
Storage	J	450 led ring-put vorking shift nd increase have been of C/1-2h to re electrodes	ft of 8h. Ex the risk of exposed: store to as- at $50 - 200$	306 sper cartor xcessive ex porosity. packed cor °C in holdi	n, with unlim xposure of e ndition. Mai ing oven or	01 hited shelf lectrodes ximum 35 heated qu	to humid 50° C, 3 c iver: no l	l condition cycles, 10h limit, but 1	ns will ca n total. naximum	use some
Storage Fume data	pieces/carton <b>3 hermetically sea</b> for longer than a v moisture pick-up a For electrodes that <b>Redry</b> 150 – 250° <b>Storage</b> of redried	450 led ring-pu vorking shift nd increase have been C/1-2h to re electrodes commended	ft of 8h. Ex the risk of exposed: store to as- at $50 - 200$ l ambient st	306 sper cartor xcessive ex porosity. packed cor °C in holdi	n, with unlim xposure of e ndition. Mai ing oven or	01 hited shelf lectrodes ximum 35 heated qu	to humid 50° C, 3 c iver: no l	l condition cycles, 10h limit, but 1	ns will ca n total. naximum	use some
	<b>bieces/carton</b> <b>3 hermetically sea</b> for longer than a v moisture pick-up a For electrodes that <b>Redry</b> 150 – 250° <b>Storage</b> of redried recommended. Re	450 led ring-pu vorking shift nd increase have been C/1-2h to re electrodes commended	ft of 8h. Ex the risk of exposed: store to as- at $50 - 200$ l ambient st	306 s per cartor xcessive ex porosity. packed cor °C in holdi orage cond	n, with unlim xposure of e ndition. Mai ing oven or	D1 hited shelf lectrodes ximum 35 heated qu ened tins	to humid 50° C, 3 c iver: no l	l condition cycles, 10h limit, but n astic lid): <	ns will ca n total. naximum	use some

### 35.45.Nb

Solid welding wire for TIG welding

Product description	Straigh	Straight lengths and spooled wire for manual and automatic TIG/GTAW welding.											
Specifications	There are no national specifications for this wire.												
ASME IX Qualification	QW43	<b>32</b> F-No	,	QW442	2 A-No								
Composition		С	Mn	Si	S	Р	Cr	Ni	Nb	Мо	Ti	Zr	Fe
(wire wt %)	min	0.40	0.8	1.0	-	-	34	44	0.6	-	0.04	-	-
	max	0.50	1.5	1.5	0.015	0.02	38	48	1.3	0.50	0.15	0.15	bal
	typ	0.43	1.0	1.2	0.005	0.012	36	46	0.9	0.05	0.1	0.05	13
All-weld mechanical	Typica	l values a	as welde	ed			TIG	i					
properties	Tensile	e strength	۱			MPa	690	)					
	0.2% F	Proof stre	SS			MPa	550	)					
	Elonga	ation on 4	d			%	3						
	Hardne	ess				HV	280	)					
Typical operating				TI	G								
parameters	Shieldi	ing		Arg	gon								
1	Curren	t		D									
	Diame	ter		2.41	nm								
	Param	eters		120A	, 12V								
Packaging data	ø mm			TI	G		Spooled	ł					
	1.2			-		12	2.5kg sp	ool					
	2.4			2.5kg	tube		-						
	3.2			2.5kg	tube		-						
Fume data	Fume	composit	tion (wt	: %) (TI	G fume 1	egligible	:)						
			Fe	Mn	С	3	Ni	Мо	C	u	OES (mg/i	m³)	
			15	5	28	3	28	< 0.5	<0	.5	1.8		



565168 Sales

569449 Technical

**C-70** 

# High Temperature Alloys

## HIGH CARBON 25Cr-35Ni-WCo

#### Alloy type

0.5%C-25%Cr-35%Ni-15%Co-5%W cast alloy for elevated temperature service.

#### Materials to be welded

#### Proprietary cast alloys:

MORE 6 (Duraloy) Supertherm (Duraloy) Lloyds T66 (LBA) Centralloy ET35Co (Schmidt & Clemens – Centracero) Manaurite 35K (Manoir Industries)

#### Applications

This electrode matches similar cast alloys originating from the Abex alloy Supertherm, which is itself related to the cobalt free Blaw-Knox alloy 22H (data sheet C-80).

The high carbon high alloy matrix provides excellent hot strength and oxidation resistance at typical service temperatures of 950-1250°C. Cobalt and tungsten are important for maintaining matrix strength beyond about 1150°C when carbides are progressively dissolved.

Applications include highly stressed furnace parts,

sintering and calcining muffles, cement kiln components resistant to hot abrasion, radiant tubes and pyrolysis coils.

DATA SHEET

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#### **Microstructure**

The as-welded microstructure consists of high alloy austenite with primary eutectic and secondary carbides.

#### Welding guidelines

Preheat is often recommended owing to the low ductility of this alloy, coupled with high strength and residual stress levels of multipass welds. For thicker sections, preheat of 300°C or more may be advisable.

#### **Related alloy groups**

The cobalt free 22H alloy is related to this alloy and is used for similar applications (data sheet C-80).

Process	Product	Specification
MMA	Thermet HP50WCo	



## **THERMET HP50WCo**

MMA electrode for matching high carbon austenitic cast alloys

Product description	<ul><li>All-positional basic MMA electrode designed to match similar cast alloys. Basic flux system with alloy additions on high purity NiCrFe core wire.</li><li>Recovery is about 150% with respect to core wire, 65% with respect to whole electrode.</li></ul>												
Specifications	There are no national specifications for this electrode.												
ASME IX Qualification	QW43	QW432 F-No-, QW442 A-No											
Composition (weld metal wt %)	min	C 0.40	Mn 0.5	Si 0.2	S 	P 	Cr 24.0	Ni 34.0	Co 13.0	W 4.0	Mo 	Cu 	Fe 
	max typ	0.60 0.50	1.5 0.6	1.2 0.5	0.020	0.030	28.0 25	40.0 35	18.0 14	6.0 4.6	0.5	0.5	bal 19
All-weld mechanical	As weld	ded				n	nin *	typical '	*				
properties	0.2% P Elonga Elonga	Minimu <10% e The hig precipit signific	ss d d ea im value longatic h streng ation an	on. gth of the nd strain	M r static cas e weld me -hardening	Pa % % % HV stings. A etal is der g by succ	ived fron ressive w	n the chill	-cast mi . Room	icrostru 1 tempe	cture co prature e	upled wi	MPa with th carbide has little
	min A max A			70 95		85 120		110 160					
Packaging data	ø mm length i kg/carto pieces/	on		2.5 265 10.5 396		3.2 320 12.0 267		4.0 320 13.2 159					
Storage								unlimited of electro					
	moistur For ele <b>Redry</b> Storag	re pick-u ctrodes t 150 – 25 e of redr	p and in hat have 50°C/1-2 ried elec	ncrease the been ex 2h to res strodes at	he risk of kposed: tore to as- t 50 – 200	porosity. packed co °C in hol	ondition. ding ove		m 350° d quive	r: no li	mit, but	n total. maximu	m 6 weeks
Fume data	moistur For ele <b>Redry</b> <b>Storag</b> recomr	re pick-u ctrodes t 150 – 25 e of redr	p and ir hat have 50°C/1-2 ied elec Recom	to reserve the been exp the to reserve the to reser	he risk of kposed: tore to as- t 50 – 200 ambient st	porosity. packed co °C in hol	ondition. ding ove	n or heate	m 350° d quive	r: no li	mit, but	n total. maximu	n 6 weeks
Fume data	moistur For ele <b>Redry</b> <b>Storag</b> recomr	re pick-u ctrodes t 150 – 25 e of redr nended.	p and ir hat have 50°C/1-2 ied elec Recom	to reserve the been exp the to reserve the to reser	he risk of kposed: tore to as- t 50 – 200 ambient st	porosity. packed co °C in hol	ondition. ding ove	n or heate or opened	m 350° d quive	r: no li	mit, but stic lid):	n total. maximu	n 6 weeks H,>18°C.



565168 Sales

569449 Technical

C - 80

# High Temperature Alloys

## ALLOY 22H HEAT RESISTANT AUSTENITIC STAINLESS STEEL

#### Alloy type

0.5%C-28%Cr-50%Ni-5%W cast high temperature alloy.

#### Materials to be welded

DIN: 2.4879 G-NiCr28W G-X45NiCrWSi 48 28

22H (Duraloy) Super 22H (Duraloy; +2%Co) Paralloy H48T (Doncasters Paralloy) Centralloy 4879 (Schmidt & Clemens – Centracero) Marker G4879 (Schmidt & Clemens) Pyrotherm G 28/48/5W (Pose-Marre) HR23 (Cronite) Lloyds T75 (LBA) Thermax 70 (Sheepbridge) Manaurite 50W (Manoir Industries) Thermalloy T75 (Manoir Electroalloys)

#### Applications

This electrode is designed to match similar high carbon cast alloys originating from Blaw-Knox (Now Duraloy) alloy 22H.

The high carbon 28% Cr-50% Ni-5% W matrix provides excellent hot strength and oxidation resistance at typical service temperatures of 950-1250°C. High nickel gives

the alloy good resistance to carburisation and under oxidising conditions high chromium provides useful resistance to sulphidation.

DATA SHEET

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Applications include highly stressed **furnace parts**, **sintering** and **calcining muffles**, **cement kiln components resistant** to **hot abrasion**, **radiant tubes** and **pyrolysis coils**.

#### Microstructure

The as-welded microstructure consists of high alloy austenite with primary eutectic and secondary carbides.

#### Welding guidelines

Preheat is often recommended owing to the low ductility of this alloy, coupled with high strength and residual stress levels of multipass welds. For thicker sections, preheat of 300°C or more may be advisable.

#### **Related alloy groups**

In an alternative alloy for similar applications about 15% Ni is replaced with cobalt, see data sheet C-70.

#### **Products available**

Process	Product	Specification
MMA	Thermet 22H	

## **Proprietary cast alloys:** 22H (Duraloy)

Rev 00 05/01



Product description	All-positional basic MMA electrode designed to match similar cast alloys. Basic flux system with alloy additions on high purity NiCr core wire.										
	Recovery is about 140% with respect to core wire, 65% with respect to whole electrode.										
Specifications	There are no national specifications for this electrode.										
ASME IX Qualification	QW432 F-No-	QW432 F-No									
Composition	С	Mn	Si	S	Р	Cr	Ni	W	Fe		
weld metal wt %)	min 0.40	0.5	0.5			27.0	47.0	4.0			
	max 0.60	1.5	1.2	0.020	0.030	30.0	54.0	6.0	bal		
	typ 0.50	1	0.7	0.006	0.010	28	51	5	14		
All-weld mechanical	As welded					min *	typical	**			
properties	Tensile strength			М	IPa	440	780				
	0.2% Proof stres			Μ	IPa		590				
	Elongation on 40				%		7				
	Elongation on 50 Reduction of are				% %	4	6 6				
	Hardness	a		F	HV		270				
	Hardness     HV      270       *     Minimum values for DIN 2.4879 castings.										
	* Minimu ** The high precipita	n strengt ation and	th of the d strain-	N 2.4879 weld me hardening	castings etal is de g by suc	rived from	veld beads	. Roo	nicrostructure coupled v m temperature elongation		
Operating parameters	* Minimu ** The high precipita	n strengt ation and	th of the d strain-	N 2.4879 weld me hardening	castings etal is de g by suc	rived from		. Roo	m temperature elongati		
Operating parameters	* Minimu: ** The higl precipitz significa DC +ve	n strengt ation and	th of the d strain- weld me	N 2.4879 weld me hardening	castings etal is de g by suc ned for o	rived from	veld beads emperature	. Roo	m temperature elongative.		
Operating parameters	* Minimu: ** The higl precipitz significa	n strengt ation and	th of the d strain- weld me 2.5	N 2.4879 weld me hardening	castings etal is de g by suc ned for o 3.2	rived from	veld beads emperature 4.0	. Roo	m temperature elongative.		
Operating parameters	<ul> <li>Minimut         * Minimut         * The high             precipita             significat      </li> <li>DC +ve         </li> <li>ø mm</li> </ul>	n strengt ation and	th of the d strain- weld me	N 2.4879 weld me hardening	castings etal is de g by suc ned for o	rived from	veld beads emperature	. Roo	m temperature elongative.		
	* Minimu ** The high precipita significa DC +ve ø mm min A	n strengt ation and	th of the d strain- weld me 2.5 70	N 2.4879 weld me hardening	castings etal is de g by suc ned for d 3.2 85	rived from	4.0 110	. Roo	m temperature elongative.		
	<ul> <li>* Minimut</li> <li>** The high precipita signification</li> <li>DC +ve</li> <li>ø mm</li> <li>min A max A</li> <li>ø mm</li> <li>length mm</li> </ul>	n strengt ation and	2.5 70 95 2.5 260	N 2.4879 weld me hardening	castings etal is de g by such and for a 3.2 85 120 3.2 3.2 3.2	rived from	4.0 4.0 110 160 4.0 310	. Roo	m temperature elongative.		
	<ul> <li>Minimut         <ul> <li>Minimut                 <ul> <li>The high precipita signification</li> </ul> </li> <li>DC +ve</li></ul></li></ul>	n strengt ation and	2.5 70 95 2.5 2.5	N 2.4879 weld me hardening	castings etal is de g by such and for a 3.2 85 120 3.2	rived from	4.0 110 160 4.0	. Roo	m temperature elongative.		
Packaging data	<ul> <li>Minimu:</li> <li>Minimu:</li> <li>The high precipita significa</li> <li>DC +ve</li> <li>Ø mm</li> <li>min A max A</li> <li>Ø mm</li> <li>length mm kg/carton pieces/carton</li> <li>3 hermetically s for longer than moisture pick-up For electrodes the Redry 150 – 25</li> <li>Storage of redri</li> </ul>	a strengt ition and ince for sealed ri a workin p and in- hat have 0°C/1-2 ied elect	2.5 70 95 2.5 260 10.5 492 ing-pull ng shift crease th been ex h to rest rodes at	metal tim of 8h. E: ne risk of tore to as- tore to as- tore to as- tore to as-	castings etal is de g by such and for of 3.2 85 120 3.2 310 12.0 300 s per ca xcessive porosity packed °C in ho	rton, with exposure condition exposure condition	4.0 4.0 110 160 4.0 310 12.3 198 unlimited e of electro . Maximu en or heato	shelf li m 350°	m temperature elongative.	s satisfactor cause som	
Packaging data Storage	<ul> <li>Minimu:</li> <li>Minimu:</li> <li>The high precipita significa</li> <li>DC +ve</li> <li>Ø mm</li> <li>min A max A</li> <li>Ø mm</li> <li>length mm kg/carton pieces/carton</li> <li>3 hermetically s for longer than moisture pick-up For electrodes the Redry 150 – 25</li> <li>Storage of redri</li> </ul>	sealed ri a workin p and in- hat have 0°C/1-2 ied elect Recomn	2.5 70 95 2.5 260 10.5 492 ing-pull ng shift crease th been ex h to rest rodes at nended a	metal tim of 8h. E: ne risk of sposed: 50 – 200 umbient st	castings etal is de g by such and for of 3.2 85 120 3.2 310 12.0 300 s per ca xcessive porosity packed °C in ho	rton, with exposure condition exposure condition	4.0 4.0 110 160 4.0 310 12.3 198 unlimited e of electro . Maximu en or heato	shelf li m 350°	m temperature elongative.	s satisfactor cause som	
Operating parameters Packaging data Storage Fume data	<ul> <li>Minimu:</li> <li>Minimu:</li> <li>The high precipita significa</li> <li>DC +ve</li> <li>ø mm</li> <li>min A max A</li> <li>ø mm</li> <li>length mm kg/carton pieces/carton</li> <li><b>3 hermeticallys</b> for longer than moisture pick-up For electrodes the <b>Redry</b> 150 – 25</li> <li><b>Storage</b> of redrire recommended. If</li> <li>Fume composition</li> </ul>	sealed ri a workin p and in- hat have 0°C/1-2 ied elect Recomn	2.5 70 95 2.5 260 10.5 492 ing-pull ng shift crease th been ex h to rest rodes at nended a	metal tim of 8h. E: ne risk of sposed: 50 – 200 umbient st	castings etal is de g by such and for of 3.2 85 120 3.2 310 12.0 300 s per ca xcessive porosity packed °C in ho	rton, with exposure rton, with exposure 7. conditions	4.0 110 160 4.0 310 12.3 198 unlimited e of electro Maximu en or heato for opened	shelf li m 350°	m temperature elongative.	s satisfactor cause some	



## **SPECIAL ELECTRODE FOR IN-657**

#### Alloy type

50Cr-50Ni alloy for high temperature corrosion resistance.

#### Materials to be welded

Inco IN-657, IN-671 ASTM A560 Grade 50Cr-50Ni-Cb DIN 2.4678, 2.4680, 2.4813 Paralloy N50W (Doncasters Paralloy) Duraloy 50/50Cb

#### **Applications**

**Nimrod 657** (formerly 50.50.Nb) was developed in conjunction with Inco to match their proprietary cast alloy IN-657 produced by licenced foundries world-wide. It is also suitable to weld the Ti-bearing wrought version IN-671.

Alloy 657 with its high chromium content has exceptional resistance to hot corrosion (800-950°C) by fuel ash containing vanadium pentoxide and alkali metal sulphates arising from the combustion of low grade heavy fuel oils.

IN-657 castings are used in a wide range of components in oil-fired furnaces and boilers such as **tube sheets**, **tube hangers**, supports and **spacers** in **ships**, **power stations**, **refineries**, and **petrochemical plants**.

#### Microstructure

Very careful control of chromium and niobium is maintained to minimise the risk of weld metal cracking. The microstructure of IN-657 castings and Nimrod 657 weld metal consists of two phases: a chromium-rich alpha phase (bcc) and a nickel-rich gamma phase (fcc). The precise structure obtained is complicated by thermal history and composition, but has an important effect on the control of weld metal cracking. At lower chromium and niobium contents, the primary dendrites which form during solidification are gamma phase and this tends to promote sensitivity to solidification cracking. Higher chromium and niobium contents result in a primary alpha dendritic phase which is less ductile and hence more prone to cold cracking during cooling. An undesirable but infrequent eutectic phase may also occur. The composition of both weld metal and castings is therefore carefully balanced to minimise detrimental microstructural components and so reduce the risk of cracking. Carbon and nitrogen also reduce ductility and are kept as low as practicable.

#### DATA SHEET C-90

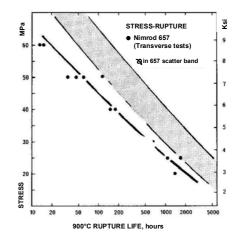
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#### Welding guidelines

Arc length should be kept low to avoid nitrogen pick up. Preheating is usually necessary; 150-200°C at 10mm thick with 200-250°C for most applications and up to 450°C for the thickest sections. Maintain interpass temperatures and slow cool.

#### Additional information

Weldment stress-rupture tests have been carried out on transverse specimens extracted from 25 mm thick centricast IN-657 tube. Tests were carried out at 900°C and the results are shown in the graph. It can be seen that about 75% joint efficiency is achieved in the long-term tests.



#### References

Thornley J.C. 'Welding of 50Ni-50Cr and 50Ni-50Cr-1.5Nb Alloys' Parts 1 & 2, Metal Construction Nov 1976, pp 480-487, and Dec 1976, pp 535-541.

'High chromium Cr-Ni alloys to resist residual fuel oil ash corrosion'. Inco publication No. 4299 (1975).

'IN-657 cast-nickel-chromium-niobium alloy for service against fuel-ash corrosion'. Inco publication no. 4320 (1974).

Process	Product	Specification
MMA	Nimrod 657	AWS ENiCr-4



Nimrod 657									MN	/IA ele	ectrod	e for alloy	657/671
Description	MMA	electro	de mad	e on a sj	pecial n	ickel-chr	omium co	ore wire	, with a l	pasic lin	ne-fluor	spar flux cov	ering.
	Recov	very is ap	pprox 1	60% wi	th respe	ct to cor	e wire, 65	% with	respect	to whole	e electro	ode.	
Specifications	AWS	A5.11		ENiC	r-4								
ASME IX Qualification	QW4	22 P-No	0-, <b>Q</b>	<b>N432</b> ]	F-No -								
Composition (weld metal wt %)	min max	C  0.10	Mn  1.5	Si  1.0	S  0.02	P  0.02	Cr 48 52	Ni bal 	Nb 1.0 2.5	Fe  1.0	N  0.16	Cu  0.25	
All-weld mechanical	typ As-we	0.07	1.0	0.5	0.01	0.01	50 min Nimrod			0.5 bical od 657	0.07 IN-6	0.05 657 (as cast)	
properties	0.2% I Elonga Hardn		ess 4d			MPa MPa % HV	760  	I	830 570 2 3	)-985 )-725 2-4 40		600-700 330-400 10-40 210-260	
Operating parameters	place	during n fectively	nultipas v elimin	s weldir	ng. IN-6 ring ser	657 respo				berature	and dif	ferences betw	veen the two
	ø mm			2.5		3	.2		4.0	Ų	$\checkmark$		▋▛▏Ĺ⅃Ĺ⅃
	min A max A	<u> </u>		70 95		8	5 20		110 160				
Packaging data	ø mm			2.5		3	.2		4.0				
	length kg/car pieces			260 10.5 450	5	12	05 2.0 00		305 12.0 195				
Storage	for mu moistu For ele <b>Redry</b> Stora	uch long ure pick- ectrodes y 250 – 3 ge of rec	er than a -up and that ha 300°C/1 dried el	a workin increas we been -2h to r ectrodes	ng shift e the ris e expose restore t s at 50 -	of 8h. Ex k of pord d: o as-pacl - 200°C i	cessive e osity. ced condi n holding	xposure tion. M g oven o	of electro aximum r heated	odes to l 350° C quiver:	humid co , 3 cyclo no limi	use from tin is onditions will es, 10h total. t, but maximu c lid): < 60% l	cause some um 6 weeks
Fume data	Fume	compos	ition (w	/t %)									
			Fe 1	Mr 2		Ni 2.5	Cr 8	Mo 0.1	Cu 0.1		F 23	OES (mg/m	3)

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SECTION D

## NICKEL BASE ALLOYS

## Nickel Base consumables

As a whole, nickel-base consumables have a very wide range of applications. They can be roughly divided into those with compositions matching specific parent materials, usually for corrosion resistance, and those with compositions unique to weld metal specifications some of which have specialised uses and others more general purpose applications.

Electrode characteristics vary according to the intended application and the constraints dictated by particular alloys. Most types have basic flux coverings, those with the suffix KS being suitable for positional welding of fixed pipework. Rutile flux systems are compatible with some of the high molybdenum corrosion-resistant alloys. A low level of impurities is desirable in all cases to minimise sensitivity to hot cracking and microfissuring.

The most important general purpose group are the 'Inconel' types, very loosely based on heat-resistant alloy 600 with 15%Cr-75%Ni-8%Fe. Compared with alloy 600, all these weld metals have significant additions of manganese and niobium which give resistance to hot cracking and raise hot strength. Nimrod 182/182KS have the highest manganese to maximise resistance to hot cracking, whereas in Nimrod AB/AKS manganese is partially replaced by molybdenum which has the additional effect of improving creep resistance. In many applications these two types can be used interchangeably, particularly in dissimilar metal welds between nickel base and most steels or other ferrous alloys. Useful service properties range from cryogenic up to elevated temperatures of 1000°C plus. Related to these is the more specialised heat resisting type Nimrod 132KS used primarily for welding 600 and similar materials in cast or wrought form.

**Nimrod 625/625KS** electrodes and **62-50** wires are designed to match alloy 625 which was originally developed for heat-resisting applications. However, parent material and consumables of this alloy have gained more widespread use for many applications exploiting its excellent pitting and crevice corrosion resistance and high strength at all service temperatures.

Electrode types Nimrod C276, C276KS, C22KS and Nimax B2L and complimentary solid wires match the current specifications for corrosion-resistant parent alloys C276, C22 and B2 respectively. Also related to this group is the higher alloy Nimrod 59KS, matching alloy 59. Their uses include overmatching welds for various superaustenitic stainless steels.

The precursor to alloy C276 was alloy C which is represented by rutile electrodes **Nimrod C** and the high efficiency type **Nimax C**. Their general corrosion resistance is useful for overlays and high work-hardening rate and thermal fatigue resistance for build-up and repair of hot-work dies.

Welding 5%Ni and 9%Ni steels for cryogenic service requires a combination of strength and toughness that cannot be obtained reliably using weld metal of similar composition. In practice dissimilar nickel base weld metal is used. **Nimrod NCM6** is a high efficiency electrode particularly intended for this purpose, but others may be suitable alternatives depending on design requirements.

Nickel, nickel-copper (Monel<sup>®</sup>) and cupronickel consumables are well established for use in high integrity fabrication welds between their respective parent alloys. For surfacing steels or dissimilar welds it should be noted that tolerance to iron dilution decreases with increasing copper content and the pure nickel type is therefore used as a buffer layer.

<sup>®</sup> Inconel and Monel are trademarks of Special Metals.



Data	Alloy	Process	Product	Spec	cifications
Sheet	Alloy	FIDCESS	Froduct	AWS	BS EN
			Nimrod 182KS	ENiCrFe-3	E Ni6182
D-10	182	MMA	Nimrod 182	ENiCrFe-3	E Ni6182
D-10	102		Nimax 182	ENiCrFe-3	E Ni6182
		TIG/MIG/SAW	20.70.Nb	ERNiCr-3	SNi6082
			Nimrod AKS	ENiCrFe-2	E Ni6092
D-11	AB	MMA	Nimrod AB	ENiCrFe-2/4	E Ni6093
U-11	AD		Nimax A	ENiCrFe-2	E Ni6092
		TIG/MIG/SAW	20.70.Nb	ERNiCr-3	SNi6082
D-12	132	MMA	Nimrod 132KS	ENiCrFe-1	E Ni6062
		MMA	Nimrod 625	ENiCrMo-3	E Ni6625
D-20	625	MWA	Nimrod 625KS	ENiCrMo-3	E Ni6625
		TIG/MIG/SAW	62-50	ERNiCrMo-3	SNi6625
		MMA	Nimrod C276	ENiCrMo-4	E Ni6276
D-30	C276	MMA	Nimrod C276KS	ENiCrMo-4	E Ni6276
		TIG/MIG/SAW	HAS C276	ERNiCrMo-4	SNi6276
D-31	59	MMA	Nimrod 59KS	ENiCrMo-13	E Ni6059
0-31		TIG/MIG	HAS 59	ERNiCrMo-13	SNi6059
D-32	C22	MMA	Nimrod C22KS	ENiCrMo-10	E Ni6022
D-32	CZZ	TIG/MIG	HAS C22	ERNiCrMo-10	SNi6022
E-45	С	MMA	Nimrod C	(ENiCrMo-5)	DIN: E23-UM-200CKT
E-43	L	MMA	Nimax C	(ENiCrMo-5)	DIN: E23-UM-200CKT
D-40	617	MMA	Nimrod 617KS	ENiCrCoMo-1	E Ni6617
D-40	017	TIG	61-70	ERNiCrCoMo-1	SNi6617
D-41	690	MMA	Nimrod 690KS	ENiCrFe-7	E Ni6152
D-50	Nickel	MMA	Nimrod 200Ti	ENi-1	E Ni2061
D-20	Nickel	TIG/MIG	Nickel 2Ti	ERNi-1	SNi2061
D-60	Monel	MMA	Nimrod 190	ENiCu-7	E Ni4060
D-00	Monet	TIG/MIG	65NiCu	ERNiCu-7	SNi4060
		MMA	Cupromet N30	ECuNi	
D-70	Cupronickel	TIG	70CuNi	ERCuNi	BS: C18
		TIG	90CuNi		BS C16
D-80	B2	MMA	Nimax B2L	ENiMo-7	E Ni1066
D-90	DZ	TIG	HAS B2	ERNiMo-7	SNI1066
D-87	Dissimilar	MMA	EPRI P87		
D-90	9%Ni steels	MMA	Nimrod NCM6	ENiCrMo-6	E Ni6620



# Nickel Base Alloys

## NICKEL BASE 182 CONSUMABLES

#### Alloy type

Inconel<sup>TM</sup> type consumables with manganese and niobium additions.

#### Materials to be welded

Nickel alloys such as Inconel<sup>™</sup> 600, Nimonic 75. Nickel base alloys to themselves and to mild, low alloy and stainless steels. High temperature transition joints. Cryogenic 3% and 5% Ni steels.

#### Applications

These weld metals have no directly equivalent parent material, although the composition is related to Inconel<sup>TM</sup> 600. Mn and Nb are added to give high resistance to hot cracking, tolerance to dilution by many combinations of nickel-base and ferrous alloys, with stable properties over a wide range of service temperatures from  $-269^{\circ}$ C to above 900°C.

Applications include heat-resisting nickel-base alloys to themselves for use in **furnace equipment** up to about 900°C. Other applications include:

**Mixed** welds between most nickel-base alloys, including Monel 400 and stainless, low alloy or CMn steels without need to preheat.

**Transition** welds between creep-resisting ferritic and austenitic steels, such as 2CrMo and 316H for long term service at elevated temperature in petrochemical and power generation plants.

Low temperature applications such as 3% or 5% Ni steels used for cryogenic vessels and pipework in service at or below -100 °C.

**DATA SHEET** 

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#### Microstructure

High nickel austenite with some carbides.

#### Welding guidelines

Requirements for preheat and PWHT will be dependent on the base material being welded. For most nickel-base materials, no preheat is required.

#### **Related alloy groups**

The AB alloys (data sheet D-11) cover similar applications.

#### **Products available**

Process	Product	Specification
MMA	Nimrod 182KS	AWS ENiCrFe-3
	Nimrod 182	AWS ENiCrFe-3
	Nimax 182	AWS ENiCrFe-3
TIG/MIG/ SAW	20.70.Nb	AWS ERNiCr-3
SAW flux	NiCr	SA FB2

## General Data for all 182 MMA Electrodes

Storage	longer than a up and increas For electrodes <b>Redry</b> 200 – <b>Storage</b> of re	working sl se the risk s that have 300°C/1-2 edried elec	nift of 8h. 1 of porosity been expo the to restore ctrodes at	Excessive e y. osed: e to as-pact 50 - 200°	exposure o ked condit C in hold	f electrodes ion. Maxir ing oven o	to humid c num 380° ( r heated q	onditions C, 3 cycles uiver: no	use from tin is satisfactory for will cause some moisture pick- a, 10h total. limit, but maximum 6 weeks c lid): < 60% RH, > 18°C.
Fume data	Fume compos	sition, wt 9	% typical:						
		Fe	Mn	Cr	Ni	Мо	Cu	F	OES (mg/m <sup>3</sup> )
	_	2	13	5	10	0.2	0.1	15	1



NIMROD 182	KS					All	-positi	onal lı	ncone	I™ typ	be M№	1A elec	trode
Product description	MMA electrode – optimum operabil positions including	ity and	l radiog	graphical	lly sound	weld me	tal. Nir						
	Recovery is about	110%	with re	spect to	core wire	, 65% wi	th respec	t to who	le electr	ode.			
Specifications	AWS A5.11 BS EN 14172 DIN 1736 (Wer	kstoff	No)	ENie	CrFe-3 5182 NiCr15Fel	Mn (2.48	07)						
ASME IX Qualification	QW432 F-No 43												
Composition	CN	Лn	Si	S	Р	Cr	Ni	Nb	Fe	Cu	Ti	Co *	Ta *
(weld metal wt %)	min 5	5.0				13.0	61	1.0	2.0				
			1.0	0.015	0.02	17.0	bal	2.5	9.0	0.50	1.0	0.12	0.30
	typ 0.05	7	0.5	0.01	0.01	16	~ 65	1.5	< 8	0.1	0.1	< 0.05	0.05
	* Co and Ta maxin	mums o	only wl	nen spec	ified at tir	ne of ord	er.						
All-weld mechanical	As-welded					min		typical					
properties	Tensile strength				MPa	550		660					
	0.2% Proof stress	;			MPa	360		420					
	Elongation on 4d				%	30		40					
	Elongation on 5d				%	27		37					
	Reduction of area	l	100		%			38					
	Impact energy		-196	C	J			100					
	Hardness				HV			190					
Operating parameters	DC +ve only								Ų	$\checkmark$		Ê	Î
	ø mm		2.5		3.2		4.0		5.0				
	min A		60		70		100		130				
	max A		80		110		155		210				
Packaging data	ø mm		2.5		3.2		4.0		5.0				
	length mm		280		300		350		350				
	kg/carton		12.0		12.3		15.0		15.0				
	pieces/carton		705		450		300		198				

NIMROD 182			h	ncone	el™ typ	e MM/	A elect	rode f	or dov	vnhan	d welc	ling a	nd surfa	acing
Product description	optimu		bility an	d weld	metal sour		2	U			0 2		signed to p bility prima	
	Recov	ery is ab	out 1209	% with	respect to	core wire	, 65% wi	ith respec	t to who	le electr	ode.			
Specifications	BS E	A5.11 N 14172 736 (W	-	ff No)	ENi6	CrFe-3 182 MCr15Fel	,	m will no 07)	t necess	arily sati	sfy 3G u	sability	criteria)	
ASME IX Qualification	QW43	32 F-No	43											
Composition		С	Mn	Si	S	Р	Cr	Ni	Nb	Fe	Cu	Ti	Co *	Ta *
(weld metal wt %)	min		5.0				13.0	61	1.0	2.0				
	max	0.10	9.5	1.0	0.015	0.02	17.0	bal	2.5	9.0	0.50	1.0	0.12	0.30
	typ	0.05	6	0.5	0.01	0.01	16	~ 65	1.5	< 8	0.1	0.1	< 0.05	0.05
	* Co a	nd Ta m	aximum	s only v	when speci	ified at ti	ne of ord	ler.						



# NIMROD 182 (continued)

All-weld mechanical	As-welded			min	typical	
properties	Tensile strength		MPa	550	660	
	0.2% Proof stress		MPa	360	420	
	Elongation on 4d		%	30	40	
	Elongation on 5d		%	27	37	
	Reduction of area		%		38	
	Impact energy	-196°C	J		100	
	Hardness		HV		190	
Operating parameters	DC +ve					$\square$
	ø mm	3.2	4.0	5.0		
	min A	70	100	130		
	max A	110	155	210		
Packaging data	ø mm	3.2	4.0	5.0		
	length mm	280	330	330		
	kg/carton	12.0	14.1	14.1		
	pieces/carton	375	249	165		

NIMAX 182						I	High re	ecover	y elect	trode	for cla	adding	& sur	facing
Product description						oowder ty f Nimrod								
	Recove	ery is abo	out 140	% with r	espect to	core wire	e, 65% wi	th respec	t to who	le electr	ode.			
Specifications	BS EI	A5.11 N 14172 736 (W	-	off No)	ENie	CrFe-3 5182 NiCr15Fe	Mn (2.48	07)						
ASME IX Qualification	QW43	32 F-No	43											
Composition		С	Mn	Si	S	Р	Cr	Ni	Nb	Fe	Cu	Ti		
(weld metal wt %)	min		5.0				13.0	61	1.0	2.0				
	max	0.10	9.5	1.0	0.015	0.02	17.0	bal	2.5	9.0	0.50	1.0		
	typ	0.06	6	0.4	0.008	0.01	15	~ 69	1.5	7	0.05	0.07		
All-weld mechanical	As-we	lded					min		typical					
properties	Tensile	e strengt	h			MPa	550		660					
		Proof stre				MPa	360		390					
	-	ation on 4				%	30		40					
	-	ation on				%	27		38					
		tion of a	rea			%			40					
		t energy		-196	5°C	J			> 80					
	Hardn	ess				HV			190					
Operating parameters	DC +v	e only										U	$\checkmark$	
	ø mm			2.0		2.5		3.2		4.0		5.0		
	min A			40		70		90		130		160		
	max A			60		115		155		210		260		
Packaging data	ø mm			2.0		2.5		3.2		4.0		5.0		
	length	mm		255		300		350		350		450		
	kg/car	ton		9.9		12.0		13.5		13.5		17.1		
	pieces	/carton		807		468		291		192		129		



20.70.Nb								Solid v	velding	wire	for TIG,	MIG a	and SAW
Product description				TIG, MI stainless		b-arc we	lding of ni	ckel base	e alloys an	d dissim	ilar joints b	etween 1	nickel alloys,
Specifications	BS EI BS29 DIN 1 UNS	A5.14 N ISO 01:PT 736 (W	i /erksto	off No)	SNie NA3	35 NiCr20N 082	īb (2.4806 ?)	)					
ASME IX Qualification	QW43	<b>32</b> F-No	43										
Composition (wire wt %)	min max typ	C  0.05 0.02	Mn 2.5 3.5 3	Si  0.50 0.1	S  0.015 0.005	P  0.020 0.01	Cr 18.0 22.0 20	Ni 67.0 bal 73	Nb 2.0 3.0 2.5	Cu  0.50 0.01	Ti  0.7 0.4	Fe  3.0 1	
All-weld mechanical properties	Tensile 0.2% F Elonga	al values e streng Proof str ation on t energy	th ess 4d		6°C	MPa MPa % J	typica 640 360 40 > 100						
Typical operating parameters	Shield Currer Diame Param	nt ter		E 2.4	TIG Ar DC- 4mm A, 12V		MIG Ar Pulseo 1.2mn 180A, 2	n	N	SAW iCr flux DC+ 6mm 0A, 26V			
Packaging data	ø mm 1.2 1.6 2.0 2.4 3.2			2. 2. 2.	FIG  .5kg .5kg .5kg .5kg		MIG 15kg   			SAW 25kg 25kg 25kg 			
Fume data	MIG fi	ume con	Fe 1	n (wt %) Mr 6		ne negliş Cr <sup>3</sup> 15	gible) Ni 56	Mo < 0.1	Cu < 0.5	OE	S (mg/m <sup>3</sup> )		

NiCr FLUX											Sub-arc fl	lux
Product description	Sub-arc flux – Ag of critical alloying of the weld meta operation is prefe about 10% to avo	g elemer l and re erred. F	nts in the tra duces the lux:wire ra	ansfer fr risk of l tio is 1-	om wire to hot cracki	weld dep ng. NiCr	osit; the le flux can	ow silica be used	content en DC+, DO	nsures a l C- and A	ow silicon con C, although D	tent DC+
Specifications	DIN 32522 BS EN 760		BFB7 65 SA FB2	34 AC5								
Composition		С	Mn	Si	S	Р	Cr	Ni	Nb	Fe	Ti	
(typical)	20.70.Nb wire	0.02	3	0.1	0.005	0.01	20	bal	2.5	1	0.4	
	deposit	0.01	3	0.2	0.006	0.006	20.5	bal	2.3	1	0.08	
All-weld mechanical	As welded					typical						
properties with	Tensile strength			N	ſPa	640						
20.70.Nb wire	0.2% Proof stres	s		N	ſPa	360						
	Elongation				%	40						
Operating parameters	Current: DC +v	e ranges	as below:									
	ø mm		amp-volt	range		t	ypical		stic	kout		
	1.6		200-350	A, 27-31	V	3	00A, 28V	1	20-2	25mm		
	2.4		250-450	A, 28-32	2V	3	50A, 29V	7	20-2	25mm		
Packaging data	Metrode NiCr Fl drums: <60%RH range 250-400°C	I, > 18°										



## NICKEL BASE AB CONSUMABLES

#### Alloy type

Inconel<sup>™</sup> type consumables similar to the 182 but with lower Mn and a Mo addition.

#### Materials to be welded

Inconel 600, Incoloy 800, Incoloy DS, Nilo, Brightray and other nickel base or high nickel alloys to themselves and to mild, low alloy, and stainless steels. Cryogenic 3-5%Ni steels.

#### **Applications**

The weld metal deposited by these consumables has no directly equivalent parent material, although its composition is related to Inconel 600 (0.05C-75Ni-16Cr-8Fe). Mo and Nb are added to give high resistance to hot cracking, tolerance to dilution by many combinations of nickel base and ferrous alloys, and stable properties over a wide range of service temperatures from -269°C to above 900°C. The presence of Mo improves elevated temperature properties above about 600°C, compared to the 182 alloys (data sheet D-10).

These consumables are used for welding Inconel 600, Incoloy 800/800H and similar heat resisting or high nickel alloys to themselves for use in **furnace equipment** and **petrochemical plants** up to about 900°C.

In addition they are suitable for **dissimilar** combinations of the above alloys and others such as Monel 400, Incoloy 825 to stainless, low alloy CMn steels without the need to preheat. Stress relief may be carried out if necessary, and transition welds for high temperature service have good structural stability.

DATA SHEET

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They can also be used for low temperature applications such as 3%Ni or 5%Ni steels used for **cryogenic vessels** and **pipework** in service at or below -100°C.

#### Microstructure

In the as-welded condition this nickel base weld metal consists of austenite with a few carbides.

#### Welding guidelines

Requirements for preheat and PWHT will be dependent on the base material being welded. For most nickel base materials no preheat or PWHT is required.

#### **Related alloy groups**

The 182 alloys (data sheet D-10) cover similar applications.

#### **Products available**

Process	Product	Specification
MMA	Nimrod AKS	AWS ENiCrFe-2
	Nimrod AB	AWS ENiCrFe-2/4
	Nimax A	AWS ENiCrFe-2
TIG/MIG/ SAW	20.70.Nb	AWS ERNiCr-3
SAW flux	NiCr	BS EN SA FB2

Storage	for longer tha moisture pick For electrode: <b>Redry</b> 200 – <b>Storage</b> of re	in a work -up and i s that hav 250°C/1- dried elec	ting shift on ncrease the re been exp 2h to resto ctrodes at t	of 8h. Exc e risk of po posed: ore to as-pa 50 – 200°C	essive exp prosity. acked cond C in holdir	bosure of e dition. Ma	lectrodes t ximum 350 heated qui	o humid o )° C, 3 cy ver: no lir	et use from tin is satisfa conditions will cause s cles, 10h total. mit, but maximum 6 w stic lid): < 60% RH, > 1	some
					0		(	0,		
Fume data	Fume compos	sition, wt	• •							
Fume data			% typical: Mn	Ni	Cr	Мо	Cu	F	OES (mg/m <sup>3</sup> )	

### **General Data for all MMA Electrodes**

D-11



NIMROD AKS							All	-posit	tional	Incone	el™ typ	be MN	IA elec	ctrode
Product description		MMA electrode with a basic flux system on a nearly matching core wire designed to give radiographically sound weld metal. It is optimised for DC+ welding in all positions including pipework in the ASME 5G/6G positions.												
	Recov	ery is al	out 1	10% with	respect	to core w	ire, 65%	with re	espect to	whole e	electrod	<del>2</del> .		
Specifications	BS EI	WS A5.11         ENiCrFe-2           S EN 14172         E Ni6092           IN 1736         EL-NiCr15MoNb (2.4625)												
ASME IX Qualification	QW43	<b>32</b> F-No	o 43											
Composition (weld metal wt %)	min max typ * Co	C  0.10 0.05 0 and Ta	Mn 1.0 3.5 2.8 maxir	Si  0.75 0.5 nums only	S  0.015 0.01 y when	P  0.02 0.01 specified	Cr 13.0 17.0 16 at time c	Ni 62 Bal 69 of order	Nb 1.5 3.0 2	Fe  12.0 8	Mo 1.0 2.5 1.5	Cu  0.50 0.05	Co *  0.12 0.05	Ta *  0.30 0.05
All-weld mechanical properties	0.2% F Elonga Elonga Reduc Impact	Ided Proof strengt ation on ation of a tion of a t energy ess cap	ess 4d 5d rea	- 196	5°C	MPa MPa % % % J HV	min 550 360 30 27  		typical 700 420 42 39 50 110 200/215					
Operating parameters	DC +v ø mm min A max A			2.5 60 80		3.2 70 110			4.0 100 155	Ų	5.0 130 210		È	Û
Packaging data	ø mm length kg/cart pieces			2.5 280 12.0 762		3.2 300 12.0 441	)	1	4.0 350 14.4 300		5.0 350 13.5 186			

NIMROD AB		Inconel <sup>™</sup> type MMA electrode for downhand welding and surfacing										
Product description	prefer usabil	MMA electrode with a basic flux system on a nearly matching core wire. It is designed for DC or AC (DC+ preferred) welding in the flat/downhand and HV positions; the 3.2mm diameter will not necessarily satisfy the 3G isability criterion in AWS A5.11. Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.										
Specifications	BS E	AWS A5.11         ENiCrFe-2/4           BS EN 14172         E Ni6092           DIN 1736         EL-NiCr15MoNb (2.4625)										
ASME IX Qualification	QW4	<b>32</b> F-No	o 43									
Composition		С	Mn	Si	S	Р	Cr	Ni	Nb	Fe	Мо	Cu
(weld metal wt %)	min		1.0				13.0	62	1.5		1.0	
	max	0.10	3.5	0.75	0.015	0.02	17.0	bal	3.0	12.0	2.5	0.50
	typ	0.05	2.5	0.7	0.01	0.01	16	69	2	7	1.5	0.05



# NIMROD AB (continued)

All-weld mechanical	As welded			min	typical		
properties	Tensile strength		MPa	550	700		
	0.2% Proof stress		MPa	360	410		
	Elongation on 4d		%	30	36		
	Elongation on 5d		%	27	35		
	Reduction of area		%		43		
	Impact energy	- 196°C	J		90		
	Hardness		HV		200/215		
Operating parameters	DC +ve or AC (OC	V: 70V min)				U	
	ø mm	3.2	4.0		5.0		
	min A	75	100		130		
	max A	120	155		210		
Packaging data	ø mm	3.2	4.0		5.0		
5 5	length mm	280	330		330		
	kg/carton	12.0	14.4		13.8		
	pieces/carton	387	249		162		

NIMAX A						Hig	h recc	overy	electro	ode foi	<sup>r</sup> clad	ding a	ind su	rfacing
Product description	weldin	MMA electrode with a basic flux system on a high conductivity pure nickel core wire. It is optimised for DC welding in the flat/downhand position for surfacing and cladding. Recovery is about 140% with respect to core wire, 65% with respect to whole electrode.										for DC+		
Specifications		A5.11 N 14172 736	2	E	ViCrFe-2 Ni6092 L-NiCr15		2.4625)							
ASME IX Qualification	QW4	<b>32</b> F-No	o 43											
Composition (weld metal wt %)	min max typ	C  0.10 0.05	Mn 1.0 3.5 2	Si  0.75 0.5	S  0.015 0.01	P  0.02 0.01	Cr 13.0 17.0 16	Ni 62 bal 69	Nb 1.5 3.0 2	Fe  12.0 8	Mo 1.0 2.5 1.5	Cu  0.50 0.05		
All-weld mechanical properties	0.2% I Elonga Elonga Reduc	e strengt Proof str ation on ation on ction of a	ess 4d 5d rea	- 19	5°C	MPa MPa % % % J HV	min 550 360 30 27  		typical 700 410 36 35 43 80 205					
Operating parameters	DC +v ø mm min A max A			2.5 70 115		3.2 90 155			4.0 130 210			Ų		
Packaging data	ø mm length kg/car pieces	mm		2.5 300 12.0 492		3.2 350 13.3 291	) 5		4.0 350 13.5 186					



20.70Nb

Solid wire for TIG, MIG and SAW

Product description	Solid v	wire for T	IG, MI	G and SAV	W.							
Specifications	BS EI BS 29 DIN 1 UNS			ERNiCr-3 SNi6082 NA35 SG-NiCr20Nb (2.4806) N06082 erically as filler metal 82 (FM82)								
ASME IX Qualification	QW43	<b>32</b> F-No	43									
Composition		С	Mn	Si	S	Р	Cr	Ni	Nb	Cu	Ti	Fe
(wire wt %)	min		2.5				18.0	67.0	2.0			
,	max	0.05	3.5	0.50	0.015	0.020	22.0	bal	3.0	0.50	0.7	3.0
	typ	0.02	3	0.1	0.005	0.01	20	73	2.5	0.01	0.4	1
All-weld mechanical	Typica	Typical values as welded TIG										
properties	Tensile	e strength			M	Pa 6	40					
	0.2% F	Proof stres	s		MF	Pa 3	60					
	0	ation on 40	ł				40					
	Impact	energy		- 196°C	2	J   >	100					
Typical operating							lig		SAW			
parameters	Shield	ing		Argon *	¢		on **		NiCr fl	ux		
	Curren			DC-		-	+ ***		DC+			
	Diame			2.4mm			mm		2.4mi			
	Param			100A, 12			A, 30V		300A, 3	1V		
	*			is a purge f He mixtur								
	***			may provid			spect to o	perabilit	y and a	c transfer	characte	ristics.
Packaging data	ø mm			TIG		N	lig		SAW	1		
and and and	1.2						spool					
	1.6			2.5kg tub	be				25kg c	oil		
	2.0			2.5kg tuł					25kg c			
	2.4			2.5kg tub					25kg c			
	3.2			2.5kg tub	be							
Fume data	MIG f	ume com	positior	n (wt %) (1	TIG & SA	W fume	negligible	e)				
			Fe	Mn	Cr <sup>3</sup>	Ni	Мо	C	u	OES (mg/r	n³)	

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#### Product description

MMA electrode with a special basic flux covering on a matching core wire. The electrode is optimised for DC+ welding in all positions including fixed pipework in the ASME 5G/6G positions.

Recovery about 105% with respect to core wire, 65% with respect to whole electrode.

#### **Specifications**

AWS A5.11	ENiCrFe-1
BS EN 14172	E Ni6062
DIN 1736	EL-NiCr15FeNb (2.4805)

#### **ASME IX Qualification**

QW432 F-No 43

#### Materials to be welded

#### Alloy 600 and similar:

Inconel 600 (Special Metals)
Nicrofer 7216 (Krupp VDM)
Nicrofer 7216H (Krupp VDM)
Pyromet 600 (Carpenter)
RA600 (rolled Alloys)

#### **Other alloys:**

Alloy 330 Alloy 601 (to about 900°C) Nimonic 75 (Special Metals)

#### Applications

Nimrod 132KS deposits an Inconel type weld metal similar in composition to the 182 types (data sheet D-10) but with lower manganese. The electrode is used mainly for welding alloy 600, the nearest equivalent base material, with service applications up to about 1000°C. The lower Mn level is preferred by some authorities, as Mn raises thermal expansion coefficient and high levels may reduce oxidation resistance at the upper service temperatures. Additions of both Mn and Nb are sufficient to suppress hot cracking and provide good hot strength.

The good oxidation and excellent nitriding and carburisation resistance of alloy 600 is exploited for **heat treatment** equipment and annealing muffles. Resistance to dry chlorine up to about 550°C is important in plants for PVC synthesis, and it has many applications in the chemical, petrochemical, food processing and nuclear industries.

#### **Microstructure**

High alloy austenite with some carbides.

#### Welding guidelines

No preheat or PWHT required. Related alloy groups

The 182 (data sheet D-10) and AB alloys (data sheet D-11)



### DATA SHEET D-12

## NIMROD 132KS

are very similar; and the 20.70.Nb solid wire would be used in conjunction with Nimrod 132KS.

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	Fe
min	0.03	1.0				14.0	62.0	0.25	1.5	6.0
max	0.08	3.5	0.75	0.015	0.030	17.0	Bal	0.50	3.5	11.0
typ	0.05	3	0.4	0.01	0.01	16.5	70	0.3	2.6	6.5

Cu < 0.50%.

Minimum Mo and Fe applies to DIN only. Residual Co<0.12% and Ta<0.30% when requested.

#### All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	550	680
0.2% Proof stress		MPa	360	510
Elongation on 4d		%	30	38
Elongation on 5d		%	27	35
Reduction of area		%		38
Impact energy	- 196°C	J		100

		Param	neters		
DC +ve		Ų	$\checkmark$	Ê	Û
ø mm	2.5	3.2	4.0		
min A	60	70	100		
max A	80	110	155		

#### Packaging data

			-
ø mm	2.5	3.2	4.0
length mm	280	300	300
kg/carton	12.0	12.9	15.0
pieces/carton	759	474	300

#### Storage

**3 hermetically sealed ring-pull metal tins** per carton, with unlimited shelf life. Direct use from tin is satisfactory for much longer than an 8h working shift.

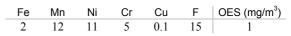
For electrodes that have been exposed:

**Redry** 200-250°C/1-2h to restore to as-packed condition. Maximum 350°C, 3 cycles, 10h total.

**Storage** of redried electrodes at 100-200°C in holding oven or 50-150°C in heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, >18°C.

#### **Fume data**

Fume composition, wt % typical:





## **ALLOY 625 CONSUMABLES**

#### Alloy type

Consumables matching the nickel base 625 alloy with typical composition of Ni-21%Cr-9%Mo-3.5%Nb.

#### Materials to be welded

#### Matching Alloy 625

ASTM-ASME	DIN	BS
UNS N06625	2.4856	NA21
A494 CW-6MC (cast)		

#### **Proprietary Alloys**

Inconel 625 (Inco) Nicrofer 6020hMo (VDM) Nicrofer 6022hMo (VDM)

#### **Other Alloys**

High Nickel Alloys:	Superaustenitic alloys:
Inconel 601 (Inco)	UNS S31254
Incoloy 800H (Inco)	254SMO (Avesta)
Incoloy 825 (Inco)	904L
And equivalents	Similar alloys
-	-

**Cryogenic:** 9%Ni steels

Combinations of above

**Dissimilar:** 

#### **Applications**

These consumables are designed to match the composition and properties of alloy 625. Originally developed to give high temperature strength and structural stability, alloy 625 is also widely used for its resistance to general corrosion, pitting, crevice and stress corrosion cracking in severe chloride media. These properties are conferred by high levels of chromium, molybdenum and niobium, which also raise strength to the highest amongst standard nickel-base alloys. Useful properties from - 269°C to above 1000°C are achieved.

In addition to matching alloy 625, suitable for welding **heat resisting** alloys including Inconel 601 (except severe sulphidising conditions), Incoloy 800/800H (preferred to

### DATA SHEET D-20

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**Nimrod AKS** above about 900°C), or combinations of these with other alloys for **furnace equipment**, **petrochemical** and **power generation** plants. Some other applications include:

Overmatching corrosion-resistant welds in alloy 825, Hastelloys G and G3, alloy 28, 904L, 6%Mo superaustenitic stainless 254SMo, and also **overlays** on **pumps**, valves and shafts, often in offshore and marine environments where high pitting resistance (PRE = 50) and tolerance to weld metal dilution are essential.

Welds in **high strength** ferrous alloys including **cryogenic** 9% nickel steels and for reclamation of dies where rapid **work-hardening** and **toughness** are required.

#### **Microstructure**

In the as-welded condition this nickel base weld metal consists of solid-solution strengthened austenite with carbides.

#### Welding guidelines

No preheat required and maximum interpass of 250°C. When welding superaustenitic alloys the interpass temperature should be controlled to a maximum of 100°C.

#### **Related alloy groups**

For welding superaustenitic stainless steels C276 (D-30), alloy 59 (D-31) and alloy C22 (D-32) are also suitable.

Process	Product	Specification
MMA	Nimrod 625	AWS ENiCrMo-3
	Nimrod 625KS	AWS ENiCrMo-3
TIG/MIG	62-50	AWS ERNiCrMo-3
SAW	62-50	AWS ERNiCrMo-3
	NiCr	BS EN SA FB2



#### **General Data for all MMA Electrodes** 3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory Storage 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. For electrodes that have been exposed: Redry 200 – 250°C/1-2h to restore to as-packed condition. Maximum 350° 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, $> 18^{\circ}$ C. Fume data Fume composition, wt % typical: Fe Mn Ni Cr Мо Cu F OES (mg/m<sup>3</sup>) 1 4 9 6 1 0.1 20 0.8

NIMROD 625								Dov	vnhand	MMA	electi	rode fo	r surfacing
Product description	bead of 625 op surfaci	f good a perates c ing and	ppeara n AC o overlay	nce. Th or DC+ /s, for jo	e electroc and is de pining Ni	le has a ba	sic-rutile imarily fo KS is pre	flux s or the ferred	ystem and downhan	d is made d/flat or	e on a ni H-V po	ckel core ositions.	and a finished wire. <b>Nimrod</b> Optimised for
Specifications	AWS BS EN DIN 1	N 14172	2	E	NiCrMo- Ni6625 L-NiCr 2	-3 0 Mo 9 N	lb (2.462)	l)					
ASME IX Qualification	QW43	<b>32</b> F-No	43										
Composition (weld metal wt %)	min max typ	C  0.10 0.04	Mn 0.5 1.0 0.8	Si  0.75 0.7	S  0.015 0.005	P  0.020 0.008	Cr 20.0 23.0 21.5	Ni 55  64	Nb 3.15 4.15 3.4	Fe  2.5 < 1.5	Mo 8.0 10.0 9	Cu  0.50 0.05	
All-weld mechanical	As wel	ded					min *	,	typical				
properties	Tensile	e strengt	h			MPa	760		800				
	0.2% F	Proof stre			MPa	420		480					
	Elonga	tion on 4	4d			%	30		34				
	Elonga	tion on	5d			%	27		32				
	Reduct	tion of a	rea			%			30				
	Impact	energy			- 196°C	J			> 28				
		ess (as v				HV			250				
	Hardne	ess (wor	k-harde	ened)		HV			450				
													> 414MPa and > 485MPa.
Operating parameters	DC +v	e A	C (OC	V: 70V)	I							U	
	ø mm			3.2		4.0			5.0				
	min A			90		130	)		160				
	max A			155		210			260				
Packaging data	ø mm			3.2		4.0			5.0				
	length	mm		350		350	)		450				
	kg/carton 13.8						2		16.8				
	pieces/carton 243					153	5		93				



NIMROD 625	(S					Basi	c coate	d MM	A pipe	-weldin	g elec	trode fo	or 625
Product description	operati appear ASME	on with t ance. <b>Ni</b> 6G posit	the depo mrod 6 tion.	osition of 25KS is	f high qu optimise	ality, rad d for DC-	iographic	ally sou ; in all p	nd weld ositions	metal an including	d a finisi pipewoi	l to combi hed bead rk qualifie	of good
Specifications	AWS A BS EN DIN 17	14172		ENi	CrMo-3 6625 NiCr 20 N	Mo 9 Nb	(2.4621)						
ASME IX Qualification	QW43	<b>2</b> F-No	43										
Composition (weld metal wt %)	min max typ	C  0.10 0.03	Mn 0.5 1.0 0.8	Si  0.75 0.4	S  0.015 0.005	P  0.020 0.008	Cr 20.0 23.0 21.5	Ni 55  64	Nb 3.15 4.15 3.5	Fe  2.5 < 1.5	Mo 8.0 10.0 9	Cu  0.50 0.05	
All-weld mechanical properties	0.2% P Elonga Elonga Reduct Impact Hardne Hardne	e strength Proof strest tion on 4 tion on 5 tion of are energy ess (as we ess (work- annot med	ss d a elded) hardene et TS >	ed) 827MPa				2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2				5 0 3 1 2	
Operating parameters	DC +v ø mm min A max A	e		2.5 60 80		3.2 70 110		4.0 100 155		5.0 130 210			Û
Packaging data	ø mm length kg/cart pieces/	on		2.5 260 11.1 660		3.2 300 13.5 375		4.0 350 15.0 300		5.0 350 15.0 189			



62-50									Solid v	wire fo	or TIG	, MIG	and S	SAW
Product description	Solid w	ire for T	IG, MI	G and S	AW.									
Specifications	AWS A BS EN BS 290 DIN 17 Approv	ISO 18 01: Pt5 36	274	SNi60 Grade SG-N	CrMo-3 625 e NA43 fiCr 21 M (MIG)	lo 9 Nb	(2.4831)							
ASME IX Qualification	QW432	<b>2</b> F-No	43											
Composition (wire wt %)	min max	C  0.05	Mn  0.50	Si  0.50	S  0.015	P  0.015	Cr 20.0 23.0	Ni 60.0 bal	Mo 8.0 10.0	Nb 3.15 4.15	Cu  0.50	Al  0.40	Ti  0.40	Fe  1.0
All-weld mechanical	typ Typical	0.015 values a	0.02 s welde	0.1	0.005	0.005	22 TIG	65 SAW	9 + NiCr	3.5	0.05 +165°C	0.2	0.2	0.8
properties		roof stree ion on 4 ion on 5 energy energy ss cap/m meet T	ss d d nid S > 82'		N °C °C equired by	y cold ro	780 520 42 40 100 80 205/225 olled AST olution an	4 2 1 235 7M N06		4 4 2 2				Pa and
Typical operating parameters	Shieldin Current Diamete Parame * Al	er ters		TIG * Ar DC- 2.4mr 100A, 1 a purge f	n	130A,	MIG or ArHe Pulsed 1.2mm 29V (me	an)	NiC I 1.	SAW Cr flux DC+ 6mm A, 26V				
Packaging data	ø mm 0.8 1.0 1.2 1.6 2.0 2.4 3.2			TIG  2.5kg tu 2.5kg tu 2.5kg tu 2.5kg tu	ube ube	Г	MIG ikg spool To order ikg spool   		251	SAW   kg coil  kg coil				
Fume data	MIG fu	me com	position Fe	n (wt %) Mn	(TIG & S Cr <sup>3</sup>		ne negligi		Cu	059	(mg/m <sup>3</sup>	\ \		
			ге 1	IVIN	17	N 50		10 9	Cu < 0.5	UES	1	)		



### DATA SHEET D-30

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# **CORROSION RESISTANT ALLOY C276**

#### Alloy type

Alloy C276 is a Ni-15%Cr-16%Mo-4%W-5%Fe nickel base alloy.

#### Materials to be welded

	wrought	cast
ASTM	UNS N10276	A494 CW-12MW
		A743/A744 CW-12M
DIN	2.4819	2.4883 (G-NiMo16Cr)
	(NiMo16Cr15W)	

#### **Proprietary alloys:**

Hastelloy<sup>™</sup> Alloy C-276 (Haynes International Inc) Inco Alloy C-276 (Special Metals) Nicrofer 5716hMoW (VDM)

#### Applications

The weld deposit composition matches parent alloy C276 with Ni-15%Cr-16%Mo-4%W-5%Fe. Carbon and silicon are controlled as close as possible to the very low levels of the wrought alloy to minimise carbide and intermetallic phase precipitates which can reduce as-welded corrosion resistance. Cast versions of the alloy typically have higher carbon and silicon (like the original wrought Hastelloy alloy C, now obsolete), but repair welds are usually solution treated for optimum corrosion resistance.

Alloy C276 has high resistance to corrosion in a wide range of acids and salts under oxidising and especially reducing conditions. These include hydrochloric and hydrofluoric acids, hypochlorites, chlorides and wet chlorine gas, sulphuric, phosphoric and many organic acids. Exceptional resistance to crevice corrosion and pitting in seawater and chloride-induced stresscorrosion cracking (superior to alloy 625). High temperature stability is limited by intermetallic phase formation.

In addition to fabrication welds in alloy C276, these

consumables have good tolerance to dilution by most ferrous and high nickel alloys, and are suitable for surfacing and dissimilar welds which exploit the corrosion resistance, strength and toughness. Excellent properties to below -196°C allow its use for welding 5-9%Ni cryogenic installations.

Applications include **pumps**, valves, **pipework** and **vessels** for use in aggressive environments in **chemical process plants**; also in equipment for **flue gas desulphurisation** and critical equipment in **offshore oil** and **gas production**.

#### Microstructure

In the as-welded condition the weld metal consists of austenite with some carbides.

#### Welding guidelines

Preheat is not required, interpass temperature should preferably be kept below 100°C and heat input restricted to 1.5kJ/mm.

#### **Related alloy groups**

Alloy 59 (D-31) and alloy C22 (D-32) are also NiCrMo alloys but with higher Cr for improved corrosion resistance.

-		
Process	Product	Specification
MMA	Nimrod C276	AWS ENiCrMo-4
	Nimrod C276KS	AWS ENiCrMo-4
TIG/MIG	HAS C276	AWS ERNiCrMo-4
SAW	HAS C276	AWS ERNiCrMo-4
	NiCr flux	BS EN SA FB2



## General Data for all C276 Electrodes

Storage	for longer the moisture pick For electrode <b>Redry</b> 250 – <b>Storage</b> of re	an a work c-up and i es that hav 300°C/1- edried elect	ing shift o ncrease the e been exp 2h to resto ctrodes at 5	f 8h. Exce e risk of po oosed: re to as-pa 50 – 200°C	essive expo rosity. cked condi	osure of ele ition. Max g oven or h	ectrodes to imum 350° leated quive	humid co C, 3 cycl er: no lim	use from tin is satisfac nditions will cause s es, 10h total. it, but maximum 6 w c lid): < 60% RH, > 1	some
Fume data	Fume compo	sition, wt	% typical:							
		Fe	Mn	Ni	Cr	Мо	Cu	F	OES (mg/m <sup>3</sup> )	
	_	1	4	10	5	5	0.2	16	1	

NIMROD C276	5					Ru	itile C	276 el	lectrod	le prin	narily (	used fo	or surf	acing
Product description	ensure used fo	IMA electrode manufactured on special nickel-chromium core wire, with an alloyed basic-rutile flux coating insure low carbon and silicon transfer and a high refining capacity to remove undesirable impurities. Prima sed for surfacing and cladding; for joining applications the Nimrod C276KS is preferred. ecovery is about 130% with respect to core wire, 65% with respect to whole electrode.												
Specifications	AWS BS EI DIN 1	N 14172	2	Е	NiCrMo- Ni6276 L-NiMo1	4 5Cr15W	(2.4887	)						
ASME IX Qualification	QW43	<b>32</b> F-No	43											
Composition (weld metal wt %)	min max typ	C  0.02 0.02	Mn  1.0 0.3	Si  0.2 0.20	S  0.015 0.01	P  0.02 0.01	Cr 14.5 16.5 15.0	Ni 50.0  58.0	Mo 15.0 17.0 16.0	W 3.0 4.5 4.0	Fe 4.0 7.0 5.0	V 0.35 0.1	Cu  0.50 0.05	Co  2.5 0.05
All-weld mechanical properties	0.2% F Elonga Elonga Hardne	e strengtl Proof stre ation on 4 ation on 5	ess Id 5d		/mid HV.	MPa MPa % % HV	min 690 400 25 22 		typical 770 550 26 25 230/255					
Operating parameters	DC +v ø mm min A max A	e or AC		: 70V m 2.5 60 90	in)	3.2 75 120		1	4.0 100 155		5.0 130 210		Ê	Û
Packaging data	ø mm length kg/cart pieces			2.5 260 12.0 600		3.2 310 13.5 378		1	4.0 310 4.1 234		5.0 310 13.2 141			



NIMROD C27	6KS					All-	positic	onal pi	pe we	lding	electro	ode for	alloy	C276		
Product description	clean a	and home	ogenou	s weld m	etal. Nin	nrod C27	ng on matching nickel-chromium-molybdenum core wire to provid 276KS has exceptional operability, optimised for DC+ welding in a d in the ASME 6G (inclined overhead) position.									
	Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.															
Specifications		A5.11 N 14172 736	2	Е	NiCrMo- Ni6276 L-NiMo1	4 5Cr15W	(2.4887	)								
ASME IX Qualification	QW4	<b>32</b> F-No	6 43													
Composition		C	Mn	Si	S	Р	Cr	Ni	Мо	W	Fe	V	Cu	Со		
(weld metal wt %)	min						14.5	50.0	15.0	3.0	4.0					
	max	0.02	1.0	0.2	0.015	0.02	16.5		17.0	4.5	7.0	0.35	0.50	2.5		
	typ	0.02	0.3	0.20	0.01	0.01	15.0	58.0	16.0	4.0	5.0	0.1	0.05	0.05		
All-weld mechanical	As we	Ided					min		typical							
properties		e strengt				MPa	700		780							
		Proof stre				MPa	400		520							
	-	ation on 4				%	25		30							
	-	ation on a	5d			%	25		28							
	Impac	t energy			50°C	J			65							
	Hardn	ess *		-19	96°C	J HV			55 240							
		k harder	ns to ab	out 4501	HV.				2.0							
Operating parameters	DC +v	ve								U			Ê	Î		
	ø mm			2.5		3.2			4.0							
	min A			60		75		]	00							
	max A	L .		80		110	)	1	155							
Packaging data	ø mm			2.5		3.2			4.0							
	length	mm		250		300	)	3	350							
	kg/car	ton		11.4		13.5			5.0							
	pieces	/carton		789		435	5	2	294							



### Solid wire for TIG and MIG welding of alloy C276

Product description	Solid w	vire for T	ΊG, MI	G and S.	AW.								
Specifications	-	I ISO 18 01: Pt5	274	SNi62 NA48	iMo16Cr1	6W (2.4	886)						
ASME IX Qualification	QW43	<b>2</b> F-No	43										
Composition (wire wt %)	min            max         0.02           typ         0.005				S  0.015 0.005	P  0.020 0.01	Cr 14.5 16.5 16	Ni bal  58	Mo 15.0 17.0 16	W 3.0 4.5 3.5	Fe 4.0 7.0 6	V  0.3 0.2	Cu  0.50 0.05
All-weld mechanical properties	Tensile 0.2% P Elongat Elongat	values a strength roof stres tion on 4 tion on 4 ion of are	ss d d	ed		IPa IPa % % %	min 700 400  30 	TIG 740 500 46 43 50	)				
Typical operating parameters	Shieldir Current Diamet Parame	er eters	quired a	TIG Ar ' DC 2.4m 100A, as purge	* - m	160.	MIG gon or Ar Pulsed 1.2mm A, 28V (1						
Packaging data			TIG  2.5kg t 2.5kg t 2.5kg t	tube der tube		MIG 15kg spo 15kg spo spool (to   	ol						
Fume data	MIG fu	ime com	position Fe 14	n (wt %) Mn 3	(TIG and Cr <sup>3</sup> 10	SAW fu Ni 28	M	lo	Cu 1	OES (n		-	



# Nickel Base Alloys

## **CORROSION RESISTANT ALLOY 59**

#### Alloy type

Ni-23%Cr-16%Mo alloy commonly known as alloy 59.

#### Materials to be welded

#### Alloy 59 and similar:

- ASTM/UNS N06059
- **DIN** 2.4605 (NiCr23Mo16Al)
- ProprietaryNicrofer 5923hMo (Krupp VDM).<br/>Inconel™ Alloy 686 (Special Metals)<br/>+W.<br/>Hastelloy™ Alloy C-2000™ (Haynes<br/>International Inc) +Cu.

#### Alloy C22 and similar:

ASTM/UNS	N06022
	A494 Grade CX2MW (cast)
DIN	2.4602 (NiCr21Mo14W)
	2.4811, 2.4836 (NiCr20Mo15)
	2.4697 (G-NiCr20Mo15) (cast)
Proprietary	Hastelloy <sup>™</sup> Alloy C-22 <sup>™</sup> (Haynes
	International Inc)
	Nicrofer 5621hMoW (Krupp VDM)

#### Superaustenitics including:

ASTM/UNS S32654, S31254, S34565 Proprietary 654SMO (Avesta Polarit) Uranus B66 (Usinor Industeel)

Also dissimilar joints between any combination of the above and dissimilar joints between them and superduplex stainless steels.

#### Applications

The weld deposit composition of 59%Ni-23%Cr-16%Mo is designed to match the nickel base corrosion resistant alloy commonly known as alloy 59. The high level of Mo is similar to alloys C276 and C4 but performance in a wide range of more oxidising media is significantly enhanced by increasing Cr to 23% in alloy 59. Total alloying exceeds the level typically present in alloy C22; it is therefore considered suitable for welding this group of alloys. Alloy 59 consumables also provide strong, tough Nbfree weld metal for **dissimilar** welds in superaustenitic and superduplex stainless steels or combinations of these with nickel base alloys. Some authorities do not allow or have discontinued use of 625 type consumables for such applications, where deleterious Nb-rich precipitates may form in diluted or partially mixed regions around the fusion boundary. Alloy C276 is possibly a more economic alternative depending on the required properties in this situation.

DATA SHEET

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Applications of alloy 59 in aggressively corrosive media include scrubbers for flue gas desulphurisation (FGD), digesters and papermaking equipment, chemical process plants, corrosion resistant overlays and in severe offshore and petrochemical environments.

#### **Microstructure**

Solid-solution strengthened high nickel austenite, with some microsegregation typical of as-deposited weld metal.

#### Welding guidelines

No preheat required, heat input <1kJ/mm and interpass temperature 100°C maximum are desirable to minimise precipitates which may reduce corrosion resistance and ductility of the weld metal.

#### **Related alloy groups**

The alloy C22 is related and covers many of the same applications and base materials.

Process	Product	Specification
MMA	Nimrod 59KS	AWS ENiCrMo-13
TIG/MIG	HAS 59	AWS ERNiCrMo-13



Product description	metal. The sp fixed p	MMA electrode with special basic flux covering on high purity NiCrMo core wire to give clean homogenou metal. Very low levels of C and Si minimise the occurrence of deleterious precipitates in the as-welded cor The special flux coating provides exceptional operability, optimised for DC+ welding in all positions in fixed pipework in the ASME 5G/6G positions. The electrode is equally suitable for general fabrication Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.										
Specifications	AWS BS EI	AWS A5.11         ENiCrMo-13           BS EN 14172         E Ni6059           DIN 1736         EL-NiCr22Mo16 (2.4609)										
ASME IX Qualification	QW43	<b>32</b> F-No	43									
Composition (weld metal wt %)	min max typ	C  0.02 0.01	Mn  1.0 0.5	Si  0.2 0.15	S  0.010 0.006	P  0.015 0.01	Cr 22.0 24.0 23	Ni 57.0 bal 60	Mo 15.0 16.5 15.5	Fe  1.5 1	Cu  0.50 0.01	
All-weld mechanical properties	0.2% F Elonga Elonga Reduc	ded e strength Proof stree ation on 4 ation on 5 tion of are t energy	ss d d	- 50°C		min           MPa         690           MPa         350           %         30           %         25           %            J		typical 750 520 32 30 30 50				
Operating parameters	DC +ve ø mm min A			2.5 60 80		3.2 75		<b>4.0</b> 100				ĹÎ
Packaging data	ø mm length kg/car	max A				120 3.2 300 13.5 480		4.0 350 15.0 297				
Storage	for lor moistu For ele <b>Redry</b> Storag	pieces/carton714480297 <b>3 hermetically sealed ring-pull metal tins</b> per carton, with unlimited shelf life. Direct use from tin is a for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will a moisture pick-up and increase the risk of porosity.For electrodes that have been exposed: Redry 250 – 300°C/1-2h to restore to as-packed condition. Maximum 350° C, 3 cycles, 10h total. Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximu recommended. Recommended ambient storage conditions for opened tins (using plastic lid): <60% R									conditions will cause cles, 10h total. nit, but maximum 6	e sor
Fume data	Fume	composit	ion, wt	% typical	:							
			Fe	Mn	Ni	С	r N	1o	Cu	F	OES (mg/m <sup>3</sup> )	



HAS 59						Ś	Solid w	vire for	TIG a	nd MIG	G weld	ling of	alloy 59
Product description	Solid v	vire for T	IG and	MIG.									
Specifications	AWS A BS EN DIN 17	I ISO 18	274	SNi605	ERNiCrMo-13 SNi6059 SG-NiCr23Mo16 (2.4607)								
ASME IX Qualification	QW43	QW432 F-No 43											
Composition (wire wt %)	min max typ	C  0.010 0.003	Mn  0.5 0.2	Si  0.10 0.03	S  0.005 0.003	P  0.015 0.003	Cr 22.0 24.0 23	Ni 56.0 Bal 60	Mo 15.0 16.5 15.6	Fe  1.5 0.4	Co  0.3 0.1	Al 0.1 0.4 0.3	
All-weld mechanical properties	Tensile 0.2% P Elonga Elonga	values a strength roof stres tion on 40 tion on 50 energy ess	is I	ed + 20°C	N	1Pa 1Pa % % J HV	TIG 730 510 34 32 140 240						
Typical operating parameters	Shieldii Curren Diamet Parame * Als	t er eters	ed as a	TIG Argon DC- 2.4mn 100A, 1 purge for	n 2V	160A	MIG on or Ar- Pulsed 1.2mm , 28V (m						
Packaging data	ø mm 1.2 1.6 2.4			TIG  To orde 2.5kg tu		15	MIG kg spool  						
Fume data	MIG fi	ime comj	position	n (wt %) (	TIG fum	e neglig	ible)						
		Fe			Cr <sup>3</sup>		Ni Mo		Cu	OES (r		_	
			1	1	17	50	) 1	11	<0.5	1	l		



# Nickel Base Alloys

# **CORROSION RESISTANT ALLOY C22**

#### Alloy type

Nickel base 22%Cr-13.5%Mo-3%W, alloy C22.

#### Materials to be welded

#### Matching Alloy C22:

#### ASTM

A494 CX2MW (cast) **UNS N06022** DIN 2.4602 (NiCr21Mo14W) 2.4811, 2.4836 (NiCr20Mo15) 2.4697 (G-NiCr20Mo15) (cast) **Proprietary Alloys** Hastelloy™ Alloy C-22™ (Haynes International Inc) Nicrofer<sup>™</sup> 5621hMoW (VDM)

Inconel<sup>TM</sup> 622 (Special Metals)

#### **Other Alloys:**

Allov C4

ASTM UNS N06455 DIN 2.4610 (NiMo16Cr16Ti) Hastelloy<sup>™</sup> Alloy C-4 (Haynes International Inc) **Superaustenitics** UNS S31254, S31266, S32654, S34565, N08367, N08925, N08926. 1.4529, 1.4565, 1.4575, 1.4652. 254SMO and 654SMO (Outokumpu) Uranus B66 (Usinor Industeel)

#### Applications

The weld deposit composition of Ni-22Cr-13.5Mo-3W is designed to match the nickel base alloy commonly known as alloy C22. The high level of molybdenum is similar to alloys C276 and C4 but performance in a wide range of more oxidising media is significantly enhanced in alloy C22 by increasing chromium to 22%. Alloy C22 also provides a tough Nb-free weld metal for dissimilar welds in superaustenitic and superduplex stainless steels or combinations of these with nickel base alloys. Some authorities do not allow or have discontinued using alloy 625 consumables for such applications, where deleterious Nb-rich precipitates may form in diluted or partially mixed regions around the fusion boundary.

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Applications of alloy C22 in aggressively corrosive media include scrubbers for flue gas desulphurisation (FGD), digesters and papermaking equipment, chemical process plant, corrosion resistant overlays and in severe offshore and petrochemical environments.

#### **Microstructure**

Solid solution strengthened high nickel austenite, with some microsegregation typical of as-deposited weld metal.

#### Welding procedure

Preheat not normally required, interpass temperature restricted to 100°C and heat inputs below 1kJ/mm are desirable.

#### **Related alloy groups**

Alloy 59 is similar but with slightly higher Cr and Mo for similar or more severe applications - see data sheet D-31.

Process	Product	Specification
MMA	Nimrod C22KS	AWS ENiCrMo-10
TIG/MIG	HAS C22	AWS ERNiCrMo-10



Nimrod C22K		a						II-positi						
Description						eptional op 5G/6G p								
	Special basic flux covering on matching high purity nickel alloy core wire to give clean and homogenous well metal. Very low levels of carbon and silicon minimise the occurrence of deleterious precipitates in the as-welde condition.													
	Recov	very is a	pprox 1	10% wi	th respec	t to core w	vire, 6	5% with	respect t	o whole	e electro	de.		
Specifications	-	AWS A5.11         ENiCrMo-10           BS EN 14172         E Ni6022												
ASME IX Qualification	QW4	22 P-N	o 43, 🕻	QW432	F-No 43	3								
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	W	V	Со	Cu	Fe
(weld metal wt %)	min						20.0	49.0	12.5	2.5				2.0
	max typ	0.02	1.0	0.2	0.015	0.02	22.5 21	58	14.5 14	3.5	0.35	2.5	0.50	<u>6.0</u> 4
All-weld mechanical	Туріса	al as-wel	ded					min	typ	ical				
properties		e streng				MPa		690		80				
		Proof str						350	550					
	-	ation on				%		25	-	6				
	-	ation on ction of a				%		22		5				
		t energy			-196°C	%	o J		4					
	-	ess, cap			-190 C	HV			245					
Operating parameters	DC +v	ve								Ū		1 4		
	ø mm			2.5		3.2		4.0						
	min A			60		75		100						
	max A	1		80		120		155						
Packaging data	ø mm			2.5		3.2			4.0					
	length			250		300			350					
	kg/car pieces	ton s/carton		10.5 711		13.5 486			5.6 306					
Storage	3 herr for mu moistu For el Redry Storag maxim	neticall uch long ure pick ectrodes y 250 – 2 ge of re	er than -up and s that ha 300°C/2 dried el veeks re	d ring-p an 8h we increas we been 1-2h to r ectrodes	ull metal orking sh e risk of j exposed estore to s at 100 -	tins per c ift. Exces porosity.	sive ex l cond n hold	with unlin cposure o ition. Ma	mited sh of electro aximum , or 50 -	des to h 350°C, - 150°C	umid co 3 cycles in heat	onditions s, 10h to ed quive	s will cau otal. ers: no li	se son mit, b
Fume data	Fume	compos	sition (v	vt %)										
			Fe	Mr	I N	Ji (	Cr	Мо	Cu		F	OES (r	ng/m³)	
	1		1	4	1		5	6	0.2		16			-



HAS C22								S	olid w	ire fo	r nicke	l bas	e alloy	C22
Product description	Solid	wire for T	ΓIG and	MIG.										
Specifications		A5.14 N ISO 18	ERNiCrMo-10 3274 SNi6022											
ASME IX Qualification	QW4	QW432 F-No 43												
Composition (wire wt %)	min max typ	C  0.01 0.003	Mn  0.50 0.2	Si  0.08 0.03	S  0.010 0.002	P  0.02 0.01	Cr 20.0 22.5 21	Ni 49.0  56	Mo 12.5 14.5 13.5	W 2.5 4.5 3	V  0.3 0.15	Co  2.5 1.5	Cu  0.50 0.1	Fe 2.0 6.0 4
All-weld mechanical properties	Tensil 0.2% I Elonga Elonga	al values a e strength Proof stre ation on 4 ation on 5 t energy	n ss d	- 196°	N C	ЛРа ЛРа % % J HV	TIG 770 525 44 42 130 220							
Typical operating parameters	Shield Currer Diame Param *	nt eter	uired as a	TIG Argon DC- 2.4mi 100A, 1 a purge f	n 2V	1604	MIG gon or A Pulsed 1.2mm A, 28V (1							
Packaging data	ø mm 1.0 1.2 1.6 2.4 3.2			TIG  2.5kg tr 2.5kg tr 2.5kg tr	ube		MIG To orde To orde  	-						
Fume data	Fume	composit	tion (wt Fe	%) (TIG Mn	fume ne Cr <sup>3</sup>	gligible) N		Мо	Cu	OE	S (mg/m	<sup>3</sup> )		

30

10

< 0.5

1.7

14

1

17



# Nickel Base Alloys

## **HIGH TEMPERATURE ALLOY 617**

#### Alloy type

Nickel base alloy of nominally Ni-24%Cr-12%Co-9% Mo designed for high temperature service.

#### Materials to be welded

#### Matching Alloy 617

**ASTM-ASME** DIN 2.4663 (NiCr23Co12Mo) **UNS NO6617** 

**Proprietary Alloys** Inconel alloy 617 (Special Metals) Nicrofer 5520Co (Krupp VDM)

#### **Other Alloys**

#### Alloys 800H and 800HT

ASTM UNS N08810, N08811 BS NA15H DIN 1.4876 (X10NiCrAlTi 32 20) Incoloy 800H and 800HT (Special Metals) Nicrofer 3220H (Krupp VDM)

#### Alloy 601 & other oxidation resistant alloys

ASTM UNS N06601 DIN 2.4851 Inconel alloy 601 (Special Metals) Nicrofer 6023 (Krupp VDM) ASTM UNS N06333 RA333 (Rolled Alloys)

#### **High Carbon Austenitic Alloy** Cast HK40, HP40Nb, etc

Also dissimilar welds between above.

#### **Applications**

Nimrod 617KS is primarily intended for high temperature applications up to about 1100°C. It provides good microstructural stability, high creep strength and excellent resistance to oxidation and carburisation. In a variety of aqueous media, the alloy also has useful resistance to general corrosion, pitting and stress-corrosion cracking.

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The electrode is optimised for DC+ welding in all positions including fixed pipework qualified in the ASME 5G/6G positions.

In addition to welding the parent alloy 617, some authorities specify it in preference to other nickel-base filler metals for welding alloys 800H and 800HT for service above 760°C. It is also suitable for the heatresistant alloy 601 (usually above 900°C) and dissimilar welds including high carbon heat resistant cast alloys and any combination of those mentioned.

Applications include combustion, pyrolysis, heat treatment and furnace components, flare tips, ducting and gas turbine parts.

#### **Microstructure**

High nickel alloy austenite with carbides.

#### Welding guidelines

Normally no preheat required, interpass temperature generally limited to 150°C maximum.

Process	Product	Specification
MMA	Nimrod 617KS	AWS ENiCrCoMo-1
TIG	61-70	AWS ERNiCrCoMo-1



Product description	parent	t materia	al to ma	intain o	xidation	alloy con resistance ed pipewo	e at a lo	wer alu	minium l	evel. 7	The elec	trode is			
	Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.														
Specifications	BS E	WS A5.11         ENiCrCoMo-1           S EN 14172         E Ni 6617           IN 1736         (EL-NiCr21Co12Mo, 2.4628)													
ASME IX Qualification	QW4	32 F-N	o 43												
Composition		С	Mn	Si	S	Р	Cr	Ni	Co	Мо	Nb	Cu	Fe	AI	Ti
(weld metal wt %)	min	0.05	0.3				21.0	45.0	9.0	8.0					
	max	0.10	2.5	0.75	0.015	0.020	26.0 24	bal 52	15.0 12	10.0	1.0	0.50	5.0	1.5 0.15	0.6
	typ	0.07	1.0	0.4	0.003	<0.01	24	52	12	9	<0.5	0.05	1	0.15	0.2
All-weld mechanical	As we						mi		typica	I					
properties		e streng				MPa	70		760						
		Proof sti				MPa %	400		520 43						
	-	ation on ation on				%	25 25		43 40						
	•	ction of a				%			40 40						
		t energy		+ 2	20°C	J			40 70						
	-	iess mic				HV			230/24	5					
Operating parameters	DC +	ve								Ū			╡┣	₽.	î
	ø mm		1	2.5	5	3.2	2		4.0						
	min A			60		70			100						
	max A	۱.		80		11		155							
Packaging data	ø mm			2.5	5	3.2	2		4.0						
	length	mm		300	0	35	0		350						
	kg/car			12.		15.			15.0						
	pieces	s/carton		73	8	45	9		273						
Storage	for lo moist For el Redry Stora	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is sat for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cau moisture pick-up and increase the risk of porosity.</li> <li>For electrodes that have been exposed:</li> <li>Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 350° C, 3 cycles, 10h total.</li> <li>Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum recommended. Recommended ambient storage conditions for opened tins (using plastic lid): &lt;60% RH,</li> </ul>								cause num 6 v	some				
Fume data	Fume	compos	sition, v	vt % tyr	oical:										
		1	Fe	Mn	Ni	Co	. (	Cr <sup>6</sup>	Мо	Cu	F	C	ES (m	g/m³)	



61-70

### Solid TIG wire matching alloy 617

Product description	Solid	wire for	TIG.											
Specifications	BS E BS 29	WS A5.14       ERNiCrCoMo-1         SS EN ISO 18274       SNi6617         SS 2901: Pt5       NA50         DIN 1736       (SG-NiCr22Co12Mo, 2.4627)												
ASME IX Qualification	QW4	32 F-N	o 43											
Composition		С	Mn	Si	S	Р	Cr	Ni	Со	Мо	Cu	Fe	AI	Ti
(wire wt %)	min	0.05					20.0	44.0	10.0	8.0			0.80	
	max typ	0.15	1.0	0.5	0.015	0.020	24.0 22	bal 55	15.0 12	10.0	0.5	3.0	1.50	0.60
		al values					min		typical	-				
All-weld mechanical properties		e streng		eu		MPa	700		750					
properties		Proof str				MPa	400		500 500					
		ation on				%	25		43					
	Elongation on 5d					%	30		41					
	Impact energy			+ 20	)°C	J			230					
	Hardn	ess cap/	/mid			HV		20	0/225					
Typical operating				Т	ïG									
parameters	Shield	ling			gon									
	Currer	nt			C-									
	Diame				mm									
	Param	neters		100A	A, 12V									
Packaging data	ø mm			Т	ïG									
	1.6			2.5k	g tube									
	2.4			2.5k	g tube									
Fume data	Fume	compos	ition (w	t %) (T	IG fume	negligible	e)							
			Fe	Mn	C	r <sup>3</sup>	Ni	Мо	Co	OE	S (mg/m	<sup>3</sup> )		
			1	1	1	7	45	9	11		0.9			

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#### **Product description**

Nickel base MMA electrode designed for welding matching base materials, and for surfacing CMn and low alloy steels. Special basic flux coating on a matching alloy core wire optimised for DC+ welding in all positions including pipework in the ASME 5G/6G positions. Metal recovery is about 105% with respect to core wire, 65% with respect to the whole electrode.

#### **Specifications**

 AWS A5.11
 ENiCrFe-7

 BS EN 14172
 E Ni6152

#### **ASME IX Qualification**

QW432 F-No 43.

#### Materials to be welded

ASTM	B163, B166-8
DIN	2.4642 (NiCr29Fe)
UNS	N06690
Proprietary	Inconel 690 (Special Metals)
	Nicrofer 6030 (Krupp VDM)

#### Applications

This electrode is designed to match alloy 690, which is finding increasing use in place of alloy 600 for high temperature corrosion applications, especially in nuclear applications. The high chromium content provides good elevated temperature corrosion resistance in oxidising and sulphidising atmospheres.

In addition to joining matching base materials, the electrode can also be used for **surfacing** applications on CMn and low alloy steels.

Applications include **nuclear engineering**; **sulphuric**, **nitric** and **hydrofluoric acid processing equipment**.



## DATA SHEET D-41

## NIMROD 690KS

#### **Microstructure**

High alloy nickel base austenite.

#### Welding guidelines

Preheat and PWHT is not generally required.

#### Parameters

DC+ve

ø mm

min A

max A

e		U	$\checkmark$	Î	Î
	4.0				
	100 155				
L .	155				

#### Packaging data

ø mm	4.0	
length mm	350	
kg/carton	15.0	
pieces/carton	294	

#### Storage

**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.

For electrodes that have been exposed:

**Redry** 200–250°C/1-2h to restore to as-packed condition. Maximum  $350^{\circ}$  C, 3 cycles, 10h total.

**Storage** of redried electrodes at  $50 - 200^{\circ}$ 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.

#### Fume data

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Мо	F	OES (mg/m <sup>3</sup> )
2	13	10	8	0.2	0.1	16	0.6

			As w	velded	PWHT 610°C/40h		
			min	typical	RT	+360°C	
Tensile strength		MPa	552	680	661	532	
0.2% Proof stress		MPa	360	450	414	325	
Elongation on 4d		%	30	40	42	45	
Elongation on 5d		%	27	38	38	42	
Reduction of area		%		45	60	46	
Impact energy, KCV	- 50°C	J		>50			
Impact energy, KCU	+ 20°C	J/cm <sup>2</sup>			84		

#### All-weld mechanical properties

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Cr	Ni	Nb	Fe	Мо	Ti	AI	Cu	Со
min		3.0				28.0	50.0	1.2	8.0					
max	0.045	5.0	0.65	0.008	0.02	31.5	bal	2.2	12.0	0.5	0.5	0.5	0.5	0.05
typ	0.04	4.5	0.4	0.005	0.01	29	55	1.8	10	0.1	0.05	0.05	0.05	0.02



# Nickel Base Alloys

## **PURE NICKEL**

#### Alloy type

Low carbon pure nickel wed metal with titanium deoxidation.

#### Materials to be welded

ASTM-ASME	BS	DIN
UNS N02200	NA11	2.4066
UNS N02201	NA12	2.4068
		2.4061

#### **Proprietary alloys**

Nickel 200 and 201 (Special Metals) Nickel 99.6 and 99.2 (VDM)

#### **Applications**

These consumables give low carbon pure nickel with the addition of titanium for refinement and de-oxidation. They are used for joining pure nickel to itself, for buffer layers, and for cladding joint faces and flanges. The solid wire is also useful for welding **cast iron** to give soft low strength deposit.

Applications include tanks and vessels, process

caustic soda. Also used for handling corrosive alkalis and halides.

#### **Microstructure**

In the as-welded condition the microstructure consists of almost pure nickel austenite. It is strongly ferromagnetic at room temperature.

pipework and heat exchangers, in chemical plant for

salt production, chlorination and evaporation of

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#### Welding guidelines

Pure nickel weld metals are sluggish and can lead to irregular weld beads which may require inter-run dressing.

#### **Products available**

Process	Product	Specification
MMA	Nimrod 200Ti	AWS ENi-1
TIG/MIG	Nickel 2Ti	AWS ERNi-1

### NIMROD 200Ti

#### All-positional pure nickel MMA electrode

Product description	offer e	MMA electrode with special carbonate-fluoride-rutile flux system on matching core wire. Smaller diame offer excellent all-positional operability. Recovery is about 100% with respect to core wire, 65% with resp to whole electrode.										
Specifications	AWS A5.11 BS EN 14172 DIN 1736			ENi-1 E Ni 2 (EL-N	061 iTi3, 2.41	156)						
ASME IX Qualification	QW4	QW432 F-No 41										
Composition		С	Mn	Si	S	Р	Ni	Ti	AI	Fe	Cu	Nb
(weld metal wt %)	min						92.0	1.0				
· ,	max	0.10	0.7	1.2	0.015	0.02	bal	4.0	1.0	0.7	0.2	0.5
	typ	0.04	0.5	0.6	0.005	0.005	97	1.5	0.1	0.3	0.1	<0.1
All-weld mechanical	As we	lded				n	nin	typical				
properties	Tensil	e strength	I		MPa	ι 4	10	450				
	0.2%	Proof stre	SS		MPa	1 2	00	295				
	Elonga	ation on 4	d		%	5 2	20	22				
	Elonga	ation on 5	d		%	5   1	8	20				
		tion of ar	ea		%			40				
		t energy		- 30°C	J	·		160				
	Hardn	ess			HV	7   ·		160				



# NIMROD 200Ti (continued)

Operating parameters	DC +ve						
	ø mm	2.5	3.2	4.0			
	min A	60	70	90			
	max A	80	110	145			
Packaging data	ø mm	2.5	3.2	4.0			
	length mm	300	350	350			
	kg/carton	12.3	13.5	15.0			
	pieces/carton	720	414	300			
Storage	for longer than a v moisture pick-up a For electrodes that <b>Redry</b> 200 – 250°C <b>Storage</b> of redried	vorking shift of a nd increase the r have been expose C/1-2h to restore electrodes at 50	<ul> <li>8h. Excessive explicitly explicitly of porosity.</li> <li>sed:</li> <li>to as-packed content of a co</li></ul>	bosure of elec dition. Maxin ng oven or hea	trodes t num 35 ated qui	life. Direct use from tin is s to humid conditions will c 0° C, 3 cycles, 10h total. iver: no limit, but maximus fusing plastic lid): < 60% R	ause some m 6 weeks
Storage Fume data	for longer than a v moisture pick-up a For electrodes that <b>Redry</b> 200 – 250°C <b>Storage</b> of redried	vorking shift of nd increase the r have been expose C/1-2h to restore electrodes at 50 commended amb	<ul> <li>8h. Excessive explicitly explicitly of porosity.</li> <li>sed:</li> <li>to as-packed content of a co</li></ul>	bosure of elec dition. Maxin ng oven or hea	trodes t num 35 ated qui	to humid conditions will c 0° C, 3 cycles, 10h total. iver: no limit, but maximum	ause some m 6 weeks

NICKEL 2Ti								Solid p	ure nie	ckel TIG	and N	/IG wire
Product description	Solid wi	re for TIG	& MI	G.								
Specifications	DIN 173 UNS	1: Pt5 ISO 1827 36	'4	ERNi-1 NA32 SNi2061 SG-NiTi4 N02061 as filler me								
ASME IX Qualification	QW432	F-No 41										
Composition (wire wt %)	min max typ	C  0.15 <0.02	Mn  1.0 0.4	Si  0.7 <0.3	S  0.015 0.005	P  0.020 0.005	Ni 93.0 bal 96	Ti 2.0 3.5 3	Al  1.5 0.1	Cu  0.2 <0.02	Fe  1.0 0.1	
All-weld mechanical properties	Tensile s 0.2% Pro Elongation Elongation Reduction	oof stress on on 4d	velded		MPa MPa % % % HV	min 410 200  25  		TIG 585 335 35 31 65 155/185				
Typical operating parameters	Shielding Current Diamete Voltage		1	TIG Argon * DC- 2.4mm 00A, 12V	1	MIC Ar or A Pulso 1.2m 50A, 29V	.r-He ed m		+ 1-5%1	H <sub>2</sub> also suit	table.	
Packaging data	ø mm 1.2 1.6 2.4			TIG  2.5kg tube 2.5kg tube		MIG 15kg sj 						
Fume data	MIG fur	ne compos Fe	;	wt %) (TIO Mn 2	G fume ne Cr <sup>3</sup>	egligible) Ni 68	Mo 0.1	Cu <0.5	OES	S (mg/m <sup>3</sup> ) 0.7		



## **NICKEL-COPPER ALLOY 400**

#### Alloy type

Nickel-copper alloy based on alloy 400 with raised levels of manganese and titanium to suppress hot cracking and porosity.

#### Materials to be welded

ASTM-ASME	BS	DIN
UNS N04400	NA13	2.4360
UNS N04405	NA1 (cast)	2.4361
UNS N05500		2.4365 (cast)
A494 M-35-1 (cast)		
A494 M-35-2 (cast)		
Proprietary		
Monel allov 400 R405	5. K500 (Special	Metals)

Monel alloy 400, R405, K500 (Special Metals) Nicorros (VDM)

#### Applications

Nimrod 190 deposits 65%Ni-30%Cu weld metal based on Monel alloy 400 with raised levels of manganese and titanium to suppress hot cracking and porosity. It is optimised to give the highest as-welded ductility and strength attainable in weld metal of this type.

For welding alloy 400 and similar parent material to itself and to others in the Ni-Cu alloy system, such as pure nickel and cupronickel. Welds in alloy K500 are satisfactory, but cannot match the strength of this precipitation-hardened alloy. Castings of alloy 400 with up to about 1.5%Si are welded with Nimrod 190, but higher silicon grades such as BS3071 NA2 and ASTM A743 M35-2 are virtually unweldable because of HAZ cracking.

For **dissimilar** joints between alloy 400 and other alloys or steels, sensitivity to dilution by Fe (20-30%) or Cr (3-6%) can lead to low ductility (or bend-test fissuring) in weld metal close to the fusion boundary. Direct welds to mild or low alloy steels are satisfactory with dilution control, although ENiCrFe-X (ERNiCr-3

### DATA SHEET D-60

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wire) is preferable and necessary for stainless and higher chromium alloys (see data sheets D-10 and D-11). Alternatively, the steel or alloy can be buttered with pure nickel (see data sheet D-50) and this procedure is also useful when **surfacing** with alloy 400 consumables.

Alloy 400 has a useful combination of strength, thermal conductivity and resistance to corrosion by seawater, inorganic salts, sulphuric and hydrofluoric acids, hydrogen fluoride and alkalis. Applications include **heat exchangers, piping, vessels** and **evaporators** in the **offshore, marine, chemical, petrochemical** and **power engineering** industries.

#### Microstructure

Solid solution, single phase alloy, slightly ferromagnetic near room temperature.

#### Welding guidelines

No preheat required, maximum interpass temperature 150°C and no PWHT required.

#### **Additional information**

Alloy 400 parent material is noted for its good resistance to both **hydrofluoric acid** and **hydrogen fluoride vapour**. However, weld metal compositions within standard specification limits have inferior resistance to these media. A fully optimised composition for this specific application is not currently available. Contact Metrode for guidance.

Process	Product	Specification
MMA	Nimrod 190	AWS ENiCu-7
TIG/MIG	65NiCu	AWS ERNiCu-7



NIMROD 190	1				Nic	kel-cop	per MI	MA ele	ectrode	for Mor	nel alloy 40
Product description	Special basic can Deoxidation sys suppress hot cra- attainable in wel- demanding quali	tem de cking a d metal	signed to nd poros of this ty	ensure ity. Ana pe. The	sound c lysis is smaller o	leposits. optimisec electrode	The rai to give	sed leve the high	els of ma lest as-we	nganese ar elded ducti	nd titanium hel lity and strengt
	Recovery is about	ut 110%	% with re	spect to	core wir	e, 65% w	ith respec	et to wh	ole electr	ode.	
Specifications	AWS A5.11         ENiCu-7           BS EN 14172         E Ni 4060           DIN 1736         (EL-NiCu30Mn, 2.4366)										
ASME IX Qualification	QW432 F-No 42										
Composition (weld metal wt %)	C           min            max         0.15           typ         0.08           * DIN maximum	Mn 1.0 4.0 3.5 n 1.0%	Si *  1.5 1.2 Si	S 0.015 0.005	P  0.02 0.01	Ni 62.0 69.0 63	Cu 27.0 34.0 30	Ti  1.0 0.9	Fe 0.5 2.5 1	Al  0.5 0.03	
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stres Elongation on 4d Elongation on 5d Reduction of area Impact energy Hardness	-	- 30°C	Μ	IPa IPa % % % J HV	min 480 200 30 27  	typic 550 350 40 35 60 110 160-1	0 0 ) ; ) 0			
Operating parameters	DC +ve ø mm min A max A		2.5 60 80		3.2 70 110		4.0 90 145		5.0 120 190	) ) )	Ê
Packaging data	ø mm length mm kg/carton pieces/carton	-	2.5 300 12.6 612		3.2 350 13.5 417		4.0 350 15.0 294		5.0 350 15. 189	) 0	
Storage	<ul> <li>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. For electrodes that have been exposed:</li> <li>Redry 200 – 250°C/1-2h to restore to as-packed condition. Maximum 350° C, 3 cycles, 10h total.</li> <li>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): &lt;60% RH, &gt;18°C.</li> </ul>										
Fume data	Fume composition	on, wt '	% typical	:							
		_	Fe 1	Mn 7			Cu 16	F 8	OES (r 1.		



65Ni	Cu
------	----

### Solid TIG and MIG to match Monel alloys

Product description	Solid	Solid wire for TIG & MIG.											
Specifications	BS EI BS 29 DIN 1		5	SNi NA: (SG	NiCu-7 4060 33 -NiCu30 ler metal								
ASME IX Qualification	QW432 F-No 42												
Composition		С	Mn	Si	S	Р		Ni	Cu	Ti	Fe	AI	
(wire wt %)	min		3.0					62.0	28.0	1.5			
. ,	max	0.15	4.0	1.2	0.015	0.02	20	69.0	32.0	3.0	2.5	1.2	
	typ	0.03	3.2	0.2	0.005	0.00	)5	64	29	2.2	<1	0.1	
All-weld mechanical	Typical values as weld			ed	ed			min	TIC	3			
properties	Tensile	e streng	th			MPa		460	52	5			
	0.2% F	Proof str	ess			MPa		200	28	)			
		ation on				%			41				
	-	ation on	5d			%		25	38				
	Impact	t energy		- 30	°C	J			120	)			
Typical operating				Т	IG			MIG		e,	SAW		
parameters	Shielding			Argon *			Ar or Ar-He			NiCu			
	Currer	nt			C-			Pulsed			DC+		
	Diame				mm			1.2mm			4mm		
	Param *				, 12V		50A	, 29V (m	ean)	300	A, 28V		
	*	Also req	uired as	s a purg	e for root	runs.							
Packaging data	ø mm			Т	TIG		MIG			SAW			
	1.2						1	5kg spoo	1				
	1.6			2.5kg tube									
	2.4			2.5kg	g tube					25	kg reel		
Fume data	MIG fume composition (wt %) (TIG fume negligible)												
			Fe	N	n	Cr	3	Ni	Cu	OES (I	mg/m³)		
				3	4	5	<0.	.1 4	47	24	1	1	



## **CUPRONICKEL ALLOYS**

#### Alloy type

70/30 and 90/10 copper-nickel alloys.

#### Materials to be welded

	70/30	90/10
ASTM	C71500	C70600
	C96400 (cast)	C96200 (cast)
DIN	2.0882	2.0872
	2.0883	
BS	CN106	CN102
	CN107	
	CN108	
CDA	CA715	CA706
Proprietary	Kunifer 30 (IMI)	Kunifer 10 (IMI)
	Cunifer 30	Cunifer 10
	(Krupp VDM)	(Krupp -VDM)

The Cupromet N30 and 70CuNi can be used for welding the 70/30 and 90/10 base materials; the 90CuNi is only suitable for the 90/10 alloys.

#### **Applications**

These consumables deposit a copper-nickel weld metal; the MMA electrode and 70CuNi solid wire are both nominally 67%Cu and 30%Ni, whereas the 90CuNi solid wire is nominally 86%Cu and 10.5%Ni. The 70/30 consumables are suitable for welding 70/30, 80/20 and 90/10 base materials. The 70/30 consumables match the 70/30 base materials for strength and colour and overmatch the 90/10 alloys for strength.

The consumables are suitable for surfacing and

DATA SHEET D-70

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cladding provided the need for an appropriate buttering layer is addressed, normally either alloy 400 (D-60) or pure nickel (D-50).

Applications include offshore construction, desalination plant, evaporators, condensers etc, in salt and sea water processing systems.

#### Microstructure

Solid solution, single phase alloy.

#### Welding guidelines

Preheating not normally required, maximum interpass temperature 150°C and no PWHT. Contamination of the weld zone with foreign material, particularly any source of lead, tin or zinc (eg. Gun metals) must be scrupulously avoided to prevent weld metal cracking.

#### **Related alloy groups**

No closely related alloys but the alloy 400 (D-60) or pure nickel (D-50) consumables may be required as a buffer layer for cladding applications.

Process	Product	Specification
MMA	Cupromet N30	AWS ECuNi
TIG/MIG	70CuNi	AWS ERCuNi
TIG	90CuNi	BS C16



CUPROMET N	130				All-p	oositio	nal MI	MA el	ectrode	for cu	pronickel
Product description	MMA electrode ma P, Pb, Sn, Zn etc) a Recovery is about	and hence r	naximun	n crack res	istance.	Suitable	e for all-	position	nal weldir		residuals (S,
Specifications	AWS A5.6 DIN 1733		CuNi L-CuNi3	0Mn (2.08	38)						
ASME IX Qualification	QW432 F-No 34										
Composition (weld metal wt %)	C         M           min          1.0           max          2.5           typ         0.03         1.           * Total maximum         *         *	00 50 0.50 8 0.2	S  0.015 0.005	P  0.020 0.010	Cu bal  67	Ni 29.0 33.0 30	Fe 0.40 0.75 0.6	Ti  0.50 0.15	Pb  0.02 0.002	Sn *   0.01	Zn *  0.005
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Impact energy Hardness	+ 20	0°C	MPa MPa % % % J HV	min 350  20    	2	pical 420 270 39 34 57 115 120				
Operating parameters	DC +ve ø mm min A max A	2.5 60 90		3.2 75 120		4.0 10 15	0	Ų	5.0 130 210		ê î
Packaging data	ø mm length mm kg/carton pieces/carton	2.5 280 12.6 684		3.2 345 15.0 450		4.0 34 15. 29	0 5 .0		5.0 345 16.5 198		
Storage	3 hermetically sea for longer than a v moisture pick-up a For electrodes that Redry 250 – 300° Storage of redried recommended. Re	vorking shi nd increase have been C/1-2h to re electrodes	ft of 8h. e the risk exposed estore to at $50 - 2$	Excessive of porosit as-packed 200°C in h	e exposu y. conditio olding o	ure of ele on. Max	ectrodes imum 3 leated qu	to hum 50° C, 3 uiver: n	nid condit 3 cycles, 1 0 limit, bu	ions will 0h total 1t maxin	cause some
Fume data	Fume composition	, wt % typi Fe < 1	М		li 3	Cu 16	F 15	OE	S (mg/m <sup>3</sup> )	)	

## **CUPROMET N30**

## 70CuNi

### Solid 70/30 cupronickel wire for TIG and MIG

Product description	Solid v	lid wire for TIG and MIG.											
Specifications	BS EI BS 29 DIN 1	VS A5.7       ERCuNi         S EN 14640       S Cu 7158 / CuNi30         S 2901: Pt3       C18         N 1733       SG-CuNi30Fe (2.0837)         so known generically as filler metal 67 (FM67)											
ASME IX Qualification	QW43	<b>32</b> F-No	34										
Composition		Mn	Si	S	Р	Cu	Ni	Fe	Ti	Pb	AI	С	
(wire wt %)	min	0.5				bal	30.0	0.40	0.20				
	max	1.00	0.1	0.01	0.01		32.0	0.75	0.50	0.007	0.03	0.05	
	typ	0.8	0.01	0.005	0.003	67	31	0.5	0.3	0.001	0.01	0.03	



70CuNi (	continued)
----------	------------

	,						
All-weld mechanical	Typical values as v	velded		TIG			
properties	Tensile strength		MPa	ı 365			
	0.2% Proof stress		MPa	1 200			
	Elongation on 5d		%	40			
	Hardness		HV	105			
Typical operating			TIG			MIG	
parameters	Shielding	Argon	or Ar + 1-5%	H <sub>2</sub>	Ar	gon or Ar-	·He
-	Current		DC-			Pulsed	
	Diameter		2.4mm			1.2mm	
	Voltage	1	00A, 12V		160.	A, 28V (m	lean)
Packaging data	ø mm		TIG			MIG	
	1.2					15kg spoo	1
	1.6		2.5kg tube				
	2.0	2	2.5kg tube				
	2.4	2	2.5kg tube				
Fume data	MIG fume compos	sition (wt %)	) (TIG fume 1	negligible)			
	Fe		Cr <sup>3</sup>	Ni	Мо	Cu	OES (mg/m <sup>3</sup> )
	<1	5	<0.1	22	< 0.1	72	0.3

## 90CuNi

Solid 90/10 cupronickel wire for TIG

Product description	Solid v	wire for T	ΓIG.										
Specifications	_	N 14640 001: Pt3 733		S Cu 7061 / CuNi10 (C16) SG-CuNi10Fe (2.0873)									
ASME IX Qualification	QW43	<b>QW432</b> F-No 34											
Composition (wire wt %)	min max typ * BS r	Mn 0.5 1.0 0.8 ange Fe	Si  0.1 0.02 = 1.5-1.8	S  0.01 0.001 8%.	P  0.01 0.002	Cu bal  86	Ni 10.0 11.0 10.5	Fe * 1.0 2.0 1.2	Ti 0.20 0.50 0.3	Pb  0.007 0.001	Al  0.03 0.005	C  0.05 0.01	
All-weld mechanical properties	Tensile 0.2% F	l values a e strength Proof stre ation on 5 ess	n ss	d	М	Pa Pa % IV	TIG 365 200 40 105						
Typical operating parameters	Shieldi Curren Diame Param	it ter		-	TIG or Ar + 1 DC- 2.4mm 00A, 12V								
Packaging data	ø mm 1.6 2.4				TIG 2.5kg tube 2.5kg tube								
Fume data	Fume	composit			fume neg				•	0.50	. 3.		
			Fe 2	Mn 5	Cr <sup>3</sup>	N {		Ло 0.1	Cu 80	OES (m 0.3			



D-80

# Nickel Base Alloys

# NICKEL-MOLYBDENUM ALLOY B2

#### Alloy type

Ni-28%Mo consumables to match alloy B2.

#### Materials to be welded

wrought:	
ASTM	B333, B335, B619, B626:
	UNS N10001 (alloy B)
	UNS N10665 (alloy B2)
DIN	2.4617
Proprietary	Hastelloy alloy B-2 (Haynes)
	Nimofer 6928 (VDM)
cast:	
ASTM	A494: N-7M
	A743: N-12M
	A744: N-12M
BS	3146: ANC 15
DIN	2.4685, 2.4882
Proprietary	NB (Paralloy)
-	Langalloy B (Meighs)
	AR5 (LaBour/Darwins)

#### Similar alloys:

UNS N10675, Hastelloy Alloy B-3 (Haynes). UNS N10629, DIN 2.4600, Nimofer 6629 (VDM), alloy B-4.

#### Applications

These consumables deposit nickel-molybdenum weld metal with very low carbon and silicon levels appropriate for alloy B-2, although it is equally suitable for the original alloy B, now obsolete in wrought form. In addition, specially controlled levels of iron and chromium ensure good aswelded ductility in multipass deposits.

These modifications bring the composition close to the more recent alloys B-3 and B-4 which have better microstructural stability and weldability than alloy B-2. There are no electrode specifications for these alloys at present, and these consumables are therefore offered as an acceptable candidate within current specification limits. These alloys are designed to resist hydrochloric acid at all concentrations and temperatures up to boiling point under non-oxidising conditions. They are also resistant to hydrogen chloride gas, sulphuric and acetic acids under certain conditions. The newer alloys B-3 and B-4 with additional Fe and Cr have improved SCC resistance in chloride media. Contamination of acid media with oxidising ferric or cupric salts must be avoided. Alloys with much higher chromium (C-4 or C-276 etc.) are superior under oxidising conditions.

DATA SHEET

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Applications include **pumps**, **valves** and **process equipment** operating in **aggressive environments** in **chemical plant**.

#### **Microstructure**

Solid solution alloy, high nickel austenite with some microsegregation typical of as-deposited weld metal (homogenised by solution treatment around 1150°C and rapidly cooled for casting repairs).

#### Welding guidelines

No preheat and maximum interpass of 150°C for wrought alloys.

For castings of low ductility a preheat-interpass of up to 200-300°C may be required on sections above 15mm. In this case a post-weld solution treatment must be applied to restore satisfactory weld area properties.

#### **Additional information**

Alloy B-2 was introduced to suppress the formation of carbides and silicon-rich intermetallic phases which occur in the original alloy B during processing and welding. However, experience has revealed that elimination of Fe promoted sensitivity to another intermetallic, beta phase Ni<sub>4</sub>Mo. This can be limited significantly by controlled Fe (and Cr) additions within the B-2 specification, and this modification is extended in the new alloys B-3 (1.5%Fe, 1.5%Cr) and B-4 (3%Fe, 1.3%Cr). Intermetallics reduce ductility and corrosion resistance.

If PWHT is required to restore maximum corrosion resistance of casting repairs, castings should be solution treated at about 1150°C followed by a rapid cool.

#### **Products available**

Process	Product	Specification
MMA	Nimax B2L	AWS ENiMo-7
TIG	HAS B2	AWS ERNiMo-7

### Rev 02 05/04



NIMAX B2L		Hig	Ih molyb	denum	nickel	l base	MMA	electr	rode to	o mato	h alloy	B-2
Product description	MMA electrode n Sizes above 3.2m						c flux c	oating t	o give lo	ow level	s of impu	rities.
	Recovery is abou	t 130% wi	th respect to	pect to v	vhole el	ectrode.						
Specifications	AWS A5.11 BS EN 14172 DIN 1736		ENiMo-7 E Ni1066 EL-NiMo29	)								
ASME IX Qualification	QW432 F-No 44	1										
Composition (weld metal wt %)	C           min            max         0.02           typ         0.018	 1.75 0	Si S  .2 0.015 .1 0.005		Cr 0.3 1.0 0.7	Ni 64.5 bal 68	Mo 26 30 28	W  1.0 0.1	Cu  0.50 0.01	Fe 1.0 2.0 1.5	Co  1.0 0.04	V  0.4 0.1
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stress Elongation on 4d Elongation on 5d Reduction of area Hardness ASTM A494 cast			MPa MPa % % HV n >6% (1	min 760 400 25 22   V-12MV	75	pical 775 525 31 30 25 260 % (N-71	M) after	solutio	n treatm	ent.	
Operating parameters	DC +ve							Ū			Ê	Î
	ø mm	2.	5	3.2		4.0	)					
	min A	7		90		13						
	max A	11	5	155		21						
Packaging data	ø mm	2.	5	3.2		4.(	)					
	length mm	30	0	350		35	0					
	kg/carton	12	.6	15.0		14.	1					
	pieces/carton	44	7	300		174	4					
Storage	<b>3 hermetically se</b> for longer than a moisture pick-up	working s and increa	hift of 8h. se the risk o	Excessiv	e exposi			s to hum	nid cond	litions w	vill cause	
	For electrodes that <b>Redry</b> 250 – 300 <b>Storage</b> of redrie recommended. R	°C/1-2h to d electrod	restore to a es at $50 - 2$	00°C in h	olding c	oven or h	eated q	uiver: n	o limit,	but max	imum 6 v	
Fume data	For electrodes that Redry 250 – 300 Storage of redrie	°C/1-2h to d electrode ecomment	restore to a es at $50 - 2$ led ambient	00°C in h	olding c	oven or h	eated q	uiver: n	o limit,	but max	imum 6 v	
Fume data	For electrodes that <b>Redry</b> 250 – 300 <b>Storage</b> of redrie recommended. R Fume compositio	°C/1-2h to d electrode ecommend n, wt % ty	restore to a es at $50 - 2$ led ambient	00°C in h storage c	olding c	oven or h	eated q	uiver: n	o limit, plastic l	but max	imum 6 % RH, >	



HAS B2

Solid TIG wire to match alloy B-2

Product description	Solid v	wire for	TIG.										
Specifications		N ISO 1 01: Pt		SNi NA4	4	(2.4615)							
ASME IX Qualification	QW43	<b>32</b> F-No	o 44										
Composition (wire wt %)	min max typ	C  0.02 0.01	Mn  1.0 0.7	Si  0.10 0.05	S  0.015 0.005	P  0.020 0.005	Cr  1.0 0.5	Ni 64.0 bal 70	Mo 26.0 30.0 27	W  1.0 0.5	Cu  0.50 0.02	Fe  2.0 1.5	Co  1.0 0.05
All-weld mechanical properties	Tensile 0.2% F Elonga Elonga Reduc Impact	I values e strengt Proof stre ation on a tion of a tion of a energy ess cap/	h ess 4d 5d rea	led + 20	°C	MPa MPa % % % J HV	TIG 815 510 48 47 40 220 230/24	5					
Typical operating parameters	Shieldi Curren Diame Param	it ter		TI Arg D( 2.41 100A	gon C- nm								
Packaging data	ø mm 2.4			TI 2.5kg	-								
Fume data	Fume	composi	ition (w	rt %) (TI	G fume	negligible	)						
			Fe	Mn	С	r <sup>3</sup> I	Ni	Мо	Cu	OE	S (mg/m	<sup>3</sup> )	
			2	2	<0	.5 .5	50	25	< 0.5		1		

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#### **Product description**

MMA electrode with a special basic flux covering on a nickel-iron alloy core wire. The electrode is optimised for DC+ welding in all positions including fixed pipework in the ASME 5G/6G positions.

Recovery about 115% with respect to core wire, 65% with respect to whole electrode.

#### Specifications

Currently no relevant national standard but there is a patent pending.

#### Materials to be welded

Designed for dissimilar joints between austenitic stainless steels (eg. 304H) and creep resisting CrMo (eg. P91). Suitable for as-welded, PWHT or N+T joints in CrMo steels.

#### Applications

EPRI P87 electrode is designed for welding high temperature creep resisting CrMo steels, including P91. The electrode can be used for dissimilar applications between CrMo creep resisting steels and austenitic stainless steels. The EPRI P87 electrode is also suitable for joining CrMo steels to themselves.

The EPRI P87 weld metal is also proposed for N+T joints in P91. The weld metal will allow joints to be buttered in the workshop and then subjected to a full N+T heat treatment; joints on the buttered faces can then be completed in the field without the need for PWHT.

The all-weld metal strength at ambient temperature may not meet that of P91 but transverse tests have shown strengths above the P91 base material requirement, and elevated temperature strength exceeds the minimum base material requirement.

#### Microstructure

High alloy austenite.

#### Welding guidelines

Preheat and PWHT requirements will be determined by the base material being welded. For example P91 is normally preheated to 200°C and PWHT at 760°C for 2 hours (or time appropriate to material thickness). Alternatively if P91 is subjected to a full N+T the heat treatment would typically be 1060°C/1 hour + 760°C/2 hours.



### DATA SHEET D-87

## **EPRI P87**

#### **Additional information**

The alloy is balanced to provide excellent resistance to carbide formation at the fusion boundary. The thermal expansion coefficient is also closer to the base material than with standard nickel base weld metals.

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	Fe
typical	0.1	1.5	0.3	0.008	0.008	9	Bal	2	1	38

#### All-weld mechanical properties

Typical values		Ambient	Hot stren	gth 593°C
		as- welded	as- welded	N+T
Tensile strength	MPa	560	530	440
0.2% Proof stress	MPa	360	340	225
Elongation on 4d	%	34	21	25
Reduction of area	%	49	24	33
Impact energy +20	°C J	80		

# Parameters DC +ve Image: Colspan="3">Image: Colspan="3" Image: Colspan="3

#### Packaging data

ø mm	2.5	3.2	4.0
length mm	305	355	355
kg/carton	12.6	15.0	14.7
pieces/carton	684	420	264

#### Storage

**3 hermetically sealed ring-pull metal tins** per carton, with unlimited shelf life. Direct use from tin is satisfactory for much longer than an 8h working shift.

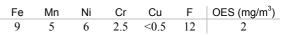
For electrodes that have been exposed:

**Redry** 200-250°C/1-2h to restore to as-packed condition. Maximum 350°C, 3 cycles, 10h total.

**Storage** of redried electrodes at 100-200°C in holding oven or 50-150°C in heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, >18°C.

#### **Fume data**

Fume composition, wt % typical:





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#### **Product description**

Nickel base MMA electrode designed for welding 9%Ni steels. High efficiency metal powder type electrode with basic carbonate-fluoride flux coating on high conductivity nickel core wire. Moisture resistant coating provides radiographically sound weld metal. Metal recovery is about 140% with respect to core wire, 65% with respect to the whole electrode.

> Specifications 1 ENiCrMo-6

 AWS A5.11
 ENiCrMo

 BS EN 14172
 E Ni6620

**ASME IX Qualification** 

QW432 F-No 43.

#### Materials to be welded

9%Ni steels including:

ASTM	A353, A553 UNS K81340 & K71340
BS	1501 grade 510 & 510N
	1502 & 1503 grade 509-690
DIN	1.5662, X8Ni9 (wrought)
	G-X8Ni9 (cast)
5%Ni steels in	cluding:
ASTM	A645
	A352 LC4 (cast)

#### Applications

Nimrod NCM6 is a high efficiency electrode designed for welding 5-9%Ni steels used in the fabrication of **cryogenic containment plant** demanding good properties at temperatures down to  $-196^{\circ}$ C. It deposits a controlled carbon and solid solution strengthened alloy with high strength and toughness in the as-welded condition. To satisfy procedural and property requirements in these applications Nimrod NCM6 meets the following criteria:

- All-positional.
- Operates on all power source polarities: AC, DC+, DC-.
- High deposition efficiency and wide operating current range without overheating.
- Basic flux coating for metallurgical quality, manufactured using advanced moisture resistant low hydrogen technology.
- Weld metal proof stress >390MPa (typically >450MPa).
- Nickel base alloy weld metal gives excellent procedure independent impact toughness at -196°C, and similar thermal expansion coefficient to 9%Ni steels.

This electrode is equally suitable for welding other low alloy and hardenable steels, including applications where PWHT is required, and for **dissimilar** welds between these and austenitic steels or high nickel alloys.



## DATA SHEET D-90

## NIMROD NCM6

#### Microstructure

High alloy nickel base austenite with some carbides.

#### Welding guidelines

Preheat is not generally required. PWHT is not normally applied up to 50mm thickness.

#### All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	670	>710
0.2% Proof stress		MPa	350	>450
Elongation on 4d		%	35	40
Elongation on 5d		%	32	39
Reduction of area		%		40
Impact energy	- 196°C	J	45	>50
Lateral expansion	- 196°C	mm	0.38	>0.75

#### Parameters

AC (OCV: 55V preferred or DC	,		Û <		
ø mm	2.5	3.2	4.0	5.0	
min A	70	90	130	160	
max A	115	155	210	260	

#### Packaging data

		0		
2.5	3.2	4.0	5.0	
300	350	350	450	
12.0	13.2	13.5	18.0	
456	294	183	123	
	300 12.0	2.5         3.2           300         350           12.0         13.2	2.5         3.2         4.0           300         350         350           12.0         13.2         13.5	2.5         3.2         4.0         5.0           300         350         350         450           12.0         13.2         13.5         18.0

#### Storage

**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.

For electrodes that have been exposed:

**Redry** 200–250°C/1-2h to restore to as-packed condition. Maximum  $350^{\circ}$  C, 3 cycles, 10h total.

**Storage** of redried electrodes at  $50 - 200^{\circ}$ 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.

#### **Related alloy groups**

There are no matching solid wires for this electrode but the 625 (data sheet D-20) alloy is generally suitable.

#### Fume data

Fu	Fume composition, wt % typical:											
	Fe	Mn	Ni	Cr	Cu	Мо	F	OES (mg/m <sup>3</sup> )				
	2	13	10	5	< 0.5	1	15	1				

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Cr	Ni	Мо	W	Nb	Fe	Cu
min	0.04	2.0				12.0	55.0	5.0	1.0	0.5		
max	0.10	4.0	1.0	0.015	0.02	17.0	bal	9.0	2.0	2.0	10.0	0.5
typ	0.07	3	0.3	0.005	0.01	15	64	8	1.6	1.6	6.5	0.05



**F-10** 

# **Repair & Maintenance**

# **PURE NICKEL FOR CAST IRON**

#### Alloy type

Pure nickel type for welding cast iron.

#### Materials to be welded

ASTM **BS** A159, A319, A126, A48. 1452 - Grey iron

#### **Applications**

Pure nickel consumables are used for welding and repair of standard grades of grey cast irons and malleable cast irons to give low strength deposits which can be readily machined even in thin layers. The resistance to hardening of diluted weld metal can be useful for buttering prior to filling with more economic NiFe consumables (data sheet E-11).

They are also suitable for joining these cast irons to steels, monels, copper etc where high strength is not required.

Typical components are general engineering castings, including machine bases, engine blocks, gear housings etc operating under low stresses.

#### **Microstructure**

MMA electrode deposits austenitic nickel with finely distributed graphite; the solid wire deposits almost pure nickel refined with Ti.

#### Welding guidelines

Welding is often carried out without preheat but heavy multipass deposits or highly restrained joints may require preheat up to 150°C.

Prior to welding surfaces should be prepared by careful gouging and/or grinding using limited amounts of heat to avoid propagating cracks. The area to be welded should be cleaned as far as practicable from sand, oil, grease, paint or rust. Preheating can help to remove impregnated oil on used castings which are being repaired.

DATA SHEET

SURREY, KT16 9LL

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If welding is carried out without preheat it is desirable to minimise the width of the HAZ by using a low heat input and low interpass temperature. A skip welding technique can be beneficial in helping to achieve this.

For thicker section welds and highly restrained welds preheat up to150°C may be necessary. Light peening to reduce contraction stresses can also be beneficial but care should be taken not to exhaust the ductility of the weld metal.

Buttering the joint faces, or sides of the repair cavity, prior to filling can also be desirable whether a preheat is used or not.

On completion of welding the workpiece should be allowed to cool slowly, using insulation if necessary.

#### **Related alloy groups**

The NiFe alloy (data sheet E-11) is also used for welding cast iron and covers many similar applications.

Process	Product	Specification					
MMA	CI Soft Flow Ni	AWS ENi-CI					
	CI Cavity Fill Ni	AWS ENi-CI					
TIG/MIG	Nickel 2Ti	AWS ERNi-1					



CI SOFT FLO	W Ni					F	Pure ni	ickel N	IMA electrode for cast iro		
Product description	MMA electrode with special basic-graphite flux (no barium compounds) on pure nickel core wire. Go action provides maximum resistance to cracking and freedom from porosity. Sound welds can be provide with oil impregnated and contaminated surfaces. The stable arc characteristics also provide un penetration and minimum dilution. The smallest diameters can be used in all positions including vert Recovery is about 95% with respect to core wire, 70% with respect to whole electrode.										
Specifications	AWS A5.15 BS EN 1071 DIN 8573	<b>BS EN 1071</b> E C Ni-CI 1									
ASME IX Qualification	QW432 F-No -	-									
Composition (weld metal wt %)	C           min            max         2.0           typ         0.5	Mn  2.5 2	Si  2.0 0.1	S  0.03 0.01	P  0.03 0.01	Cu  2.5 0.1	Ni 92 bal 96	Fe  5.0 2	Al  1.0 0.1		
All-weld mechanical properties	As welded     typical       Tensile strength     MPa     275       0.2% Proof stress     MPa     190       Elongation     %     5-10       Hardness     HV     140-160       Mechanical properties will depend upon amount of dilution, and variations in welding procedure and resequence.								in welding procedure and run		
Operating parameters	DC +ve or AC (	50V min)			F						
	ø mm min A max A		2.5 60 80		3.2 70 110		4.0 90 150		5.0 * 120 190		
Packaging data	ø mm length mm kg/carton pieces/carton * 5.0mm diamet	2.5         3.2           300         350           15.0         16.5           903         480           ter made to order, minimum order		350 16.5 480	4.0 350 16.8 309			5.0 * 375 18.6 234			
Storage	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin satisfactory.</li> <li>For electrodes that have been exposed:</li> <li>Redry 100 – 150°C/1-2h to restore to as-packed condition. Maximum 150° C, 3 cycles, 10h total.</li> <li>Storage: Recommended ambient storage conditions for opened tins (using plastic lid): &lt; 60% RH, &gt; 18°C.</li> </ul>								° C, 3 cycles, 10h total.		
Fume data	Fume compositi	on, wt	% typical	•							
		Fe 0.5	Mn 1	Ni 10	Cı <0.		F 2	Ba <0.5	OES (mg/m <sup>3</sup> ) 5		



<b>CI CAVITY FII</b>	_L Ni				F	<sup>p</sup> ure ni	ckel N	/IMA electrode f	or cast iron			
Product description	MMA electrode with special basic-graphite flux on pure nickel core wire. Similar product to CI Soft Flow Ni but specially designed to allow a slag-over-slag technique to be used for filling shrinkage cavities, blow holes, piping etc. Recovery is about 95% with respect to core wire, 70% with respect to whole electrode.											
Specifications	AWS A5.15 BS EN 1071 DIN 8573	<b>BS EN 1071</b> E C Ni-CI 1										
ASME IX Qualification	QW432 F-No											
Composition (weld metal wt %)	C           min            max         2.0           typ         1	Mn Si 2.5 2.0 0.7 0.6		P  0.03 0.01	Cu  2.5 1.8	Ni 92 bal 95	Fe  5.0 2	Al  1.0 0.1				
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stress Elongation Hardness Mechanical proposequence.	in welding procedure	e and run									
Operating parameters	DC +ve or AC (OCV: 50V min)								î î			
	ø mm min A max A	2.5 70 110		3.2 80 140		4.0 100 180						
Packaging data	ø mm length mm kg/carton pieces/carton	2.5 300 15.0 879		3.2 350 18.6 546		4.0 350 18.9 360						
Storage	satisfactory. For electrodes tha <b>Redry</b> 100 – 150	at have been °C/1-2h to re	exposed: estore to as-	-packed of	condition	. Maxim	num 150	shelf life. Direct u 0° C, 3 cycles, 10h tot plastic lid): < 60% R	tal.			
Fume data	Fume compositio	n, wt % typio	cal:									
	F 0	e Mn 5 1	Ni 5	Cu <0.		F 8	Ва 34	OES (mg/m <sup>3</sup> )				



NICKEL 2Ti								Solic	l pure	nickel v	vire for	cast iron
Product description										e nickel bas w Ni electr		s (data sheet
Specifications	BS EN DIN 1	01: Pt5 N propos 736										
ASME IX Qualification	QW43	<b>32</b> F-No 4	1									
Composition (wire wt %)	min max typ	C  0.15 <0.02	Mn  1.0 0.4	Si  0.75 <0.3	S  0.015 0.005	P  0.03 0.005	Ni 93.0 bal 96	Ti 2.0 3.5 3	Al  1.5 0.1	Cu  0.25 <0.02	Fe  1.0 0.1	
All-weld mechanical properties	Tensile 0.2% F Elonga Elonga Reduc	l values as e strength Proof stres ation on 4d ation on 5d tion of area	s I a	MPa 585 MPa 335 % 35 % 31 % 65			35 35 5 1 5					
Typical operating parameters	Shielding Current Diameter Parameters			TIG Argon DC- 2.4mm 100A, 12V 15			MIG Ar or Ar-He Pulsed 1.2mm 150A, 29V (mean)					
Packaging data	ø mm         TIG           1.2            1.6         2.5kg tube           2.4         2.5kg tube					MIG 15kg spool  						
Fume data	MIG f	ume comp	osition	(wt %) (	TIG fume	negligible	e)					
			Fe	Mn	Cr <sup>3</sup>				Cu OES (mg/m <sup>3</sup> )			
			2	2	<0.1	68	0.1	<0.5	>	0.7		



# **Repair & Maintenance**

## **NICKEL-IRON FOR CAST IRON**

#### Alloy type

Nominally Fe-55% Ni alloy for the repair and joining of cast iron.

#### Materials to be welded

ASTM

BS

A602, A47, A338, A220

2789 – SG irons 6681 – Ductile irons

#### Applications

The NiFe alloy is suitable for welding all grades of cast iron but particularly for **spheroidal graphite** (SG), **nodular** or **ductile irons** and some **alloy cast irons**. It provides compatible strength, ductility and toughness, coupled with good machinability.

The NiFe consumables can also be used on some of the high alloy **austenitic irons** (**Ni-Resist**). The flake graphite grades are welded with a preheat of 300-350°C but the SG grades are best buttered using low heat input, and low temperature techniques to avoid HAZ hot cracking.

Note the martensitic **Ni-Hard** cast irons and **white irons** are generally considered to be unweldable because they are too crack-sensitive.

The NiFe consumables are also suitable for welding **transition joints** between cast iron and cast steels, and cast iron and mild/low alloy steels.

Typical components are machine bases, pump bodies, engine blocks, gears and transmission housings.

#### Welding guidelines

Welding is often carried out without preheat but heavy multipass deposits or highly restrained joints may require preheat 150-250°C.

Prior to welding surfaces should be prepared by careful gouging and/or grinding using limited amounts of heat to avoid propagating cracks. The area to be welded should be cleaned as far as practicable from sand, oil, grease, paint or rust. Preheating can help to remove impregnated oil on used castings which are being repaired.

### DATA SHEET E-11

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If welding is carried out without preheat it is desirable to minimise the width of the HAZ by using a low heat input and low interpass temperature. A skip welding technique can be beneficial in helping to achieve this.

For thicker section welds and highly restrained welds preheat in the range 150-250°C may be necessary. Light peening to reduce contraction stresses can also be beneficial but care should be taken not to exhaust the ductility of the weld metal.

Buttering the joint faces, or sides of the repair cavity, prior to filling can also be desirable whether a preheat is used or not.

On completion of welding the workpiece should be allowed to cool slowly, using insulation if necessary.

#### **Additional information**

The NiFe weld metals produce higher strength than the pure nickel cast iron types and are therefore preferable for dissimilar joints, nodular irons and higher strength cast irons. The NiFe types are also less sensitive to hot cracking caused by pick-up of impurities such as phosphorus which are often present in castings. The low matrix contraction coefficient of NiFe is also enhanced in the higher carbon electrode deposits by expansion accompanying graphite precipitation and results in lower stresses in heavy repairs; the possibility of cold cracking is therefore reduced.

#### **Related alloy groups**

The pure nickel types (data sheet E-10) are also used for welding cast iron.

Process	Product	Specification
MMA	CI Special Cast NiFe	AWS ENiFe-CI
	CI-Met NiFe	AWS ENiFe-CI
MIG	55NiFe	BS NA47



	Gene	eral D	ata fo	or all	MMA	Elec	trod	es		
Storage	satisfactory. For electrod <b>Redry</b> 100 -	es that hav - 150°C/1	ve been exp -2h to resto	posed: ore to as-p	backed cond	lition. Ma	ximum 15	0° C, 3 cy	<ul> <li>Direct use from</li> <li>cles, 10h total.</li> <li>d): &lt; 60% RH, &gt; 18</li> </ul>	
Fume data	Fume comp	osition, w	t % typical	:						
		Fe	Mn	Ni	Cr	Cu	F	Ва	OES (mg/m <sup>3</sup> )	
		3.5	1	2	<0.2	<0.5	12	< 0.5	5	

## **CI SPECIAL CAST NiFe**

NiFe MMA electrode for most grades of cast iron

Product description	refinin	MMA electrode with special basic-graphite flux (no barium compounds) on a 55%Ni alloy core wire. refining action provides maximum resistance to cracking and freedom from porosity. Recovery is about 95% with respect to core wire, 70% with respect to whole electrode.												
Specifications		A5.15 N 1071 573		ЕC	Fe-CI NiFe-CI liFe-1 BC	-								
ASME IX Qualification	QW43	<b>32</b> F-No												
Composition (weld metal wt %)	min max typ	C  2.0 0.5	Mn  2.5 1.5	Si  2.0 0.5	S  0.03 0.010	P  0.03 0.00		Ni 45.0 60.0 55	Al  1.0 <0.1	Cu  2.5 <0.1				
All-weld mechanical properties		e strength Proof stre ation			N	1Pa 1Pa % HV	typical 400 230 10-12 170-200							
Operating parameters	DC +v ø mm min A max A	ve or AC	(OCV: 5	0V min) 2.5 60 80	)	3.2 70 110		4.0 90 150				Ê	Î	
Packaging data	ø mm length kg/cart pieces			2.5 305 13.5 618		3.2 355 15.0 450	1	4.0 355 15.0 297						

CI-MET NiFe		NiFe MMA electrode on bi-metallic core wire
Product description	Good refining action wire minimises the ris operability.	special basic-graphite flux (no barium compounds) on bi-metallic Fe clad Ni core wire. provides maximum resistance to cracking and freedom from porosity. The bi-metallic core sks of over-heating normally associated with NiFe MMA electrodes and produces excellent % with respect to core wire, 70% with respect to whole electrode.
Specifications	AWS A5.15 BS EN 1071 DIN 8573	ENiFe-CI E C NiFe-CI 1 (E NiFe-1 BG)
ASME IX Qualification	QW432 F-No	

# CI-MET NiFe (continued)

Composition		С	Mn	Si	S	Р	Fe	Ni	AI	Cu	
(weld metal wt %)	min						bal	45.0			
	max	2.0	2.5	2.0	0.03	0.03	bal	60.0	1.0	2.5	
	typ	0.5	1.5	0.5	0.010	< 0.01	42	55	< 0.1	<0.1	
All-weld mechanical	As welde	d				typical					
properties	Tensile st	rength			MPa	400					
	0.2% Pro	of stress			MPa	230					
	Elongatio	n			%	10-12					
	Hardness				HV	170-200	)				
Operating parameters	DC +ve o	or AC (O	CV: 50	V min)					U		
	ø mm			2.5	3	.2		4.0			
	min A			60	7	5		100			
	max A			80	12	20		155			
Packaging data	ø mm			2.5	3	.2		4.0			
	length mr	n		300	3:	50		350			
	kg/carton			13.5	15	5.0		15.0			
	pieces/ca	rton		789	4	58		300			

## 55NiFe

Solid MIG wire for welding cast irons

Product description	Solid w	vire for M	IG.												
Specifications	BS 29 BS EN DIN 85			NA47 S C NiFe (MSG Ni											
ASME IX Qualification	QW43	<b>2</b> F-No													
Composition		С	Mn	Si	S	Р	Ni	Fe	Cu	Со					
(wire wt %)	min						52.0	bal							
. ,	max	0.15	1.0	0.5	0.02	0.03	60.0	bal	0.5	2.0					
	typ	0.05	0.7	0.2	< 0.01	< 0.01	58	40	0.01	0.05					
All-weld mechanical	Typical	values as	welded			MIG (Ar-5%CO <sub>2</sub> )									
properties	Tensile	strength			MPa		400								
	0.2% P	roof stress	;		MPa		230								
	Elongation						24								
	Hardne	SS			HV		150								
Typical operating				MIG											
parameters	Shieldi	ng	Ar / A	r + 1-2%	$O_2 / Ar + 2$	2-25%C	D <sub>2</sub> / 100%	CO <sub>2</sub>							
	Current	t			DC	+									
	Diamet				1.2m										
	Parame	eters			200A,	28V									
Packaging data	ø mm				MIG										
	1.2				15kg spo	ool									
	1.6			15kg spo	ool										
Fume data	MIG fi	ime comp	osition, w	vt %:											
				Fe	Mn	Cr <sup>3</sup>	Ni	Cu	OES	S (mg/m <sup>3</sup> )					
				35	2	< 0.1	30	< 0.5		1.7					



# **Repair & Maintenance**

## **ARMOUR WELDING CONSUMABLES**

#### Alloy type

20%Cr-10%Ni-2.5%Mo weld metal composition designed for welding armour plate.

#### Materials to be welded

Armour plate: MVEE 816 (MoD) Armox 816 (Swedish Steel) **13%Mn (Hadfield steel):** Abro M (Cresuot) Red Diamond 14

Compass B555 (Sleeman) (Spartan Redheugh) < 0.4%C hardenable steels:

BS970 709M40 (En19), 817M40 (En24), 826M40 (En26), 897M39 (En40C), etc

#### Wear-resistant steels:

Hardox 400 & 500 (Swedish Steel) ARQ360, A-R-COL (Corus) Creusabro 4000, Abro 360 and 500 (Creusot) ABR 500 (Taysteel) Red Diamond 20, 21, 22 (Spartan Redheugh) **ASTM:** CF8M

Also for **dissimilar combinations** between the above and to standard **stainless steels** and **CMn steels**.

#### Applications

These consumables are well-established and approved for **armour welding**. They deposit a modified austenitic stainless weld metal with moderately high ferrite content, giving strong, tough and crack-resistant welds in many other **hardenable steels**, often without the need for preheat. Applications include **tanks**, other **military** and **security vehicles**, general engineering components.

They are also useful for welding many **wear and abrasion-resisting steels**, to avoid the need for 'hydrogen control' procedures, particularly for heavier sections and the harder types. In addition, the high **work-hardening** rate gives these welds good resistance to impact wear and scuffing. This feature can also be exploited for **overlays** combined with **corrosion** and **wet abrasion resistance**.

Although the resistance to gouging abrasion of **13%Mn Hadfield steel** is unique and arises from its extreme workhardenability, these consumables have a long and successful history for the build-up and reclamation of this steel. It is an economic ductile **buffer layer** prior to **hardfacing** with high alloy weld metals such as chromium carbide types.

#### Microstructure

Austenite with ferrite 10 – 25FN, typically about 20FN.

### DATA SHEET E-20

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#### Welding guidelines

Preheat not generally required for CMn and low alloy steels with up to 0.3%C. However 50-200°C is recommended progressively with increasing base material thickness, hardenability and restraint.

#### **Additional information**

Because of the high ferrite level (20 FN) and moderate carbon content (0.06%), these consumables are not suitable for cryogenic applications or structural service at temperatures exceeding about 300°C. Some loss of ductility will occur if weldments are post weld heat treated. They should not be confused with low carbon austenitic and duplex stainless alloys specifically designed for corrosion resistance. However, AWS A5.4 and A5.22 include the related E308MoL which may be used for ASTM CF3M castings when a higher ferrite type than 316L is required for improved stress-corrosion resistance.

These consumables are used successfully for steels which are judged 'difficult to weld' on the basis of their carbon equivalent (CE). For example, armour plate and En26 have  $CE \sim 1$ , potentially up to 1.36 maximum for classical armour with nominal 0.3%C-2%Cr-0.5%Ni-0.4%Mo. Some proprietary armour steels are leaner, with CE 1 max. The greatly hardened HAZ of these steels is only partially tempered in a multipass weldment, resulting in high sensitivity to hydrogen (cold) cracking. By using a specially balanced austenitic consumable this problem is avoided, because very little hydrogen can diffuse from the weld into the HAZ. It is still helpful to apply some preheat since this will encourage self-tempering and reduce peak HAZ hardness. However, the presence of a hardened HAZ should be considered in relation to service conditions.

#### **Related alloy groups**

There is no equivalent solid wire but the 307 types (data sheet E-21) provide the best alternative if required. For dissimilar joints etc. the 309L (B-50), 309Mo (B-51), 307 (E-21) and 29.9 types (E-22) may also be suitable.

Process	Product	Specification
MMA	Armet 1	AWS E308Mo-16
FCW	Supercore 20.9.3	AWS E308MoT0-4
	Supercore 20.9.3.P	AWS E308MoT1-4



ARMET 1					F	Rutile M	1MA ele	ectrod	le for we	lding armour plate
Product description	manufactured	l with lov	v hydrogen	technol	ogy to g	ive weld	metal wit	h low p	otential hy	resistance, designed and drogen content.
	Recovery is a	bout 110	% with res	pect to a	core wire	e, 65% wi	th respec	t to who	ole electrod	e.
Specifications	AWS A5.4 BS EN 1600 BS 2926 DIN 8556 Approvals:	)	E 20 (19.9. E 20	10 3 R 2	.6	ass 1A an	d 1B			
ASME IX Qualification	QW432 F-N	lo 5, <b>QV</b>	V442 A-N	lo 8						
Composition (weld metal wt %)	C           min         0.03           max         0.08           typ         0.06	2.5	Si  1.0 0.7	S  0.025 0.010	P  0.030 0.025	Cr 18.5 21.0 20	Ni 9.0 11.0 9.5	Mo 2.0 3.5 2.5	Cu  0.75 0.1	FN 10 25 15
All-weld mechanical properties	As welded Tensile streng 0.2% Proof st Elongation on Elongation on Reduction of a Impact energy Impact energy Hardness * Increases	ress 4d 5d area /	+ 20°C - 50°C - 400 – 450	N	IPa IPa % % J J HV	min 620 400  20     dening	typic: 670-7 > 52 > 22 > 25 > 55 > 45 220	80 0 4 5 5 5 5		
Operating parameters	DC +ve or A ø mm min A	C (OCV:	2.5 60		3.2 70		4.0 100		5.0 150	
Packaging data	max A ø mm length mm kg/carton pieces/carton		90 2.5 300 11.4 660		120 3.2 350 13.5 408		170 4.0 350 13.5 261		230 5.0 350 16.5 228	
Storage	for longer tha moisture pick For electrode <b>Redry</b> 200 – <b>Storage</b> of re	an a work -up and i s that hav 300°C/1- dried ele	cing shift o increase the ve been exp -2h to resto ctrodes at :	of 8h. E e risk of bosed: ore to as- 50 - 200	vcessive porosity packed o°C in ho	e exposure 7. condition	e of elect . Maxim en or heat	rodes to um 400 ted quiv	o humid con ° C, 3 cycle ver: no limit	es, 10h total. t, but maximum 6 weeks lid): < 60% RH, > 18°C.
Fume data	Fume compos	sition, wt	% typical:							
	-	Fe 8	Mn 5	Ni 1	C 4		Cu 0.2	F 16	OES (mg 1.2	/m³)



SUPERCORE	20.9	.3			Down	ihand r	rutile flu	IX core	d wire	for we	lding armour plate			
Product description	downh		norizont								m designed primarily for re is also suitable for all-			
	Metal	recovery	is appro	oximately	90% witl	n respect	to wire.							
Specifications	BS EN BS EN	Supercore 20.9.3         Supercore 20.9.3.P           AWS A5.22         E308MoT0-4         E308MoT1-4           BS EN ISO 17633-A         T 20 10 3 R M 3         T 20 10 3 P M 2           BS EN ISO 17633-B         TS308Mo-FM0         TS308Mo-FM1           Approvals:         MoD MVEE 1050 Class VII         MoD MVEE 1050 Class VII												
ASME IX Qualification	QW43	<b>32</b> F-No	6, <b>QW</b>	<b>1442</b> A-N	o 8									
Composition (weld metal wt %)	min max typ	C  0.08 0.06	Mn 0.5 2.5 1.2	Si  0.9 0.5	S  0.025 0.01	P  0.035 0.03	Cr 19.5 21.0 20	Ni 9.0 11.0 9.5	Mo 2.0 3.0 2.8	Cu  0.3 0.05	FN 10 25 17			
All-weld mechanical properties	0.2% F Elonga Elonga Impact Impact Hardne	e strength Proof streation on 4 tion on 5 energy energy ess	ss d d	+ 20°C - 50°C 400 - 450					cal 20 20 0 5 5 0 0 0 0 *					
Operating parameters	exceed The wi	l 85%. ire is suit	able for	use on 10 s as below amp-vol 130A-2:	0%CO₂t , with A trange_ 5V to 250	out with s r-20%CC	some loss $D_2$ (when u ty 1	of cosme	etic appea 2, voltage	arance ar es need to stick 15-2	ed but argon should not id increased spatter. b be increased by 2-3V): out 20mm 25mm			
Packaging data	The as Resista possibi	1.6       200A-28V to 330A-34V       230A-30V       15-25mm         Spools vacuum-sealed in barrier foil with cardboard carton:       12.5kg (1.2mm), 15.0kg (1.6mm)         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 preve 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 %)													
			F	e N	Лn	Ni	Cr <sup>3</sup>	Cr <sup>6</sup>	F	C	ES (mg/m <sup>3</sup> )			
	Ar+20%	%CO2			11	1	8	4	5		1.2			
	CO <sub>2</sub>		1	7	10	1	9.5	1	5		5			



# **Repair & Maintenance**

# **307 FOR DISSIMILAR WELDS**

#### Alloy type

Strong tough austenitic weld metal composition for dissimilar joints and buffer layers.

#### Materials to be welded

Dissimilar combinations of CMn, stainless, hardenable, wear-resistant and armour steels. Also suitable for 13% Mn manganese (Hadfield) steel.

#### **Applications**

**Mixed welding** applications including the welding of mild, stainless, hardenable, and armour steels to themselves or each other with or without preheat. Tolerance to dilution (resistance to hot cracking) is provided by the high manganese content, unlike armour welding and 309 types which depend on a high ferrite level. In some cases, they may offer an alternative to high nickel weld metal in joints between **cast iron** and **stainless steels**. Weldments subject to PWHT retain ductility with satisfactory toughness down to -50°C. Reasonable scaling resistance up to 850°C.

Can be used as **buffer layers** to weld or reclaim 13% Mn (Hadfield) steel used in rock crushing plant and earth moving equipment. Buffer layer work hardens and can be used as a base for **Workhard 13Mn** or **Methard 650** or **850**. Has also been found satisfactory as buffer layer on **cast iron** prior to hardsurfacing.

Use as **surfacing** consumable which work hardens from 200 to 400 HV, suitable for repair of **alloy rails**, **crossing parts**, **frogs** etc. without need for preheat, however, the work-hardening rate is lower than 13% Mn steel and overlays of more than 1 layer may suffer unacceptable collapse under heavy rolling loads. In this case they may be used as a buffer under Workhard 13Mn.

### DATA SHEET E-21

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#### **Microstructure**

Consists of austenite with approximately 5FN.

#### Welding guidelines

Preheat not generally required unless welding thick sections, except that HAZ properties of higher carbon hardenable steels should be taken into consideration in relation to service conditions.

When welding 13%Mn (Hadfield) steels in order to minimise embrittlement and cracking the work piece must be kept cool. This means that the following controls should be applied: no preheat, maximum interpass controlled to 150°C maximum, low heat input, small weld beads and cool with water if necessary.

#### **Related alloy groups**

For dissimilar joints etc. the 309L (B-50), 309Mo (B-51), armour welding consumables (E-20) and 29.9 types (E-22) may also be suitable.

Process	Product	Specification
MMA	MetMax 307R	AWS E307-26
	19.9.6Mn	BS EN E 18 8 Mn R
MIG	19.9.6Mn	BS EN G 18 8 Mn Si



## **General Data for all MMA Electrodes**

Storage	for longer than a moisture pick-up a For electrodes tha <b>Redry</b> 200 – 300° <b>Storage</b> of redried	working s and increa t have bee C/1-2h to d electrode	hift of 8h. ase the risk en exposed o restore to es at 50 –	Excessi of poros : as-packe 200°C in	ve exposi ity. d condition holding of	ure of elect on. Maxim	rodes to l um 400° ted quive	humid con C, 3 cycle r: no limi	use from tin is satisf nditions will cause es, 10h total. t, but maximum 6 v c lid): < 60% RH, >	some
Fume data	Fume composition	n, wt % ty	pical:							
		Fe	Mn	Ni	Cr	Cu	Мо	F	OES (mg/m <sup>3</sup> )	
	Metmax 307R	19	11	1	5	< 0.2	-	18	1	
	19.9.6Mn	18	15	1	5	< 0.2	-	18	1	

METMAX 307	R							R	utile hig	gh recov	ery MMA	electrode		
Product description		high rec s sound j				ctrode m	ade on h	iigh puri	ty steel c	core wire. N	loisture res	sistant coating		
	Recov	ery is abo	out 1509	% with re	espect to	core wire	e, 65% w	ith resp	ect to wh	ole electroc	le.			
Specifications	AWS BS EI DIN 8	N 1600			-26 9 Mn Mo r to E 18		PR 26							
ASME IX Qualification	QW43	QW432 F-No 5												
Composition (weld metal wt %)	min	C 0.04	Mn 3.3	Si 	S 	P 	Cr 18.0	Ni 9.0	Mo 0.5	Cu 				
	max typ	0.14 0.1	4.75 4.0	0.9	0.025	0.035	21.5 19	10.7 9.5	1.5 0.8	0.75				
All-weld mechanical properties	As wel	ded					min		typical	PWI 600°C				
	0.2% F	e strength Proof stre	SS			/IPa /IPa	590 350		660 475					
	Elonga	ation on 4 ation on 5	d			% %	30 25		40 36					
	Impact	tion of are energy energy	ea	+ 20° - 50°		% J J			45 85 70					
	Hardne	ess	a about			HV	 ening		210 *					
Operating parameters		ve or AC								$\square$		Î		
	ø mm			2.5		3.2		4.0		5.0				
	min A max A			70 115		90 155		130 210		160 260				
Packaging data	ø mm			2.5		3.2		4.0	I	5.0				
	length kg/cart	on		350 12.0		380 13.5		380 13.2	2	450 15.0				
	pieces	/carton		429		234		153	3	102				



19.9.6Mn							AI	l-positi	onal ruti	le coat	ed MM	A elec	trode	
Product description		electrode ty free de		on nearl	y matchi	ng austen	itic steel	core wi	re. Moistur	e resistai	nt coating	g ensure:	s sound	
	Recov	ery is abo	out 1109	% with re	espect to	core wire	e, 65% w	ith respe	ct to whole	electrod	e.			
Specifications	BS E	NS A5.4         similar to E307-16           S EN 1600         E 18 8 Mn R 3 2           N 8556         E 18 8 Mn R 26												
ASME IX Qualification	QW43	<b>W432</b> F-No -												
Composition		C Mn Si S P Cr Ni Mo												
(weld metal wt %)	min		4.5				17.0	7.0						
	max	0.20	7.0	0.80	0.025	0.035	20.0	10.0	0.75					
	typ	0.12	5.8	0.5	0.01	0.02	18	9	0.4					
All-weld mechanical	As wel	ded					typical							
properties	Tensile	e strength			Ν	ИРа	680							
		Proof stres			Ν	ИРа	480							
	0	ation on 4				%	35							
		tion of are	ea	$+20^{\circ}$	~	% J	40 80							
	Hardne	energy		$+20^{-0}$		HV	210	*						
		creases to	o about	400-450		1								
Operating parameters	DC +v	e or AC	(OCV: '	70V min	)				Ū			Ê	Î	
	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		350						
	kg/cart			12.0		14.1		15.0						
	pieces	/carton		621		372		261						



19.9.6Mn

Solid wire for MIG

Product description	Solid v	vire for N	1IG.									
Specifications	BS EN BS 29	AWS A5.9 BS EN ISO 14343-A BS 2901: Pt2 DIN 8556			Similar to ER307 (AWS ranges: 3.3-4.75%Mn, 19.5-22.0%Cr and 0.5-1.5%Mo) G 18 8 Mn 307S98 SG-X 15 CrNiMn 18 8 (1.4370)							
ASME IX Qualification	QW43	32 F-No										
Composition (wire wt %)	min max typ	C 0.04 0.14 0.08	Mn 5.5 7.5 6	Si 0.65 1.0 0.8	S  0.025 0.01	P  0.03 0.015	Cr 17.0 20.0 19	Ni 7.5 9.5 8.5	Mo  0.3 0.2	Cu  0.3 0.1		
All-weld mechanical properties	Tensile 0.2% F Elonga Elonga Reduct Impact	values a strength Proof stres tion on 40 tion of are energy energy ess cap/m	ss 1 1 2a	.d + 20°C - 50°C	N	IPa IPa % % J J HV	4 2 5 1	+ 5%CC 05 14 12 10 52 05 55 /210	02			
Typical operating parameters	Shieldi Curren Diamet Param * Othe	t ter eters		MIG Ar+5%C0 DC+ 1.2mm 220A, 20 elding gas	1 6V	uitable e	g. Ar+2%	0O2, Ar-	He mixt	ures etc		
Packaging data	ø mm 1.0 1.2			MIG 15kg spo 15kg spo								
Fume data	MIG fi	ume com	positior Fe	n (wt %): Mn	Ni	Cr	<sup>3</sup> N	10	Cu	OES (mg/m <sup>3</sup> )		
			30	26	3.5	12	<	0.5	< 1	3.8		



**F-22** 

# **Repair & Maintenance**

# 29.9 DISSIMILAR WELD METALS

#### Alloy type

Austenite-ferrite weld metal composition of nominally 29%Cr-9%Ni for dissimilar joints and difficult to weld steels.

#### Materials to be welded

Medium and high carbon hardenable steels, tool steels and free-cutting steels.

Eg. BS970 part 21: 080M40 (En8), 070M55 (En9), 709M40 (En19) etc.

#### Applications

Use for welding medium and high carbon hardenable steels, of known or unknown specifications, for example tool steels, shafts, gear teeth, free-cutting steels, dissimilar alloy combinations, buffer layers, overlays etc.

Combination of high alloy and high ferrite content (40-50FN) gives extreme tolerance to dilution on a wide range of hardenable and alloy steels with minimum or no preheat. It has also been found useful for welding **free-cutting steels** or those with a low Mn:S ratio (especially < 20 or so), where other weld metals may fail to prevent hot cracking due to liquation at the fusion boundary.

Weld deposit work-hardens and gives good wear and friction resistance.

Useful for resistance to corrosion and to high temperature scaling up to about 1000°C, but not recommended for structural applications above 300°C or for welds to be post-weld heat treated, owing to embrittlement.

Not recommended for filling up heavy joints nor for sub-zero applications or where high notch toughness is required. In these cases, it is generally best to use the electrode for buttering only (preheat if appropriate), then fill with a more ductile austenitic type (no preheat needed) according to required properties.

**DATA SHEET** 

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#### **Microstructure**

Duplex austenite-ferrite microstructure with about 40% ferrite.

#### Welding guidelines

Procedure will depend on base material. Preheat not normally required for small components and buffer layers, although desirable for thicker high carbon steels to avoid possible HAZ quench cracking and to control peak hardness, 100-250°C.

#### Additional information

Although 29.9 alloys have good resistance to high temperature oxidation, duplex high ferrite weld metal is subject to 475°C embrittlement above about 300°C and sigma embrittlement at higher temperatures. This alloy is therefore not used where high temperature structural service or PWHT is involved.

#### **Related alloy groups**

For dissimilar joints etc. the 309L (data sheet B-50), 309Mo (data sheet B-51), armour welding consumables (data sheet E-20) and 307 types (data sheet E-21) may also be suitable.

#### **Products available**

Process	Product	Specification
MMA	29.9 Super R	(AWS E312-17)
TIG/MIG/SAW	312S94	AWS ER312
Flux	SSB	BS EN SA AF2 DC
	SSCr	BS EN SA FB2
	LA491	BS EN SA FB255 AC

#### Rev 04 03/07



29.9 SUPER F	R							Acid I	rutile MMA e	electrode
Product description	MMA electrode	MMA electrode with acid rutile flux on matching 312 stainless steel core wire.								
	Recovery is about 100% with respect to core wire, 65% with respect to whole electrode.									
Specifications	AWS A5.4 BS EN 1600 BS 2926 DIN 8556		(E312-17) E 29 9 R 29.9.AR E 29 9 R	32						
ASME IX Qualification	QW432 F-No	5								
Composition (weld metal wt %)	C           min            max         0.15           typ         0.1	Mn S  1.5 1. 0.8 1	2 0.025	P  0.035 0.02	Cr 28.0 31.0 29	Ni 8.0 10.5 9.5	Mo  0.5 0.1	Cu  0.75 0.1		
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stres Elongation on 40 Elongation on 50 Reduction of are Hardness * Minimum elo A high tensile st may be altered u typically raises of	ss d d ea ongation re rength wi under conc	th moderate	ductility	is typical f	for mul	tipass all	-weld test sp		
Operating parameters	DC +ve or AC (	OCV: 50	V min)							Ì
	ø mm min A max A	1.6 25 45	2. 40 60	)	2.5 60 90		3.2 75 120	4.0 100 155	5.0 130 210	
Packaging data	ø mm length mm kg/carton pieces/carton	1.6 250 9.0 1389	2. 25 9.	0 0 3	2.5 300 12.0 642	3	3.2 350 3.8 435	4.0 350 14.1 276	5.0 350 13.5 168	
Storage	<ul> <li>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. For electrodes that have been exposed:</li> <li>Redry 200 – 250°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.</li> <li>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): &lt; 60% RH, &gt; 18°C.</li> </ul>									
Fume data	Fume compositi	ion, wt %	typical:							
		Fe 8	Mn 4	Ni 1	Cr 8	Cu 0.2	F 17		mg/m <sup>3</sup> ) .6	



312S94

Solid wire for MIG, TIG and SAW

Product description	Solid v	vire for TI	G, MIG	and SAW	Ι.						
Specifications	BS EN BS EN BS 29	AWS A5.9 BS EN ISO 14343-A BS EN ISO 14343-B BS 2901: Pt2 DIN 8556			4 0CrNi 30 9	9 (1.433	37)				
ASME IX Qualification	QW43	<b>2</b> F-No 6									
Composition		С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	
(wire wt %)	min		1.0	0.30			28.0	8.0			
	max	0.15	2.5	0.65	0.02	0.030	32.0	10.5	0.3	0.3	
	typ	0.1	1.8	0.4	0.005	0.02	30	9.3	0.1	0.1	
All-weld mechanical	Typical	values as	welded				TIG			MIG	
properties									Ar + 5%C0	<b>O</b> <sub>2</sub>	Ar + 2%O <sub>2</sub>
	Tensile strength				MPa				813		789
	0.2% Proof stress				MPa		640		628		638
	Ű	tion on 4d			%		21		25		10
	0	tion on 5d			%		19		24		10
	Reduction of area				%				31		10
		energy		+ 20°C	J	50					27
	Hardne	ess			HV		275		270		300
Typical operating				TIG		I	MIG		SAW		
parameters	Shieldi	ng		Ar *		Ar + 2-	5%CO <sub>2</sub> **	¢	SSB ***		
-	Curren	t		DC-			DC+		DC+		
	Diamet	er		2.4mm			1.2mm		2.4		
	Voltage			120A, 14		220A, 26V 350A, 3			350A, 30V	7	
	*				or root run						
	**							han Ar	$-2\%O_{2}$ (se	ee proper	ties above).
	***	SSCr (Cr	compe	ensating) a	und <b>LA491</b>	also sui	table.				
Packaging data	ø mm			TIG		ſ	MIG		SAW		
	1.2					15k	g spool				
	1.6			2.5kg tul	be				25kg coil		
	2.4			2.5kg tul					25kg coil		
	3.2			To orde	r						
Fume data	MIG fi	ime compo	osition	(wt %) (T	IG and SA	W fume	negligible	:)			
		F	e	Mn	Cr <sup>3</sup>	Ni	Мо	С	u OE	S (mg/m³)	
	1		0	12	22	9				2.3	

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#### Product description

Deoxidised pure copper.

#### Specifications

AWS A5.7	ERCu
BS EN 14640	S Cu 1898 / CuSn1
BS 2901 pt 3	C7
DIN 1733	(SG-CuSn / 2.1006)

**ASME IX Qualification** 

QW432 F-No 31

#### Materials to be welded

#### Oxygen free copper

BS grade C103, UNS C10200, ISO Cu-OF / Cu-OFS

#### Applications

100Cu produces a deoxidised pure copper deposit for maximum thermal and electrical conductivity.

Applications include plate for **chemical plant** and **moulds**, **stills** and **calorifiers**, rods and wires for **electrical components** and tubes for **heat exchangers**.

#### Welding guidelines

Apart from very thin material (<3mm thick) a preheat will be required. The required preheat will range from about 100°C at 6mm thick up to about 400/500°C for material 15mm thick.

#### All-weld mechanical properties

Typical as welded		TIG	
Tensile strength	MPa	200	
0.2% Proof stress	MPa	70	
Elongation on 4d	%	20	
Hardness	HV	60	



DATA SHEET E-30

## 100Cu

#### **Microstructure**

Single phase (fcc).

#### **Typical parameters**

	TIG	MIG	
Shielding	He *	Ar, He or Ar-He	
Current	DC-	DC+	
Diameter	2.4mm	1.2mm	
Parameters	250A, 15V **	300A, 28V **	

- \* Ar can also be used but He produces deeper penetration, permits higher travel speeds and allows preheat to be reduced.
- \*\* Higher currents will be required as material thickness increases, parameters given are suitable for material of about 6mm thickness.

#### Packaging data

ø mm	TIG	MIG	
1.2		15kg spool	
1.6	2.5kg tube		
2.4	2.5kg tube		

#### Storage

Recommended ambient storage conditions: <60% RH, >18°C.

#### **Related alloy groups**

The copper silicon wire (data sheet E-31) is also used for welding copper when a more highly deoxidised filler is required.

#### Fume data

Fume composition, wt % typical (TIG fume negligible):

Fe	Mn	Cr <sup>3</sup>	Ni	Мо	Cu	OES (mg/m <sup>3</sup> )
<1	2	<0.1	<0.1	<0.1	82	0.2

#### Composition (wire wt %)

	Cu	Mn	Si	Sn	Pb	Al	Fe	Ni	As	Sb	Р	Bi
min	98.0	0.10	0.10	0.5								
max	bal	0.50	0.50	1.0	0.010	0.01	0.03	0.10	0.05	0.005	0.015	0.003
typ	99	0.3	0.3	0.6	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05	< 0.005	< 0.01	< 0.003

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### DATA SHEET E-31

## 97CuSi

#### **Product description**

Pure copper deoxidised with 3% silicon.

#### **Specifications**

AWS A5.7	ERCuSi-A
BS EN 14640	S Cu 6560 / CuSi3Mn1
BS 2901 pt 3	C9
DIN 1733	SG-CuSi3 (2.1461)

#### **ASME IX Qualification**

QW432 F-No 32

#### Materials to be welded

General purpose including phosphorus deoxidised copper, silicon bronze, nickel silver and some brasses.

#### Applications

97CuSi silicon bronze has a wider range of general purpose applications than 100Cu, including overlaying of steels and cast irons.

Applications include plate for **chemical plant** and **moulds**, **stills** and **calorifiers**, rods and wires for **electrical components** and tubes for **heat exchangers**.

#### **Microstructure**

Single phase (fcc).

#### Welding guidelines

Preheat is not required when welding silicon bronze and interpass temperature should be kept below 100°C.

If welding copper then preheat of about 100°C will be required for 6mm material increasing up to about 400/500°C for 15mm thick material.

#### Composition (weld metal wt %)

	Cu	Mn	Si	Sn	Pb	Al	Fe	Ni	Р
min	bal	0.75	2.8						
max	bal	1.25	4.0	0.2	0.020	0.01	0.10	0.10	0.020
typ	96	0.9	3	0.1	0.002	< 0.01	0.04	< 0.01	< 0.01

#### All-weld mechanical properties

Typical as welded		TIG
Tensile strength	MPa	320
0.2% Proof stress	MPa	105
Elongation on 4d	%	34
Hardness	HV	85

#### **Typical parameters**

	TIG	
Shielding	Ar or He	
Current	DC- *	
Diameter	2.4mm	
Parameters	200A, 15V	

AC with argon provides optimum arc cleaning action.

#### Packaging data

ø mm	TIG	
2.4	2.5kg tube	

#### Storage

Recommended ambient storage conditions: < 60% RH, >18°C.

#### **Related alloy groups**

The pure copper wire (data sheet E-30) is used for welding copper when optimum thermal or electrical conductivity is required.

#### Fume data

Fume composition, wt % typical (TIG fume negligible):

Fe	Mn	Cr <sup>3</sup>	Ni	Мо	Cu	OES (mg/m <sup>3</sup> )
<1	5	< 0.1	<0.1	< 0.1	80	0.3



E-33

92CuSn

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#### Product description

Tin bronze alloy wire for welding similar tin bronze (phosphor bronze) alloys.

#### **Specifications**

(ERCuSn-C)
S Cu 5210
(C11)
(SG-CuSn6 / 2.1022)

#### **ASME IX Qualification**

92CuSn QW432 F-No 33

#### Materials to be welded

Up to 10%Sn+0.5%P. BS PB101-
103, UNS C50100-C52400.
BS LG3, LG4, LPB1,
(but >5% Pb leaded types difficult).
Cu + 20-25% Sn.
Cu + 40%Zn, manganese bronze.

#### Applications

This wire is used for welding a range of copper base alloys to themselves and to CMn steels or cast irons, and also for the **repair** and **joining** of **castings**.

It is also suitable, if low dilution is achieved, for weld **surfacing** to give a bearing surface and/or corrosion resistant **overlay** on **steel components**, **shafts** etc. Stainless steels should be avoided because chromium pick-up causes embrittlement.

#### **Microstructure**

A multi phase copper base structure with complex eutectoids.

#### Welding guidelines

The tin bronze weld metal tends to be sluggish because of its wide melting range. Preheating to about 200°C can help improve fluidity when welding thick sections. To avoid hot cracking it is desirable to keep the interpass temperature below 200°C.

#### Composition (wire wt %)

DATA SHEET

	Cu	Sn	Pb	AI	D	Zn	Fe
		-		AI	F	Zn	ге
min	bal	7.0			0.1		
max	bal	9.0	0.02	0.01	0.4	0.1	0.1
typ	92	7.8	0.01	< 0.01	0.1	< 0.1	< 0.1

#### All-weld mechanical properties

Typical as welded		TIG	
Tensile strength	MPa	344	
0.2% Proof stress	MPa	154	
Elongation on 5d	%	58	
Hardness	HV	86	

#### **Typical parameters**

	TIG	
Shielding	Ar	
Current	DC-	
Diameter	2.4mm	
Parameters	250A, 15V	

#### **Packaging data**

ø mm	TIG	
1.6	2.5kg tube	
2.4	2.5kg tube	

#### Storage

Recommended ambient storage conditions: < 60% RH, >18°C.

#### **Fume data**

Fume composition, wt % typical (TIG fume negligible):

Fe	Mn	Cr <sup>3</sup>	Ni	Мо	Cu	OES (mg/m <sup>3</sup> )
<1	<1	< 0.1	< 0.1	< 0.1	80	0.3

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# **Product description**

9% Al bronze for welding similar 5-11% Al alloys.

#### **Specifications**

AWS A5.7	ERCuAl-A2
BS EN 14640	S Cu 6180 / CuAl10
BS 2901 pt 3	C13
DIN 1733	SG-CuAl8, SG-CuAl10Fe

#### **ASME IX Qualification**

QW432 F-No 36

Tel:

#### Materials to be welded

Aluminium bronze:	UNS C61400, BS CA101-103, BS 1400 AB1 (cast), Alloy D.
Beryllium copper:	Cu + 0.5-2%Be; closest strength.
Brass:	Cu–Zn.
Aluminium brass:	eg. Yorkalbro Cu-22%Zn-2%Al.
Manganese bronze:	Cu + 20-45%Zn + 1-3%Mn.
Silicon bronze:	Cu + 1-3.5%Si,
	(also see data sheet E-31).

#### Applications

For welding 5-11% Al bronzes plus other copper alloys as listed above. For brasses the weld colour is similar and the presence of aluminium in the filler helps to suppress zinc volatilisation during welding.

It can also be used to overlay CMn steels and cast irons to give wear and corrosion resistant bearing surfaces, or to join these to most copper base alloys.

Applications include corrosion resistant and spark resistant pumps, castings, machinery parts, heat exchangers for offshore, marine and mining equipment.

#### **Microstructure**

In the as-welded condition consists of a duplex  $\alpha + \beta$ microstructure.

#### Welding guidelines

For aluminium bronze alloys preheat is not required and maximum interpass temperature should be 200°C.

When welding brass a preheat of 100-300°C should be



DATA SHEET E-36

## 90CuAl

used on thicker sections, the lower preheat temperatures being used for the high-zinc brasses.

Although this wire is suitable for many dissimilar combinations of copper and ferrous alloys, care is necessary to minimise dilution by high chromium alloys such as stainless steels. The limited tolerance to chromium pick-up may cause embrittlement and cracking especially if bend tests are applied. In this situation low heat input buttering is beneficial.

#### Composition (wire wt %)

	Cu	Al	Zn	Fe	Si	Pb	Ni	Mn
min	86	8.5		0.5				
max	bal	11.0	0.02	1.5	0.10	0.007	1.0	1.0
typ	90	9	< 0.01	1.0	0.02	0.004	0.03	0.1

#### All-weld mechanical properties

Typical as welded		TIG	
Tensile strength	MPa	550-615	
0.2% Proof stress	MPa	250-350	
Elongation on 4d	%	21	
Reduction of area	%	25	

#### **Typical parameters**

	TIG	MIG
Shielding	Ar	Ar, He or Ar-He
Current	AC	Pulsed
Diameter	2.4mm	1.2mm
Parameters	250A, 15V	235A, 25V (mean)

#### Packaging data

ø mm	TIG	MIG	
1.2		15kg spool	
2.4	2.5kg tube		

#### Storage

Recommended ambient storage conditions: < 60% RH, >18°C.

#### Fume data

Fume composition, wt % typical (TIG fume negligible):

Fe	Mn	Cr	Ni	Мо	Cu	OES (mg/m <sup>3</sup> )
3	1	<0.1	<0.1	<0.1	80	0.3

Beryllium has a very low OEL  $(0.002 \text{mg/m}^3)$  so special precautions may be required when welding beryllium coppers.

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# METRODE \_\_\_\_\_

DATA SHEET E-37 80CuNiAI

#### **Product description**

Cu-9%Al-5%Ni bronze for welding similar nickel aluminium bronze alloys.

#### **Specifications**

AWS A5.7	ERCuNiAl
BS EN 14640	S Cu 6328 / CuAl9Ni5
BS 2901 pt 3	C26 (C20 also similar)
DIN 1733	(SG-CuAl8Ni6)

#### **ASME IX Qualification**

QW432 F-No 37

#### Materials to be welded

- **ASTM** C63200, C63000 (CA630), C95800 (cast), C95500 (cast), C95520 (cast).
- **BS** CA104, CA105, AB2 (cast), Alloy E.
- DIN 2.0966 (CuAl10Ni), 2.0978 (CuAl11Ni), 2.0970 (G-CuAl10Ni), 2.0980 (G-CuAl11Ni).
- MoD DGS 1043 Grade 2.

#### Applications

This wire deposits nickel aluminium bronze and is suitable for welding wrought and cast parent materials of similar composition. These alloys have high strength and resistance to stress corrosion, cavitation erosion, corrosion fatigue, and attack by acids and chlorides.

Applications include corrosion resistant and spark resistant pumps, ship propellers, heat exchangers for offshore, marine and mining equipment.

#### **Microstructure**

In the as-welded condition consists of a duplex  $\alpha + \beta$  microstructure.

#### Welding guidelines

For aluminium bronze alloys preheat is not required and maximum interpass temperature should be 150°C. Resistance to hot cracking in thick sections with high restraint is said to be inferior to plain aluminium bronze. Am alternative is to fill with higher ductility aluminium bronze (data sheet E-36) and cap with 80CuNiAl.

#### Composition (wire wt %)

	Cu	Al	Ni	Fe	Mn *	Si	Zn	Pb
min	bal	8.50	4.00	3.0	0.60			
max	bal	9.50	5.50	5.0	3.50	0.10	0.10	0.02
typ	82	9.3	4.2	3.3	0.8	< 0.01	< 0.01	< 0.01

\* DIN has 1.0-2.0%Mn.

#### All-weld mechanical properties

Typical as welded		TIG	
Tensile strength	MPa	740	
0.2% Proof stress	MPa	400	
Elongation on 4d	%	19	
Reduction of area	%	23	
Hardness	HV	220	

#### **Typical parameters**

	TIG	MIG	
Shielding	Ar	Ar, He or Ar-He	
Current	AC	Pulsed	
Diameter	2.4mm	1.2mm	
Parameters	250A, 15V	235A, 25V (mean)	

#### Packaging data

ø mm	TIG	MIG	
1.2		15kg spool	
2.4	2.5kg tube		

#### Storage

Recommended ambient storage conditions: < 60% RH, >18°C.

#### Fume data

Fume composition, wt % typical:





E-45

# Nickel Base Alloys

# ALLOY C

#### Alloy type

Alloy C is a Ni-15%Cr-16%Mo-4%W-5%Fe nickel base alloy.

#### Materials to be welded

cast

ASTM	A494 CW-12MW
	A743/A744 CW-12M
DIN	2.4883 (G-NiMo16Cr)

Also used for surfacing and overlays.

#### **Applications**

The weld deposit composition matches cast alloy C with Ni-15%Cr-16%Mo-4%W-5%Fe. Wrought forms of this alloy (C276) have low C and Si, see data sheet D-30. Cast versions of the alloy typically have higher carbon and silicon (like the original wrought alloy C which is now obsolete) but repair welds are usually solution treated for optimum corrosion resistance.

A controlled level of carbon raises strength and response to work-hardening. These properties extend to elevated temperatures, and with good resistance to impact and thermal fatigue the weld metal finds extensive use for surfacing or build-up of hot-work forging dies, especially where large volumes of weld metal must be deposited economically. It is also used as a buffer layer prior to surfacing with more exotic nickel or cobalt base alloys.

Although these consumables are not intended for aggressive chemical plant applications this alloy has intrinsically high resistance to general corrosion, pitting attack and stress corrosion in high chloride environments such as seawater. It is useful for corrosion resistant overlays especially when combined with erosion or cavitation. These properties are also exploited for site repairs without preheat on high strength martensitic stainless steels used for hydro turbines.

DATA SHEET

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#### **Microstructure**

Solid solution strengthened high nickel austenite with some carbides and microsegregation typical of asdeposited weld metal.

#### Welding guidelines

Preheat is not generally required but may be necessary for higher carbon hardenable steels. For best corrosion resistance interpass temperature should be kept below 150°C and heat input restricted to 1.5kJ/mm.

#### **Related alloy groups**

Alloy C276 (D-30), alloy 59 (D-31) and alloy C22 (D-32) are also NiCrMo.

Process	Product	Specification
MMA	Nimrod C	BS EN: E Ni2
	Nimax C	BS EN: E Ni2



# General Data for all Alloy C Electrodes

Storage	<ul> <li>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. For electrodes that have been exposed:</li> <li>Redry 200–250°C/1-2h to restore to as-packed condition. Maximum 350° C, 3 cycles, 10h total.</li> <li>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): &lt;60% RH, &gt;18°C</li> </ul>										
Fume data	Fume compo	sition, wt	% typical:								
		Fe Mn Ni Cr Mo Cu F OES (mg/m³)									
	1 4 10 5 5 0.2 16 1										

NIMROD C		Rutile alloy C electrode primarily used for surfacing										
Product description	MMA electrode manufactured on special nickel-chromium core wire, with an alloyed basic-rutile flux core primarily used for surfacing and cladding; for joining applications the Nimrod C276KS (data sheet D-preferred.											
	Recovery is about	Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.										
Specifications	BS EN 14700 DIN 8555 AWS A5.11	E23-UM-200-CKT										
ASME IX Qualification	QW432 F-No 44											
Composition (weld metal wt %)	-	An Si 0.4 0.6	S 0.01	P 0.01	Cr 15	Ni 56	Mo 15.5	W 3.5	Fe 5.5	V 0.1	Cu 0.05	Co 0.05
All-weld mechanical properties	As welded Tensile strength 0.2% Proof stress			MPa MPa	min * 495 275		typical 715 510					
	Hardness	Elongation on 4d       %       4       18-30         Hardness       Cap/mid       HV        230/255       Work hardens to about 450HV.         * Minimum properties are for ASTM A494 CW-12MW castings which are solution treated at 1120°C + WQ.										
Operating parameters	DC +ve or AC (O	CV: 70V r	nin)							Ų	$\checkmark$	
	ø mm	2.5	i	3.2			4.0					
	min A max A	60 90		75 120			100 155					
Packaging data	ø mm	2.5		3.2			4.0					
	length mm kg/carton	260 12.		310 12.9			310 13.5					
	pieces/carton	657		339			234					



NIMAX C		High recovery alloy C electrode primarily used for surfacing											
Product description	MMA electrode	with s	special m	netal po	wder rutil	e- basic f	flux co	ating on h	nigh cor	nductivit	y pure r	nickel cor	e wire.
	Recovery is about	Recovery is about 150% with respect to core wire, 65% with respect to whole electrode.											
Specifications	BS EN 14700 DIN 8555 AWS A5.11	<b>DIN 8555</b> E23-UM-200-CKT											
ASME IX Qualification	QW432 F-No 4	4											
Composition	С	Mn	Si	S	Р	Cr	Ni	Мо	W	Fe	V	Cu	Со
(weld metal wt %)	typ 0.05	0.8	0.7	0.01	0.02	16	56	16.5	3.6	5.5	0.1	0.05	0.05
All-weld mechanical	As welded					min *		typical					
properties	Tensile strength				MPa	495		680					
	0.2% Proof stress Elongation on 4d				MPa %	275 4		540 10-25					
	Hardness				HV			240	W	ork hard	ens to a	bout 450	HV.
	* Minimum prop	oerties	s are for	ASTM	A494 CW	/-12MW	castin	gs which	are solu	ution trea	ated at 1	120°C +	WQ.
Operating parameters	DC +ve										U		
	ø mm		5.0										
	min A		160										
	max A		260										
Packaging data	ø mm		5.0										
	length mm		450										
	kg/carton		18.0										
	pieces/carton		102										



# **Repair & Maintenance**

## **350 HARDFACING**

#### Alloy type

Martensitic hardfacing alloy producing a deposit of nominally 350HV hardness.

#### Materials to be welded

These consumables are used for surfacing not joining. They can be used for surfacing many materials including structural steels (BS 4360), general purpose cast steels (BS 3100) and rail steels (BS 11).

#### Applications

These consumables deposit weld metal with a hardness in the range 380-410HV; actual hardness depends on base metal composition and number of layers deposited.

The deposit gives a wear resistant crack-free deposit suitable for conditions of moderate abrasion and friction coupled with resistance to heavy impact.

Items suitable for surfacing include slideways,

### DATA SHEET E-50

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trackwheels, rails, roller guides, couplings, brake drums and shoes, rope winches, caterpillar tracks, and clutch plates and cones.

#### **Microstructure**

In the as-deposited condition the microstructure consists of martensite with some carbides.

#### Welding guidelines

Preheat is not normally required but 100-200°C may be required with thick and/or complex sections particularly with low alloy base materials or where there is a risk of hydrogen-induced cracking.

Process	Product	Specification
MMA	Methard 350	(BS EN EFe1)
FCW	Hardcore 350	BS EN TFe1

METHARD 35	0			350HV hardness MMA electrode for surfacing							
Product description		MMA surfacing electrode with a rutile metal powder type flux made on low carbon core wire. Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.									
Specifications	DIN 8555 BS EN 14700	)	E1-UM-400 (E Fe1 neare								
ASME IX Qualification	QW432 F-No	)									
Composition (weld metal wt %)	typical 0.3		Si 0.2	Cr 3	Mo 0.1						
All-weld mechanical properties	Vickers Rockwell Brinell	HV HRC HB	380-410 39-42 360-390			ild steel base plate: but will have little effect in subsequent layers.					



# **METHARD 350 (continued)**

Operating parameters	DC +ve or AC (O	CV: 70V min)			
	ø mm	3.2	4	.0	5.0
	min A	80	1	00	140
	max A	140	1	80	240
Packaging data	ø mm	3.2	4	.0	5.0
	length mm	450	4	50	450
	kg/carton	18.6	18	8.9	18.0
	pieces/carton	471	2	34	147
Storage	satisfactory. For electrodes that <b>Redry</b> 100 – 150°	t have been exp C/1-2h to resto	bosed: bre to as-pack	ked cond	arton, with unlimited shelf life. Direct use from tin is dition. Maximum 150° C, 3 cycles, 10h total. for opened tins (using plastic lid): < 60% RH, > 18°C.
Fume data	Fume composition	, wt % typical:	:		
	Fe	e Mn	Cr	F	OES (mg/m <sup>3</sup> )
	16	5	1	18	5

HARDCORE 3	50							Self-shielded flux cored wire for surfacing					
Product description				ed wire fo an extern			cation	s in the flat a	nd HV p	ositions. The lime-fluorspar flux fill			
	Metal	Metal recovery about 90% with respect to wire.											
Specifications		DIN 8555         MF1-GF-350-GP           BS EN 14700         T Fe1											
ASME IX Qualification	QW43	QW432 F-No											
Composition (weld metal wt %)	typ	C 0.25	Mn 2	Si 0.1	Cr 1	Mo 0.2	Al 1.7						
All-weld mechanical properties	Vickers Rockw Brinell	Typical hardness as-welded assuming at least three layers on mild steel base plate:         Vickers       HV       300-400         Rockwell       HRC       30-36         Brinell       HB       280-400         Preheat and dilution will affect hardness in the first two layers but will have little effect in subsequent layers.											
Operating parameters		elding g nt: DC+		s as belov amp-vo 150-250 200-300		0V		stickout 40-50mi 40-50mi 40-50mi	n				
Packaging data				ton: 13kg ed storage		ons are (	50% F	RH max, 18°	C min.				
Fume data	Fume	composi	tion (wt	%)									
			Fe	Mn	Ni		Cr	Cu	F	OES (mg/m <sup>3</sup> )			
			18	8	<0.5	5	1	<1	8	5			



# **Repair & Maintenance**

## 650 HARDFACING

#### Alloy type

Martensitic alloy for hardfacing producing a deposit of nominally 650HV hardness.

#### Materials to be welded

These consumables are not used for joining they are used for surfacing/hardfacing applications. They can be used for hardfacing many materials including structural steel (BS 4360), wear resisting steel, high strength cast steel (BS 3100 & BS 1504), and Hadfield 13%Mn steel.

#### Applications

These consumables give a hardfacing deposit with a hardness in the range 53-59 HRC dependent upon parent material dilution and the number of layers.

It is particularly suitable for resistance to abrasion but will withstand a reasonable amount of impact damage and battering.

Typical applications are **bulldozer blades**, **excavator teeth**, **crusher jaws**, **buckets**, **scrapers** and **swing hammers** in conditions of severe abrasion from soil, sand and crushed minerals, coupled with the risk of impact from large rocks and compacted materials.

#### Microstructure

In the as-deposited condition the microstructure consists of martensite with some carbides.

### DATA SHEET E-51

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#### Welding guidelines

Preheat is not normally required but 100-200°C may be required with thick and/or complex sections particularly with low alloy base materials or where there is a risk of hydrogen-induced cracking.

For substantial build-ups on plain carbon or CMn steels 350 types (data sheet E-50) should be used as a buffer layer to reduce the risk of cracking or spalling.

#### Additional information

The combination of a 307 type (data sheet E-21) buffer with two or more layers of 650 has proved to be particularly successful for excavation and crushing equipment in cement plants in areas where the high stress abrasion resistance of 13%Mn steel is inadequate.

#### **Related alloy groups**

The 350 surfacing consumables (data sheet E-50) are used for less abrasion resistant applications where better impact resistance is required. The chromium carbide types (data sheet E-55) are used for more severe abrasion applications.

#### **Products available**

Process	Product	Specification
MMA	Methard 650	(BS EN EFe2)
	Methard 650R	(BS EN EFe2)
FCW	Hardcore 650	BS EN TFe2

Storage	satisfactory For electroc <b>Redry</b> 100	les that hav – 150°C/1·	ve been exp 2h to resto	posed: ore to as-pa	acked cond	lition. Max	ximum 15	shelf life. Direct use fi 0° C, 3 cycles, 10h total. g plastic lid): < 60% RH, 3	
Fume data	Fume comp	osition, wt	% typical	:					
		Fe	Mn	Cr	Мо	V	F	OES (mg/m <sup>3</sup> )	
		20	6	2.5	0.1	0.5	18	2	

## **General Data for all MMA Electrodes**



METHARD 65	MMA hardfacing electrode producing a nominal 650HV hardness deposit											
Product description	Rutile metal powd	er flux on a lo	w carbon core	wire.								
	Recovery is about	Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.										
Specifications	DIN 8555 BS EN 14700		M-60-GP 2 nearest)									
ASME IX Qualification	QW432 F-No											
Composition (weld metal wt %)	Ctypical0.7		Si Cr 0.4 8	Mo 0.6	V 0.5							
All-weld mechanical properties	Typical hardness a Vickers HV Rockwell HRC	1 lay 600-7										
	Preheat and dilution	n will affect h	ardness in the f	ïrst two lay	yers but will	have little effect in subsequent layers.						
Operating parameters	DC +ve or AC (OC	CV: 45V min)				U 🖉 🖻 🔒 🏛						
	ø mm	3.2	4.0		5.0							
	min A	80	100		140							
	max A	140	180		240							
Packaging data	ø mm	3.2	4.0		5.0							
	length mm	450	450		450							
	kg/carton	18.6	18.6		19.5							
	pieces/carton	387	246		171							

## **METHARD 650R**

### High recovery MMA hardfacing electrode of nominal 650HV hardness

Product description	Rutile high recovery metal powder flux made on pure low carbon core wire.Recovery is about 160% with respect to core wire, 65% with respect to whole electrode.			
Specifications	DIN 8555 BS EN 14700	E6-UM-60- (E Fe2 near	-	
ASME IX Qualification	QW432 F-No			
Composition (weld metal wt %)		Mn         Si           0.3         0.8	Cr         Mo           8         1	V 0.6
All-weld mechanical properties	Typical hardness as-w	elded on mild stee 1 layer	l base plate: 3 layers	1 layer on high carbon steel
	Vickers HV Rockwell HRC	560-600 53-55	620-680 56-59	580-640 54-57
	Preheat and dilution will affect hardness in the first two layers but will have little effect in subsequent layers. The weld metal will retain its hardness up to about 450°C but then softens markedly at temperatures in the range 550-700°C.			



## METHARD 650R (continued)

Operating parameters	DC +ve or AC (O	CV: 45V min)	[	Ū ☑ <		
	ø mm	2.5	3.2	4.0	5.0	
	min A	70	80	100	140	
	max A	110	140	180	240	
Packaging data	ø mm	2.5	3.2	4.0	5.0	
	length mm	320	380	380	450	
	kg/carton	12.0	13.8	13.2	15.0	
	pieces/carton	606	255	162	102	

HARDCORE 6	Self-shielded flux cored wire of nominal 650 hardness										
Product description	Self-shield flux cored wire for surfacing applications in the flat and HV positions. The tubular wire has a lime-fluorspar flux fill which eliminates the need for an external shielding gas.										
	Metal recovery about 90% with respect to wire.										
Specifications	DIN 8555         MF2-GF-55-GP           BS EN 14700         T Fe2										
ASME IX Qualification	QW432 F-No										
Composition (weld metal wt %)	C         Mn         Si         Cr         Mo         Al           typical         0.8         2         0.8         2.5         0.2         1.7										
All-weld mechanical properties	Typical all-weld metal hardness:VickersHV $600-700$ RockwellHRC $55-60$ BrinellHB $620-680$ Typical single layer hardness on mild steel = 45 HRC.										
Operating parameters	No shielding gas is required.Current: DC+ve ranges as below:ø mmamp-volt rangestickout1.2150-250A, 20-26V40-50mm1.6200-300A, 24-30V40-50mm										
Packaging data	Spools in cardboard carton: 13kg Where possible, preferred storage conditions are 60% RH max, 18°C min.										
Fume data	Fume composition (wt %)										
	Fe Mn Ni Cr Cu F OES (mg/m <sup>3</sup> )										
	18         7         <0.5										



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MMA electrode with basic metal powder type flux made on carbon steel core wire. Electrode coating is designed to give sound porosity-free deposits coupled with smooth operation. Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.

#### **Specifications**

AWS A5.13	EFe5-B
DIN 8555	E4-UM-60-ST
BS EN 14700	E Fe4

#### **ASME IX Qualification**

QW432 F-No 71

#### Materials to be welded

Various tool steels.

Used for surfacing mild or low alloy steel blanks.

#### **Applications**

This electrode gives a Mo alloyed high speed tool steel deposit with hot hardness (up to 600°C), good toughness and crack resistance (similar to AISI M1).

Used for the reclamation, repair and modification of high speed cutting and machining tools in either the aswelded, tempered or rehardened condition. New tools can be manufactured by overlaying mild or alloyed steel blanks, annealing to facilitate machining, quenching and tempering to required hardness.

Applications include cutting and piercing tools, dies and drills, punches and knives, ingot tongs etc.

#### **Microstructure**

In the as-welded condition the microstructure consists of partially tempered martensite with carbides and some retained austenite, which is reduced if double tempered.

#### Welding guidelines

It is possible to weld without preheat provided the electrodes are properly dried but preheats on the range 100-200°C will be necessary in thick or complex sections and when welding hardenable steels.

## DATA SHEET E-53 METHARD 750TS

For machining the weld metal can be annealed (800°C + furnace cool) otherwise grinding is necessary. Rehardening is carried out by preheating slowly to 800°C then raising to 1200°C for 5 minutes followed by air or oil quenching (brittle condition); final temper can then be carried out to achieve required hardness.

As-welded properties can be improved by tempering or double tempering. During heat treatment precautions should be taken against decarburisation.

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Cr	Мо	W	V
max	0.9	0.6	0.8	0.03	0.03	5.0	9.5	2.5	1.3
typ	0.6	0.5	0.4	0.01	0.02	4	8	1.7	1.1

#### All-weld mechanical properties

Typical hardness:

	HRC	HV
As welded	62	750
Annealed (800°C + FC)	<25	<270
Tempered (550°C/2 + AC)	60-65	700-850

#### Parameters

DC +ve or AC	C (OCV: 6	0V min)	Ų	
ø mm	2.5	3.2	4.0	
min A	70	90	130	
max A	115	155	210	

#### Packaging data

		-	-
ø mm	2.5	3.2	4.0
length mm	350	380	380
kg/carton	11.7	12.6	13.2
pieces/carton	420	246	177

#### Storage

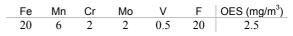
**3 hermetically sealed ring-pull metal tins** per carton, with unlimited shelf life. Direct use from tin is satisfactory.

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**: Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH,  $> 18^{\circ}$ C.

#### Fume data





# **Repair & Maintenance**

## **CHROMIUM CARBIDE HARDFACING**

#### Alloy type

Chromium carbide hardfacing.

#### Materials to be welded

These consumables are not used for joining they are used for surfacing/hardfacing applications. They can be used for hardfacing many materials including structural steel (BS 4360), wear resisting steel, high strength cast steel (BS 3100 & BS 1504), and Hadfield 13%Mn steel (with appropriate buffer layer).

#### **Applications**

These consumables produce high carbon, high chromium, chromium carbide deposits with high hardness and resistance to extreme abrasion. They also exhibit high temperature stability with good oxidation resistance up to about 1000°C (although hot hardness above about 450°C is inferior to cobalt types); also have moderate corrosion resistance.

Used for earth moving and dredging equipment, steel works equipment, sinter plants, cement works, sizing screens, augers, rolling mill guides, pump impellers, augers and feed screws; which are handling abrasive sands and sludges under conditions of extreme abrasion but limited impact.

#### **Microstructure**

In the as-welded condition the microstructure consists of an austenitic alloy matrix (bulk hardness 500-600HV) and chromium/complex carbides (approximate hardness 1500HV).

#### Welding guidelines

Use with a stringer bead technique or a wide weave for

#### DATA SHEET E-55

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maximum coverage. Thermal contraction stresses will normally cause some cold cracking (stress-relief checking). Preheating to 200-450°C and slow cooling can minimise surface cracking but not eliminate it.

Build-ups should be restricted to two layers or a maximum of three (8mm maximum build-up). For large build-ups on low alloy steels, or any hardfacing on 13%Mn Hadfield steel, a buffer layer of 307 (data sheet E-21) should be used.

#### **Additional information**

Deposits are non-machinable or heat-treatable but can be ground. With the MMA electrodes a weave/wash technique produces a very smooth glass like surface which is highly resistant to fine hard powder abrasion.

Hardness figures are quoted for all the products but these only provide a guide to expected performance, because of the complex nature of the chromium carbide weld deposit. Chromium carbide types have greater resistance to high stress abrasion than martensitic types of equivalent hardness.

#### **Related alloy groups**

For lower abrasion resistance but better impact properties the 650 hardfacing types (data sheet E51) are used. The cobalt hardfacing types (data sheet E65) have superior hot hardness.

**Products available** 

Process	Product	Specification
MMA	Methard 850	BS EN EFe14
	Methard 950	BS EN EFe14
FCW	Hardcore 850	BS EN TFe15
	Hardcore 950	BS EN TFe15

## **General Data for all MMA Electrodes**

Storage	<ul> <li>3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory. For electrodes that have been exposed:</li> <li>Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 350° C, 3 cycles, 10h total.</li> <li>Storage: Recommended ambient storage conditions for opened tins (using plastic lid): &lt; 60% RH, &gt; 18°C.</li> </ul>							
Fume data	Fume composition	n, wt % tyj	pical:					
		Fe	Mn	Cr	Мо	V	F	OES (mg/m <sup>3</sup> )
		25	4	12	2	0.5	3	0.4



Draduat description	MMA alastas da	::41	4:1	.1	an taun a flaar						
Product description		MMA electrode with a rutile metal powder type flux coating on a pure low carbon core wire. Moisture resistant coating giving freedom from porosity.									
	Recovery is abo	ut 175%	with res	pect to	core wire.						
Specifications	DIN 8555 BS EN 14700										
ASME IX Qualification	QW432 F-No -	-									
Composition	С	Mn	Si	Cr	Mo+Nb+\	V+W					
(weld metal wt %)	typ 3	0.8	1	25	2						
All-weld mechanical	Typical hardness on mild steel:										
Properties			1 la	yer	2 layers	3 layers					
	Vickers	HV	450-	500	600-700	650-750					
	Rockwell	HRC	45-	50	55-60	58-62					
	Actual hardness is dependent upon base material composition, number of layers, cooling rate and welding conditions.										
Operating parameters	DC +ve or AC (	DC +ve or AC (OCV: 70V min)									
	ø mm		3.2		4.0	5.	0				
	min A		110		150	19	0				
	max A		160		220	28	0				
Packaging data	ø mm		3.2		4.0	5.	0				
	length mm		380		380	45	0				
	kg/carton		13.2		13.2	15	.0				
	pieces/carton		213		153	10	5				

<b>METHARD 95</b>	0			M	MMA electrode producing a chromium carbide deposit						
Product description		MMA electrode with a rutile metal powder type flux coating on a pure low carbon core wire. Moisture resistant coating giving freedom from porosity.									
	Recovery is about 175% with respect to core wire.										
Specifications	DIN 8555         E10-UM-65-G           BS EN 14700         E Fe14										
ASME IX Qualification	n QW432 F-No										
Composition (weld metal wt %)	Ctyp4	Mn 1.2	Si         Cr         Mo+Nb+V+W           1         34         3								
All-weld mechanical properties	Typical hardness Vickers Rockwell Actual hardness conditions.	HV HRC	1 la 475- 48-	575 54	2 layers 675-750 56-62 e material com	3 layers 700-850 60-66 nposition, number	of layers, cooling rate and welding				
Operating parameters	DC +ve or AC (OCV: 70V min)										
	ø mm		3.2		4.0	5.0					
	min A		110		150	190					
	max A		160		220	280					
Packaging data	ø mm		3.2		4.0	5.0					
	length mm		380		380	450					
	kg/carton		13.5		13.8	15.9					
	pieces/carton		252		159	108					



			Data	For a	all FC	W				
Operating parameters	No shielding ga	ıs is req	uired.							
	Current: DC+v	ve range	es as below	<i>!</i> :						
	ø mm		amp-vol	t range		sticko	out			
	1.6		200-300	)A, 24-30	V	40-50	)mm			
Packaging data	Spools in cardb Where possible		U		ns are 60%	RH max,	18°C min			
Fume data	Fume composit	ion (wt	%)							
		Fe	Mn	Ni	Cr <sup>3</sup>	Cr <sup>6</sup>	Cu	F	OES (mg/m <sup>3</sup> )	
		35	7	1	13	5	<1	12	1	

## **HARDCORE 850**

## Self-shielded hardfacing flux-cored wire

Product description	Self-shield flux cored wire for surfacing applications in the flat and HV positions. The tubular wire has a lime-fluorspar flux fill which eliminates the need for an external shielding gas. Nominal 60HRC deposit is produced which is non-machinable.
Specifications	Metal recovery about 90% with respect to wire.       DIN 8555       MF10-GW-60-G
	BS EN 14700 T Fe15
ASME IX Qualification	QW432 F-No
Composition	C Mn Si Cr
(weld metal wt %)	Typical         4.8         2.7         1.7         22
All-weld mechanical	Typical all-weld metal hardness on mild steel:
properties	55-59 HRC
	Actual hardness dependent on base material, number of layers, cooling rate and welding conditions. Maximum deposit thickness 8mm.

HARDCORE 9	Self-shielded hardfacing flux-cored wire
Product description	Self-shield flux cored wire for surfacing applications in the flat and HV positions. The tubular wire has a lime- fluorspar flux fill which eliminates the need for an external shielding gas. Nominal 60HRC deposit is produced which is non-machinable. Metal recovery about 90% with respect to wire.
Specifications	DIN 8555         MF10-GW-65-G           BS EN 14700         T Fe15
ASME IX Qualification	QW432 F-No
Composition (weld metal wt %)	C         Mn         Si         Cr           typ         5         3         1.5         27
All-weld mechanical properties	Typical all-weld metal hardness on mild steel:         57-60 HRC         Actual hardness dependent on base material, number of layers, cooling rate and welding conditions.         Maximum deposit thickness 8mm (2-3 layers).



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MMA electrode with rutile metal powder type flux made on carbon steel core wire. Electrode coating is designed to give sound porosity-free deposits coupled with smooth operation. Recovery is about 200% with respect to core wire, 65% with respect to whole electrode.

#### **Specifications**

DIN 8555	E10-UM-65-G
BS EN 14700	E Fe16

#### Materials to be welded

Surfacing of mild and low alloy steels.

#### Applications

This electrode gives a high alloy complex chromium carbide deposit to produce very high hardness, resistance to extreme abrasion and thermal stability up to 600°C, coupled with reasonable corrosion resistance. The deposit is not machinable but can be ground if necessary.

Used for equipment in contact with hot metal, slag and hot gases at temperatures in excess of 600°C. For applications requiring high resistance to thermal shock one of the cobalt based Cobstel types should be considered. For ambient temperature applications Methard 850 or 950 (E-55) are more economic alternatives.

Used for surfacing slag crushers, ore processors, furnace guides, rollers and moulds, in the steel, ceramic, cement, pottery and glass industries.

#### **Microstructure**

In the as-welded condition the microstructure consists of an austenitic alloy matrix (bulk hardness 500-600HV) and a large proportion of chromium and complex alloy carbides (1500-2000HV).

#### Welding guidelines

Preheat to 200-450°C and slow cool to minimise surface cracking. Use a stringer bead or wide weave for maximum coverage.

## DATA SHEET E-58 METHARD 1050

Build-up is normally limited to 2 layers (maximum 3). Surface crazing or cracking (checking) is normal but can be minimised by preheating and slow cooling. For large build-ups or any surfacing on 13%Mn steels use a buffer layer of a 307 type (data sheet E-21).

#### Composition (weld metal wt %)

	С	Mn	Si	Cr	Mo+Nb+V+W	
typ	4.5	0.2	1	28	12	

#### All-weld mechanical properties

Typical hardness:

	HRC	HV
As welded	62-66	750-850

These values are for guidance only actual hardness is dependent on base material, number of layers, cooling rate and welding conditions.

#### Parameters

DC +ve or AC (OCV: 70V min)



ø mm	3.2	4.0	5.0
min A	110	150	190
max A	160	220	280

#### Packaging data

ø mm	3.2	4.0	5.0
length mm	380	380	450
kg/carton	12.6	12.6	15.3
pieces/carton	183	114	81

#### Storage

**3 hermetically sealed ring-pull metal tins** per carton, with unlimited shelf life. Direct use from tin is satisfactory.

For electrodes that have been exposed:

**Redry** 150–250°C/1-2h to restore to as-packed condition. Maximum 350° C, 3 cycles, 10h total.

**Storage**: Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

#### Fume data

Fe	Mn	Cr	Мо	V	F	OES (mg/m <sup>3</sup> )
25	4	12	2	0.5	3	0.4

#### **Product description**

MMA electrode with basic metal powder type flux made on low carbon steel core wire. Electrode coating is designed to give sound porosity-free deposits coupled with smooth operation. Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.

#### **Specifications**

AWS A5.13	EFeMn-B
DIN 8555	E7-UM-200-KP
BS EN 14700	E Fe9

#### **ASME IX Qualification**

QW432 F-No 71

#### Materials to be welded

13%Mn Hadfield steel.

Used for surfacing other steels using a suitable buffer layer.

#### **Applications**

This electrode deposits a fairly soft ductile weld metal which rapidly work hardens under heavy impact and battering to become wear and abrasion resistant. The parent steel, developed by Hadfield in 1883, is the oldest alloy steel and its resistance to gouging abrasion is exceptional and unique.

Used for the reclamation, surfacing and joining of 13%Mn steel. Applications include dredger, bucket and grab tips; hammers and rolls in crushing plants; various equipment in quarries and other mineral extraction industries. Also used for rail track points, crossings and frogs; and prison bars.

#### **Microstructure**

In the as-deposited condition the microstructure consists of a soft manganese alloy austenite which rapidly work hardens under impact loading.

#### Welding guidelines

C and Mo are carefully controlled to minimise the risk of carbide embrittlement but the weld metal and particularly base material are susceptible to embrittlement when exposed to temperatures in the range 370-590°C. To minimise embrittlement and



## DATA SHEET E-60 WORKHARD 13Mn

cracking the weld and work piece must be kept cool (below 150°C). Use no preheat, low heat inputs, small weld beads and cool with water, swabs or air blasts if necessary.

A buffer layer, such as MetMax 307R, should be used prior to surfacing mild or alloy steels with WorkHard 13Mn. MetMax 307R should also be used as a buffer to avoid the need for large multi-pass deposits of WorkHard 13Mn.

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Cr	Мо
min	0.5	11.0	0.3				0.6
max	0.9	16.0	1.3	0.03	0.03	0.5	1.4
typ	0.8	13	0.6	0.01	0.02	0.2	1

#### All-weld mechanical properties

Typical hardness:

	As deposited	Work Hardened	
Brinell, HB	170-220	380-550	
Vickers, HV	180-230	400-580	
Rockwell	87-96 HRB	41-54 HRC	

#### Parameters

DC  $\pm$ ve or AC (OCV: 70V min)

ø mm	3.2	4.0	5.0	
min A	80	100	140	
max A	140	180	240	

#### Packaging data

		-	-
ø mm	3.2	4.0	5.0
length mm	380	450	450
kg/carton	15.0	16.5	16.8
pieces/carton	357	219	147

#### Storage

**3 hermetically sealed ring-pull metal tins** per carton, with unlimited shelf life. Direct use from tin is satisfactory.

For electrodes that have been exposed:

**Redry**  $150 - 250^{\circ}$ C/1-2h to restore to as-packed condition. Maximum  $350^{\circ}$  C, 3 cycles, 10h total.

**Storage**: Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

#### Fume data

Fe	Mn	Cr	F	OES (mg/m <sup>3</sup> )
19	23	0.1	10	2.2

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MMA electrode with rutile type flux made on special cobalt alloy core wire. Electrode coating is designed to give sound porosity-free deposits coupled with smooth operation and low dilution. Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

#### Specifications

AWS A5.13	ECoCr-A
DIN 8555	E20-UM-45-CTZ
BS EN 14700	(E Co2 nearest)

#### **ASME IX Qualification**

QW432 F-No --

#### Materials to be welded

Used for surfacing mild, low alloy and stainless steels; and also for nickel base alloys.

Can also be used for the repair of UNS R30006, Stellite 6 (Deloro Stellite).

#### Applications

This is the most widely used cobalt base type and combines good abrasion resistance with resistance to corrosion, erosion and thermal shock. It also has excellent resistance to galling, sliding friction and compression at all temperatures.

It is used to surface valves and valve seats, hot shear blades, punches and dies, ingot tong ends and equipment for handling hot steel. Used for cat cracker slide valves in petrochemical industry. Also finds applications in a very wide range of industries including steel, cement, marine and power generation.

#### **Microstructure**

In the as-welded condition the microstructure consists of a cobalt based austenite with a number of carbides and other complex phases.

#### Welding guidelines

For smoothest operation DC+ve or AC should be used, but for minimum dilution DC-ve is preferable.

Preheat in the range 100-300°C or higher with slow



#### DATA SHEET E-65

## COBSTEL 6

cooling may be required to avoid the risk of cracking in multi-run deposits and/or highly restrained conditions.

Deposits are machinable with carbide tools and may be finished by grinding where necessary.

#### Composition (weld metal wt %)

	С	Mn	Si	Cr	Ni	Мо	W	Fe	Со
min	0.7			25.0			3.0		bal
max	1.4	2.0	2.0	32.0	3.0	1.0	6.0	5.0	bal
typ	1.2	0.2	0.8	28	2	< 0.5	4.5	3	60

#### All-weld mechanical properties

Typical as-welded hardness:

Terreneratione	Vialtara	Dealuvall	
Temperature	Vickers	Rockwell	
°C	HV	HRC	
+20	350-440	35-45	Dependent on dilution
+400	320	32	
+600	280	28	
+800	230	22	
+900	200		

Although the hardness reduces steadily with temperature oxidation resistance is good to in excess of 1000°C.

#### **Parameters**

DC ±ve or AC (OCV: 50V min)



ø mm	2.5	3.2	4.0	
min A	70	90	130	
max A	115	155	210	

#### Packaging data

ø mm	2.5	3.2	4.0
length mm	300	350	350
kg/carton	13.5	13.8	13.5
pieces/carton	594	333	267

#### Storage

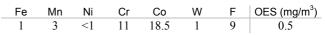
**3 hermetically sealed ring-pull metal tins** per carton, with unlimited shelf life. Direct use from tin is satisfactory.

For electrodes that have been exposed:

**Redry**  $150 - 250^{\circ}$ C/1-2h to restore to as-packed condition. Maximum 350° C, 3 cycles, 10h total.

**Storage**: Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

#### Fume data



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MMA electrode with rutile type flux made on special cobalt alloy core wire. Electrode coating is designed to give sound porosity-free deposits coupled with smooth operation and low dilution. Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

#### **Specifications**

AWS A5.13	ECoCr-E (anticipated)
UNS	W73021
DIN 8555	E20-UM-300-CKTZ
BS EN 14700	E Co1

#### Materials to be welded

Used for surfacing mild, low alloy and stainless steels; and also for nickel base alloys.

Can also be used for the repair of similar base materials (UNS R30021, Stellite 21 - Deloro Stellite, and BS 3146 ANC 14 castings) although it is optimised for surfacing not joining.

#### **Applications**

This low carbon cobalt base type combines good high temperature strength with high ductility. The improved ductility provides better resistance to weld cracking than the high carbon types. It has high resistance to corrosion, oxidation and sulphidation; good resistance to cavitation-erosion and resists thermal shock better than high carbon types. Galling resistance is inferior to high carbon types but bed-in properties are better.

It is used to surface valves and valve seats, hot shear blades, hot work dies, ingot tong ends and equipment for handling hot steel. Used for cat cracker slide valves in petrochemical industry. Also finds applications in a very wide range of industries including steel, cement, marine and power generation.

#### Microstructure

In the as-welded condition the microstructure consists of a cobalt based austenite with a number of carbides and other complex phases.

#### Welding guidelines

For smoothest operation DC+ve or AC should be used, but for minimum dilution DC-ve is preferable.

## METRODE \_\_\_\_\_

DATA SHEET E-66

## COBSTEL 8

Preheat not required, but advisable for first layer when deposited on hardenable alloy steels. Interpass control to ~200°C maximum is advisable to minimise possible hot cracking in heavy multipass deposits.

Deposits are machinable with carbide tools and may be finished by grinding where necessary.

#### Composition (weld metal wt %)

	С	Mn	Si	Cr	Ni	Мо	W	Fe	Со
min	0.2			24.0	2.0	4.5			bal
max	0.4	2.0	1.0	29.0	4.0	6.5	0.50	5.0	bal
typ	0.3	0.2	0.6	26	3	5.5	< 0.1	3	60

#### All-weld mechanical properties

#### Typical as-welded hardness:

Temperature, °C	Vickers, HV	Rockwell, HRC				
+20	320	30				
+400	210					
+600	170					
+800	110					
+900	100					

The as-deposited room temperature hardness can be increased to 450HV (44HRC) by work hardening.

#### Parameters

DC ±ve or AC (OCV: 50V min)

1 1 1	

ø mm	3.2	4.0	
min A	90	130	
max A	155	210	

#### Packaging data

		-
ø mm	3.2	4.0
length mm	350	350
kg/carton	13.5	13.5
pieces/carton	384	279

#### Storage

**3 hermetically sealed ring-pull metal tins** per carton, with unlimited shelf life. Direct use from tin is satisfactory.

For electrodes that have been exposed:

**Redry**  $150 - 250^{\circ}$ C/1-2h to restore to as-packed condition. Maximum  $350^{\circ}$  C, 3 cycles, 10h total. **Storage**: Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

#### Fume data

							OES (mg/m <sup>3</sup> )
1	4	1	10	19	1	9	0.5

#### Product description

Solid TIG wire.

**Specifications** 

No national specifications.

**ASME IX Qualification** 

QW432 F-No --.

#### Materials to be welded

Matching base materials.

Surfacing of numerous ferrous base materials and repair of tool steels.

#### Applications

As-deposited weld metal hardness allows easy machining, with a hardness of ~500HV being achieved following a low temperature PWHT of 450-480°C (maraging). Dimensional changes during maraging are minimal, allowing machining to nett size prior to hardening. Nitriding and maraging can be carried out simultaneously using gaseous ammonia, enabling surface hardnesses of ~900HV to be obtained. Typical repair applications include **cutting tools, stamping dies, die-casting moulds etc**.

#### **Microstructure**

As-deposited: low carbon partially tempered martensite. Following PWHT: tempered and age-hardened martensite with traces of austenite.



#### DATA SHEET E-68

## **MAR 250**

#### Welding guidelines

Preheat dependent on base material being welded. PWHT, normally 450-480°C, required to achieve full strength and hardness (for some applications maraging can occur during service eg. moulds).

#### Composition (wire wt %)

	С	Mn	Si	S	Р	Ni	Со	Мо	Ti	AI
max	0.03	1.0	0.5	0.02	0.03	20.0	9.0	5.5	0.6	0.2
				0.01						

#### All-weld mechanical properties

		As welded	PWHT	
Hardness	HV	300-350	500-550	

#### Typical parameters

	TIG
Shielding	Ar
Current	DC-
Diameter	2.4mm
Parameters	140A, 12V

#### Packaging data

ø mm	TIG	
2.4	2.5kg tube	

#### Storage

Recommended ambient storage conditions: < 60% RH, >18°C.

#### Fume data

Fume composition, wt % typical (TIG fume negligible):

Fe	Mn	Cr	Ni	Co	Мо	OES (mg/m <sup>3</sup> )
						2



## **Repair & Maintenance**

## **CMn STEELS**

#### Alloy type

Consumables for welding mild and CMn steels of 340-510MPa tensile strength.

#### Materials to be welded

- API 5L grades A, B, X42, X52, X60.
- ASTM/ASME A36; A106 grades A, B &C; A139; A210 grades A1 & C; A234 grade WPB; A334 grade 1
- **BS EN** 10025 grades S235 & S275
- **BS** 1449 pt 1 grades 1-15 & 34/20-43/25; 3059, 3601 & 3602 grades 320 & 360; 4360 grades 43 & 50; 1501 grades 151 & 161
- DIN St37; St44; St50; St52.

#### Applications

Used for a diverse range of applications in **general engineering and fabrication**, **pipework** and **pressure vessel** fabrication. The flux cored wire also finds widespread use in **ship** and **bridge building**.

#### DATA SHEET E-70

METRODE PRODUCTS LTD HANWORTH LANE, CHERTSEY SURREY, KT16 9LL Tel: +44(0)1932 566721 Fax: +44(0)1932 565168 Sales Fax: +44(0)1932 569449 Technical Fax: +44(0)1932 566199 Export Email: info@metrode.com Internet: http://www.metrode.com

#### Microstructure

Predominantly ferrite.

#### Welding guidelines

Preheat and PWHT would often not be required but actual requirements will depend on grade and thickness of base material being welded.

#### **Related alloy groups**

The 1%Ni consumables (data sheet A-40) are used for applications requiring better low temperature impact properties.

#### **Products available**

Process	Product	Specification
TIG	ER70S-2	ER70S-2
	ER70S-3	ER70S-3
	ER70S-6	ER70S-6
FCW	Metcore DWA 50	E71T-1M

## General Data for all Solid Wires

Storage	Recommend	Recommended ambient storage conditions: <60% RH, >18°C.								
Typical operating parameters	Shielding Current Diameter Voltage		TIG           Ar           DC-           2.4mm           150A, 15V							
Fume data	Fume compo	sition, wt	% typical	(TIG fum	e negligible	e):				
		Fe	Mn	Cr <sup>3</sup>	Ni	Мо	Cu	OES (mg/m <sup>3</sup> )		
	-	53	7	< 0.1	< 0.1	0.1	1.2	5		



ER70S-2											N	1ild ste	el TIC	G wire
Product description	'triple contam particul	deoxidi inated plarly fol	sed'. Tolate. O lowing	This is wing to PWHT.	claimed the high Also su	his wire h to have h levels of hitable for during s	advant f deoxic subseq	ages fo dants so	or rimm	ing or s ipitatior	emi-kill may oc	ed steel	ls and 1 nultipas	rusty or s welds
Specifications	AWS A BS EN BS 290 DIN 85	l 1668 01: Pt1		ER70 (W27 A15 (WS0	Γi)									
ASME IX Qualification	QW432 F-No 6, QW442 A-No 1													
Composition (wire wt %)	min max typ	C  0.07 0.05	Mn 0.90 1.40 1.2	Si 0.40 0.70 0.5	S  0.025 0.01	P  0.025 0.01	Cu  0.4 0.1	Al 0.05 0.15 0.08	Ti 0.05 0.15 0.10	Zr 0.02 0.12 0.05	Ni  0.15 0.04	Cr  0.15 0.04	Mo  0.15 0.01	V  0.03 0.005
All-weld mechanical properties	Tensile 0.2% P Elongat Impact Hardne	strengt roof stre tion on 4 energy ss cap/r	ess Id mid	- 30°	-	MPa MPa % J HV larly after	min 480 400 22 27  PWHT		typical 620 550 23 30* 220/240					
Packaging data	ø mm 1.2 1.6 2.4 3.2			TIC 5kg t 5kg t 5kg t 5kg t	ube ube ube									

ER70S-3										N	lild steel	TIG wire
Product description				re for TIG		a highe	er carbo	on double d	leoxidise	ed wire	with Mn a	nd Si which
Specifications	AWS A BS EN BS 29 DIN 85	l 1668 01: Pt1		ER70S-3 (W2Si) (A17) (WSG1)								
ASME IX Qualification	QW43	<b>2</b> F-No 6	, <b>QW</b> 4	142 A-No	1							
Composition (wire wt %)	min max typ	C 0.06 0.15 0.1	Mn 0.90 1.40 1.1	Si 0.45 0.70 0.6	S  0.025 0.01	P  0.025 0.01	Cu  0.4 0.1	Ni  0.15 0.04	Cr  0.15 0.04	Mo  0.15 0.01	V  0.03 0.005	
All-weld mechanical properties	Tensile 0.2% P Elongat Impact	values as strength roof stress tion on 4d energy ess cap/mi	3	- 30°C	MPa MPa % J HV	40 2 2	30 00 2	typ 540 460 34 180 170/200				
Packaging data	ø mm 1.6 2.4			TIG to order to order								



ER70S-6										Ν	Aild stee	I TIG wire
Product description				re for TIG. widing reli				purpose fil	ler wire	e, double	deoxidised	l with higher
Specifications		l 1668 01: Pt1		ER70S-6 (W3Si1) A18 (WSG2)								
ASME IX Qualification	QW43	<b>2</b> F-No 6	, <b>QW</b>	442 A-No	01							
Composition (wire wt %)	min max typ	C 0.06 0.12 0.08	Mn 1.40 1.60 1.5	Si 0.80 1.15 0.85	S  0.025 0.015	P  0.035 0.01	Cu  0.4 0.15	Ni  0.15 0.04	Cr  0.15 0.04	Mo  0.15 0.01	V  0.03 0.005	
All-weld mechanical properties	Typical Tensile 0.2% P Elonga Impact	values as strength roof stres tion on 4d energy ess cap/mi	s welded		MPa MPa %	I I I I I I I I I I I I I I I I I I I	nin 480 400 22 27 	typ 575 445 34 180 175/220				
Packaging data	ø mm 1.6 2.4 3.2			TIG 5kg tube 5kg tube 5kg tube								



## **METCORE DWA 50**

#### All-positional CMn rutile flux cored wire

Product description	position single-s typicall	ns, includ sided wel ly < 5ml/1	ing posi ds on ce 100g.	itional p eramic b	ipework acking s	The waystems.	vire is des	igned f	for stand	ard mild	easy operation in all we and CMn steels. Suitab eld metal hydrogen conto	ole for
Specifications	Metal r AWS A BS EN BS 708	758	90% wit	E71T T 422								
ASME IX Qualification		<b>2</b> F-No 6	, <b>QW</b> 4	142 A-1	No 1							
Composition		C	Mn	Si	S	Р	Cr	Ni	Мо	V		
(weld metal wt %)	min											
(	max	0.08	1.75	0.90	0.03	0.04	0.20	0.50	0.30	0.08		
	typ	0.05	1.2	0.5	0.01	0.01	< 0.1	0.1	0.1	0.02		
All-weld mechanical properties	As welded (PWHT with caution)						min *		as-we	typica Ided	al 600°C/4h	
properties		strength	i mai o	aatony		MPa	510-650		58		575	
		roof stres	s			MPa	420		51		485	
	Elongat	tion on 4d				%	22		29	)	32	
	-	tion on 5d				%	18		25	;	30	
	Reducti	ion of area	а			%			70	)		
	Impact	energy			0°C	J			15		140	
				- 20	0°C	J	27		90		45	
	Hardne	SS				HV			20	0		
	* As specified by AWS A5.20 E71T-1M as-welded. Since toughness may be reduced by PWHT, batch testin (to order) is advised to confirm specific requirements.										esting	
Operating	Shieldi	na aas. 8	30%Ar-2	20%CO	at 20-2	51/min I	Proprietary	v gases	may be	used but	argon should not exceed	80%
parameters		t: DC+ve					- <u>F-10</u> (M)	. 6				/ (
	ø mm		č	1	volt rang	ie.		typic	al		stickout	
	1.2				800A, 10				A, 26V		15-25mm	
Packaging data	The as- Resista possibil	Spools supplied in 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 p 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.										nt an <u>y</u>
Fume data	Fume c	ompositio	on (wt %	6)								
		r		=e	Mn	Cr	N	i	Cu	F	OES (mg/m <sup>3</sup> )	
				36	10	<0.1	<0.	1	< 0.5	2	5	

#### Product description

Special low strength MMA electrode made with a basic low hydrogen coating on pure iron core wire. Moisture resistant coating gives weld metal hydrogen content <5ml/100g.

Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.

#### **Specifications**

#### AWS A5.1 E6018

**ASME IX Qualification** 

QW432 F-No 1, QW442 A-No 1.

#### Materials to be welded

Mild and CMn steels.

#### Applications

Ultramild gives a soft, ductile low strength weld metal designed to absorb high shrinkage strains and minimise the build-up of residual stresses. It is a basic low hydrogen electrode with the lowest levels of alloying, microalloying and deoxidation compatible with satisfactory radiographic quality, resulting in ductile weld metal of about 300MPa yield strength.

Applications include **repair** of fabrication-induced cracks in CMn and low alloy steels, **buttering** layers to avoid lamellar tearing in areas of high restraint, **restrained root runs** under adverse conditions of low ambient temperature (-20°C) and minimal or no preheat, and welding of **steel conductor rails** requiring **high electrical conductivity**.

#### **Microstructure**

In the as-welded and PWHT conditions, the microstructure consists of low strength ferrite.

#### Welding guidelines

Preheating requirements will be dependent on the grade and thickness of the base material.

#### Additional information

Although Ultramild has tensile properties which match those of the commonly used low strength grades of structural and pressure vessel steels, it would not normally be chosen for the complete welding of highly stressed or pressure containment welds. It can, however be used to advantage in the repair of such welds particularly in root areas, buttering layers, and the filling of deep grooves where the high restraint can be absorbed in the weld metal and so minimise the risk of cracking. The bulk of the joint can be completed using the usual higher strength consumable without any loss in performance resulting from the use of Ultramild.

### DATA SHEET E-71

## **ULTRAMILD**

#### Composition (weld metal wt %)

	С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	Nb	V
min											
max	0.03	0.6	0.4	0.015	0.020	0.10	0.30	0.10	0.10	0.05	0.05
typ	0.02	0.4	0.3	0.010	0.010	0.02	0.05	0.01	0.03	0.01	0.01

#### All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	430	460
0.2% Proof stress		MPa	330	370
Elongation on 4d		%	22	33
Elongation on 5d		%		29
Impact energy	+ 20°C	J		200
	- 20°C	J		100
	- 30°C	J	27	45
Hardness cap/mid		HV		160/150

#### Parameters

DC +ve or AC (OCV: 70V	min)	U	∕∕ ⊂ 🔒 🛍
ø mm	3.2	4.0	
min A	80	100	
max A	140	180	

#### Packaging data

ø mm	3.2	4.0
length mm	380	450
kg/carton	15.0	18.0
pieces/carton	408	264

#### Storage

**3 hermetically sealed ring-pull metal tins** per carton, with unlimited shelf life. Direct use from tin will give **hydrogen** <5ml/100g weld metal during 8h working shift.

For electrodes that have been exposed:

**Redry** 250-300°C/1-2h to ensure  $H_2 <10ml/100g$ , 300-350°C/1-2h to ensure  $H_2 <5ml/100g$ . Maximum 420°C, 3 cycles, 10h total.

**Storage** of redried electrodes at 100-200°C in holding oven or 50-150°C in heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, >18°C.

#### Fume data

Fe	Mn	Ni	Cr	Cu	Pb	F	OES (mg/m <sup>3</sup> )
15	3	< 0.1	< 0.1	< 0.1	< 0.1	17	5





#### **Product description**

MMA electrode with a special rutile alumino-silicate flux on high purity mild steel core wire. In common with E6013 type electrodes, the as-deposited weld metal hydrogen may exceed a hydrogen potential of 15ml/100g. Metal recovery is about 95% with respect to core wire, 65% with respect to whole electrode.

#### **Specifications**

No relevant national specifications, nearest AWS A5.1 E6013.

#### **ASME IX Qualification**

QW432 F-No-, QW442 A-No-.

#### Materials to be welded

Low silicon steels. BS 2858. Armco iron.

#### Applications

Nilsil deposits mild steel weld metal with a very low silicon content of 0.10% maximum. It is designed specifically for the fabrication and repair of hot-dip zinc galvanising baths and lead pots. The steels used for these applications are usually either Armco iron, aluminium killed or rimming steel which are almost silicon free.

A low silicon content is necessary to resist corrosion/erosion by molten zinc at the operating temperature of 450-500°C, particularly at the molten metal/air interface. Residual zinc may also attack pots used for molten lead. Weld metals with more than 0.10% silicon are particularly subject to attack and at 0.4% silicon a four-fold increase would be typical. Manganese in the weld metal is also held at the optimum of about 0.5%.

Nilsil is also recommended for welding articles made from low silicon galvanising steels intended for subsequent bright zinc coating. Welds of a higher silicon content can give a dull and uneven surface.

#### Additional information

In the process of hot-dip galvanising, a thin bonding layer of Fe-Zn alloy is formed at the steel interface. Silicon content of the steel has a controlling influence on the Fe-Zn reaction and coating quality. Modern zinc baths may have about 0.1%Ni added to improve brightness of coatings on higher silicon steels.

#### Microstructure

Ferritic.

#### DATA SHEET E-72

## NILSIL

#### Composition (weld metal wt %)

	С	Mn	Si *	S	Р
min		0.2			
max	0.10	0.8	0.10	0.03	0.03
typ	0.05	0.5	0.06	0.01	0.02

\* Analysed silicon will include a small proportion present as nonmetallic silicate inclusions. Alloyed silicon is therefore lower than analysed.

#### All-weld mechanical properties

As welded		typical	
Tensile strength	MPa	450	
0.2% Proof stress	MPa	380	
Elongation on 4d	%	30	
Reduction of area	%	60	

#### Parameters

DC ±ve or AC (OCV: 70V	min)				Ê	Î
ø mm	2.5	3.2	4.0	5.0	6.0	
min A	70	80	100	140	200	
max A	110	140	180	240	300	

Sizes larger than 3.2mm not recommended for positional welding.

#### Packaging data

ø mm	2.5	3.2	4.0	5.0	6.0
length mm	350	380	450	450	450
kg/carton	15.0	18.0	21.0	21.0	20.4
pieces/carton	810	543	342	225	153

#### Storage

**3 hermetically sealed ring-pull metal tins** per carton, with unlimited shelf life. Direct use from tin satisfactory for longer than 8h working shift.

For electrodes that are damp:

**Redry** 100-120°C/1-2h. Maximum 150°C, 3 cycles, 10h total.

**Storage** of redried electrodes at 100-200°C in holding oven or 50-150°C in heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): <60% RH, >18°C.

#### Fume data



#### Product description

Agglomerated fluoride-basic flux for submerged arc welding low alloy steels.

Basicity Index (according to Boniszewski) is  $\sim$ 3.1. Particle size is 0.2 - 2.0mm. Nominal composition of the flux is:

 $\frac{40\%(CaO+MgO) + 25\%(CaF_2) + 20\%(Al_2O_3+MnO) + 15\%(SiO_2+TiO_2)}{15\%(SiO_2+TiO_2)}$ 

#### Specifications

BS EN 760	S A FB 1 55 AC H5
DIN 32522	B FB 1 55 AC 10 MHP7

AWS A5.23 With SA1CrMo: F9 P0-EB2 B2 With SA2CrMo: F9 P0-EB3 B3

#### **ASME IX Qualification**

QW432 F-No -, QW442 A-No -.

#### Materials to be welded

Suitable for use with a wide range of materials including CrMo creep resisting steels and 1-2%Ni steels for low temperature toughness.

#### **Applications**

The LA121 flux is metallurgically neutral with respect to Mn and Si. It is a hydrogen controlled flux depositing low diffusible hydrogen content weld metal and hence is suitable for thick section joints. Also suitable for use with tandem and multi-wire welding systems.

#### Welding guidelines

Guidelines will depend on the material being welded. For CrMo materials appropriate preheat and PWHT will be

## WELDING CONSUMABLES

## DATA SHEET F-10

required; for further details see the appropriate alloy data sheet, A-12 for 1CrMo and A-13 for 2CrMo.

#### **Typical parameters**

Current: DC+ or AC, 1000A maximum. Typical parameters are:

2.4mm350A, 28V, 500mm/min travel speed3.2mm450A, 28V, 500mm/min travel speed4.0mm600A, 30V, 600mm/min travel speed.

#### Packaging data

Metrode LA121 flux is supplied in sealed moisture resistant 20kg metal drums.

#### Storage

Preferred storage conditions for open drums: <60%RH, >18°C.

If flux has become damp or has been stored for a long period, it should be redried at 300-350°C for 1-2 hours, this restores to as-packed condition which typically gives  $<5 \text{ml H}_2/100$ g weld metal. This treatment should also be carried out for critical procedures if  $<5 \text{ml H}_2/100$ g weld metal must be ensured.

#### Fume data

SAW fume is negligible.

#### Typical weld deposit analysis, wt%

Wire	С	Mn	Si	S	Р	Cr	Мо
SA 1CrMo	0.07	0.8	0.25	0.020	0.015	1.2	0.5
SA 2CrMo	0.07	0.8	0.25	0.010	0.015	2.2	1.0

#### **Typical Mechanical properties**

Wire	PWHT	Tensile strength, MPa	0.2% proof stress, MPa	Elongation on 4d, %
SA 1CrMo	690°C/1h	560	480	24
SA 2CrMo	690°C/1h	590	500	22

#### **Product description**

Agglomerated fluoride-basic flux for submerged arc welding.

Basicity Index (according to Boniszewski) is ~2.7. Particle size is 0.2 - 2.0 mm. Nominal composition of the flux is:

 $\begin{array}{l} 40\%(CaO{+}MgO) \,+\, 25\%(CaF_2) \,+\, 20\%(Al_2O_3{+}MnO) \,+\, 15\%(SiO_2{+}TiO_2) \end{array}$ 

#### Specifications

BS EN 760	S A FB 255 AC
DIN 32522	B FB 6 55455 AC 8

#### **ASME IX Qualification**

QW432 F-No -, QW442 A-No -.

#### Materials to be welded

Major application is for welding modified 9CrMo (P91) creep resisting steel (data sheet A-17) but also suitable for most 300 series stainless steels eg 308L (data sheet B-30), 316L (data sheet B-32) and 309L (data sheet B-50). Also suitable for duplex (B-60) and superduplex (B-61). Not recommended for 321/347 because the Ti/Nb affects slag release.

#### Applications

The LA491 flux is metallurgically neutral with respect to Mn and Si. It is a hydrogen controlled flux depositing low diffusible hydrogen content weld metal and hence is suitable for thick section joints. Also suitable for use with tandem and multi-wire welding systems. The LA491 flux has been found to be beneficial for applications with 308S92/ER308L and 316S92/ER316L requiring cryogenic impact properties of 0.38mm lateral expansion at -196°C. Batch selection of wire is generally required and batch testing is recommended.

#### Welding guidelines

Guidelines will depend on the material being welded. For further details see the appropriate alloy data sheet eg. for modified 9CrMo (P91) using 9CrMoV-N wire see data sheet A-17, 308S92/ER308L see data sheet B-30, 316S92/ER316L see data sheet B-32 and for 309S92/ER309L data sheet B-50.

#### **Typical parameters**

Current: DC+ or AC, 800A maximum.

#### Packaging data

Metrode LA491 flux is supplied in sealed moisture resistant 20kg metal drums.

#### Storage

Preferred storage conditions for open drums: <60% RH, >18 °C.

If flux has become damp or has been stored for a long period, it should be redried in the range  $300-350^{\circ}$ C for 1-2 hours.

#### Fume data

SAW fume is negligible.

Wire	С	Mn	Si	S	Р	Cr	Ni	Мо	N	Others
9CrMoV-N	0.08	0.6	0.35	0.005	0.007	8.5	0.7	1	0.04	0.16V, 0.04Nb
308S92/ER308LCF	0.02	1.7	0.4	0.010	0.015	20	10	-	-	-
316S92/ER316LCF	0.02	1.4	0.5	0.010	0.015	18.5	12	2.5	-	-
Zeron <sup>®</sup> 100X	0.02	0.6	0.4	0.010	0.015	24.5	9.3	3.6	0.21	0.7Cu, 0.7W

#### Typical weld deposit analysis, wt%

#### **Typical Mechanical properties**

Wire	Tensile strength, MPa	0.2% proof stress, MPa	Elongation on 4d, %	Impact energy, J *
9CrMoV-N (760°C/2h)	745	630	25	40 at +20°C
308S92/ER308LCF	570	450	40	50 at -196°C
316S92/ER316LCF	570	450	40	30 at -196°C
Zeron <sup>®</sup> 100X	890	700	25	40 at -50°C

\* For -196°C impact properties with austenitic stainless steels, batch testing of the wire-flux combination is recommended.

Rev 03 09/06



## DATA SHEET F-15

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Email: Internet:	info@metrode.com http//www.metrode.co	m

Basic non-alloying agglomerated flux for submerged arc welding with a wide range of stainless steels. Basicity Index (according to Boniszewski) is ~2.2. Nominal composition of the flux is:

 $40\%(Al_2O_3+MnO) + 10\%(SiO_2+TiO_2) + 50\%(CaF_2).$ 

The low level of silica minimises pick-up of Si, and loss of Mn and Cr.

#### **Specifications**

BS EN 760	S A AF2 DC
DIN 32522	B FB6 63353 DC8M

#### **ASME IX Qualification**

QW432 F-No -, QW442 A-No -.

#### Materials to be welded

Suitable for most stainless steels including: 304L (data sheet B-30), 347 (data sheet B-31), 316L (data sheet B-32), duplex (data sheet B-60) and superduplex (data sheet B-61); see wire data sheets for further information.

#### Applications

SSB flux is designed specifically for the butt welding of stainless steels, where high integrity and good mechanical properties are required.

#### Welding guidelines

Specific guidelines will depend on the alloy being welded

but for most alloys that SSB flux is used with no preheat will be required. For austenitic stainless steels the maximum recommended interpass temperature is  $250^{\circ}$ C but for duplex and superduplex this would normally be restricted to  $100-150^{\circ}$ C maximum.

#### **Typical parameters**

Designed for DC+ only with wires up to 4mm diameter and ~750A. However wires for the materials listed below would normally be 1.6, 2.4 or 3.2mm with a maximum of ~600A; with ER329N and Zeron<sup>®</sup> 100X the wire diameter is further restricted as are the welding parameters, see alloy data sheets for further information.

Typical parameters for 2.4mm wire are: 270-430A, 27-28V, 350-500mm/min travel speed.

#### Packaging data

Metrode SSB flux is supplied in sealed moisture resistant 20kg metal drums.

#### Storage

Preferred conditions for open drums: <60%RH, >18°C.

If flux has become damp or has been stored for a long period, it should be redried in the range  $250-400^{\circ}$ C for 1-3 hours.

#### Fume data

SAW fume is negligible.

Wire	С	Mn	Si	S	Р	Cr	Ni	Мо	Cu	N	Other
308S92	0.02	1.2	0.6	0.01	0.02	19.7	10	-	0.1	-	-
347S96	0.03	1.2	0.6	0.01	0.02	19.2	10	-	0.1	-	0.5 Nb
316S92	0.02	1.2	0.6	0.01	0.02	18.2	12	2.6	0.1	-	-
309S92	0.03	1.5	0.6	0.01	0.02	24	12.5	-	0.1	-	-
ER329N	0.02	1.3	0.5	0.01	0.02	22.5	8.5	3.1	0.1	0.15	-
Zeron <sup>®</sup> 100X	0.02	0.6	0.4	0.01	0.02	24.5	9.3	3.6	0.7	0.21	0.7 W

#### Typical weld deposit analysis, wt%

#### **Typical Mechanical properties**

Wire	Tensile strength, MPa	0.2% proof stress, MPa	Elongation on 4d, %	Impact energy, J
308S92	570	450	41	50 at -130°C *
347S96	630	470	35	30 at -100°C
316S92	570	450	41	45 at -130°C *
309S92	600	475	35	70 at -50°C
ER329N	790	630	30	55 at -50°C
Zeron <sup>®</sup> 100X	890	700	25	40 at -50°C

\* For -196°C impact properties with austenitic stainless steel wires LA491 flux is preferred (see data sheet F-15) and batch testing of the selected wire-flux combination is recommended.



## DATA SHEET **F-20**

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Basic agglomerated flux for submerged arc welding and strip cladding using 65NiCu wire (AWS ERNiCu-7).

Basicity Index (according to Boniszewski) is 0.6. Particle size is 0.4 - 1.4mm. Nominal composition of the flux is:

 $50\%(SiO_2) + 30\%(CaO+MgO+MnO+K_2O) + 12\%(CaF_2) + 8\%(Al_2O_3).$ 

#### **Specifications**

**BS EN 760** S A CS 2

#### **ASME IX Qualification**

QW432 F-No-, QW442 A-No-.

#### Materials to be welded

ASTM-ASME	BS	DIN							
UNS N04400	NA13	2.4360							
UNS N04405	NA1 (cast)	2.4361							
UNS N05500		2.4365 (cast)							
A494 M-35-1 (cast)									
A494 M-35-2 (cast)									
Proprietary									
Monel alloy 400, R405, K500 (Special Metals)									

Nicorros (VDM)

#### Applications

For welding alloy 400 and similar parent material to itself and to others in the Ni-Cu alloy system, such as pure nickel and cupronickel. Welds in alloy K500 are satisfactory, but cannot match the strength of this precipitation-hardened alloy. Castings of alloy 400 with up to about 1.5%Si are welded with Nimrod 190, but higher silicon grades such as BS3071 NA2 and ASTM A743 M35-2 are virtually unweldable because of HAZ cracking.

For **dissimilar** joints between alloy 400 and other alloys or steels, sensitivity to dilution by Fe (20-30%) or Cr (3-6%) can lead to low ductility (or bend-test fissuring) in weld metal close to the fusion boundary. Direct welds to mild or low alloy steels are satisfactory with dilution control, although ERNiCr-3 wire is preferable and necessary for stainless and higher chromium alloys (see data sheets D-10 and D-11). Alternatively, the steel or alloy can be buttered with pure nickel (see data sheet D-50) and this procedure is also useful when **surfacing** with alloy 400 consumables.



## DATA SHEET **F-30**

## **NiCu FLUX**

Alloy 400 has a useful combination of strength, thermal conductivity and resistance to corrosion by seawater, inorganic salts, sulphuric and hydrofluoric acids, hydrogen fluoride and alkalis. Applications include heat exchangers, piping, vessels and evaporators in the offshore, marine, chemical, petrochemical and power engineering industries.

#### Microstructure

Solid solution, single phase alloy, slightly ferromagnetic near room temperature.

#### Welding guidelines

No preheat required, maximum interpass temperature 150°C and no PWHT required.

#### Typical composition (weld metal wt %)

	С	Mn	Si	Cu	Fe	Ti	Ni
Wire	0.07	3.8	0.4	29	0.15	2.0	bal
deposit	0.02	3.6	1.3	29	2.5	0.6	bal

#### All-weld mechanical properties

As welded			typical	
Tensile strength		MPa	490	
0.2% Proof stress		MPa	260	
Elongation on 5d		%	45	
Impact energy	+ 20°C	J	100	

#### **Typical parameters**

Current: DC+, DC- or AC. 800A maximum.

#### **Packaging data**

Metrode NiCu flux is supplied in sealed moisture resistant 20kg metal drums.

#### Storage

Preferred storage conditions for open drums: <60%RH, >18°C.

If flux has become damp or has been stored for a long period, it should be redried in the range 300-400°C for 1-2 hours.

#### Fume data

SAW fume is negligible.

#### **Product description**

Neutral, calcium silicate, fused flux.

Basicity Index (according to Boniszewski) is  $\sim$ 1.3. Nominal composition of the flux is:

 $30\%(SiO_2) + 35\%(CaO+MgO) + 20\%(CaF_2) + 5\%(Al_2O_3)$ 

#### **Specifications**

 BS EN 760
 SF CS 2 DC

 DIN 32522
 F CS 6 63346 DC9

#### **ASME IX Qualification**

QW432 F-No-, QW442 A-No-.

#### Materials to be welded

The L2N flux is specifically designed for welding austenitic stainless steels (eg. data sheets B-30, B-32, B-50) but is also suitable for CrMo creep resisting steels (eg. data sheets A-12, A-13, A-17). In some instances the L2N flux is also suitable for surfacing with nickel base alloys (eg. data sheet D-20).

#### Applications

L2N flux is suitable for joining and surfacing. L2N shows a silicon pick-up of  $\sim 0.3\%$  and manganese loss of  $\sim 0.35\%$  with a 1%Mn wire (in accordance with BS EN 760).

#### Welding guidelines

The appropriate preheat or interpass temperature controls will be dependent on the material being welded, guidelines can be found on the data sheet for the

### DATA SHEET **F-40**

## L2N FLUX

appropriate wire. PWHT recommendations, if required, will also be found on the appropriate wire data sheet.

#### **Typical parameters**

Current: DC or AC; DC+ operation is preferred. Suitable for single or multi-wire, with a current carrying capacity of 900A.

Typical parameters for a 2.4mm wire are: 270-430A, 27-28V, 350-500mm/min travel speed. For some alloys and applications smaller wires and lower currents may be preferable to minimise the risk of hot cracking.

#### Packaging data

Metrode L2N flux is supplied in sealed moisture resistant 20kg metal drums.

#### Storage

Preferred storage conditions for open drums: <60%RH, >18°C. Because L2N is a fused flux it is resistant to moisture absorption and has inherently low hydrogen potential.

If flux has become damp or has been stored for a long period, it should be redried in the range 150-250°C for 1-2 hours.

#### **Fume data**

SAW fume is negligible.

Wire	С	Mn	Si	S	Р	Cr	Ni	Мо	Nb	V	N	Fe
9CrMoV-N	0.09	0.5	0.6	0.01	0.01	8.3	0.6	1	0.04	0.16	0.05	Bal
316S92	0.03	1.1	0.8	0.01	0.01	18	12	2.5				Bal
ER329N	0.02	1.3	0.8	0.01	0.01	23	8	3.1			0.17	Bal
62-50 *	0.02	0.1	0.8	0.01	0.01	21	64	8.8	2.5			2

Typical weld deposit analysis, wt%

\* Based on analysis of two layer overlay.

#### **Typical Mechanical properties**

Wire	Tensile strength, MPa	0.2% proof stress, MPa	Elongation on 4d, %	Impact energy, J
9CrMoV-N (760°C/2h)	750	630	25	35J at +20°C
316S92	570	420	40	80J at +20°C
ER329N	840	640	30	50J at -50°C