METRODE

WELDING CONSUMABLES

A Lincoln Electric® Company

Low Alloy Steels

DATA SHEET A-10

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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	10028-2 grade 16Mo3 (1.5415)
DIN	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 450ºC.

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.

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.

Products available

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

Mo.B

Molybdenum alloyed MMA electrode for elevated temperature service

Product description

Basic flux, metal powder type coating on high purity mild steel core wire. 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	E7018-A1
BS EN 1599	E Mo B32
BS 2493	MoBH
DIN 8575	E Mo B 26

BS and AWS Mn ranges overlap, but required specification should be stated on order.

ASME IX Qualification

QW432 F-No 4, **QW442** A-No 2

Composition (weld metal wt %)

	C	Mn*	Si	S	P	Cr	Ni	Mo	Cu
min	--	0.75	--	--	--	--	--	0.40	--
max	0.10	1.20	0.60	0.025	0.030	--	--	0.65	--
typ	0.05	0.8	0.3	0.01	0.015	0.05	0.05	0.55	0.05

* BS2493 Mn:Si ≥2:1, AWS A5.5 Mn 0.90% max.

All-weld mechanical properties

PWHT 600-650ºC/h *			min	typical	As-welded typical
Tensile strength		MPa	510	550-610	590
0.2% Proof stress		MPa	400	460-525	480
Elongation on 4d		%	22	27-32	27
Elongation on 5d		%	22	23-29	23
Reduction of area		%	--	65-72	68
Impact energy	- 20°C	J	--	130	100
	- 30ºC	J	--	115	--
Hardness		HV	--	200	200

* BS and DIN: 600ºC/1h; AWS: 620ºC/1h.
Satisfactory properties are also obtained in the as-welded condition.

Operating parameters

DC +ve or AC (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	15.0	16.5	16.5
pieces/carton	552	390	237	153

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, 300-350ºC/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 ovens, or 50-150ºC 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^3)
16	7	<0.1	<0.1	<0.2	<0.1	17	5

CMo

0.5%Mo solid TIG and MIG wire for creep resisting steels

Product description

Copper coated solid wire for TIG and MIG.

Specifications

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

QW432 F-No 6, **QW442** A-No 2

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	V
min	0.08	0.90	0.50	--	--	--	--	0.45	--	--
max	0.12	1.30	0.70	0.020	0.020	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

Properties as-welded (AW) or after PWHT:				typical: TIG		MAG: Ar + 5% CO_2	
			min. *	AW	620ºC/1h	AW	620ºC/1h
Tensile strength		MPa	515	662	640	650	620
0.2% Proof stress		MPa	400	540	520	530	505
Elongation on 4d		%	19	29	25	29	25
Elongation on 5d		%	22	26	24	25	24
Impact energy	- 30°C	J	--	52	170	42	96
Hardness cap/mid		HV	--	210/245	205/230	215/235	200/220

* Minimum values are after PWHT 620ºC/1h (AWS) or 595ºC/0.5h (DIN) and as-welded for BS EN. MAG welds using more oxidising shielding gas (higher CO_2 + O_2) will have lower strength than shown.

Typical operating parameters

	TIG	MIG
Shielding	Argon	Argon + 2-20%CO_2 Argon + 1.5% O_2 or proprietary
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	260A, 26V

Packaging data

ø mm	TIG	MIG
1.2	--	15kg spool
1.6	5kg tube	--
2.4	5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
55	5	<0.1	<0.1	<0.5	1.2	5

Low Alloy Steels

DATA SHEET A-12

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1¼Cr-½Mo CREEP RESISTING STEEL

Alloy type

1¼Cr-½Mo alloyed steel consumables for elevated temperature service.

Materials to be welded

ASTM	BS EN & DIN
A387 Gr 11 & 12	13CrMo 4-5 (1.7355)
A182 F11 & F12	13CrMo 4-4 (1.7335)
A217 WC6 & WC11	16CrMo 4-4 (1.7337)
A234 WP11 & WP12	11CrMo 5-5 (1.7339)
A199 T11	GS-25CrMo 4 (1.7128)
A200 T11	GS-17CrMo 5-5 (1.7357)
A213 T11 & T12	
A335 P11 & P12	**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_3 pressure vessels** operating at up to 450°C. In the as-welded 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.

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.

General Data for all 1¼Cr-½Mo Electrodes

Description

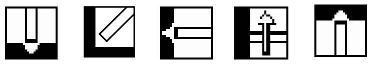
Basic flux, metal powder type coatings on low carbon high purity core wire. Recovery is approximately 115% with respect to the core wire and 65% with respect to whole electrode. Moisture resistant coating gives very low metal hydrogen levels.

Storage

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_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 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 AC (OCV: 70V min)



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 composition, wt % typical:

Fe	Mn	Cr	Ni	Cu	F	OES (mg/m^3)
15	5	< 0.5	< 0.1	< 0.2	18	5

CHROMET 1

1¼Cr-½Mo MMA electrode

Product description

MMA electrode meeting AWS and BS EN national standards suitable for most power generation applications.

Specifications

AWS A5.5	E8018-B2
BS EN 1599	ECrMo 1 B 3 2
BS 2493	1CrMo B H
DIN 8575	ECrMo 1 B 2 6

ASME IX Qualification

QW432 F-No 4, **QW442** A-No 3

Composition (weld metal wt %)

	C	Mn*	Si	S	P	Cr	Mo	Cu
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 exceed AWS 0.90% max.

All-weld mechanical properties

PWHT 690°C/1h			min	typical
Tensile strength		MPa	550	650
0.2% Proof stress		MPa	460	570
Elongation on 4d		%	19	25
Elongation on 5d		%	17	21
Reduction of area		%	--	70
Impact energy	+ 20°C	J	47	160
	-10°C	J	--	100
Hardness	(AW)	HV	--	250
	(PWHT)	HV	--	210

Preheat 150 – 250°C (BS EN), 200 – 300°C (BS), 160 – 190°C (AWS), 200 – 350°C (DIN).

Packaging data

ø mm	2.5	3.2	4.0	5.0	6.0
length mm	350	380	450	450	450
kg/carton	12.6	15.0	16.8	17.4	17.4
pieces/carton	627	372	243	159	111

CHROMET 1L

Low carbon 1¼Cr-½Mo MMA electrode

Product description

MMA electrode – 1¼Cr-½Mo deposit with low carbon which produces lower hardness and residual stresses for resistance to sulphide stress corrosion cracking when operating in wet 'sour' environments. Also suitable for thin section joints which are to be left in the as-welded condition.

Specifications

AWS A5.5	E7015-B2L
BS EN 1599	ECrMo 1 L B 3 2
BS 2493	1CrMo L B H
DIN 8575	ECrMo 1 B 2 6

ASME IX Qualification

QW432 F-No 4, **QW442** A-No 3

Composition (weld metal wt %)

	C	Mn*	Si	S	P	Cr	Mo	Cu
min	0.03	0.50	--	--	--	1.00	0.45	--
max	0.05	0.90	0.50	0.025	0.025	1.40	0.65	0.15
typ	0.04	0.8	0.35	0.012	0.015	1.25	0.55	<0.10

* Mn may exceed AWS 0.90% max.

All-weld mechanical properties

PWHT 690°C/1h			min	typical
Tensile strength		MPa	520	600
0.2% Proof stress		MPa	390	500
Elongation on 4d		%	19	26
Elongation on 5d		%	17	23
Reduction of area		%	--	68
Impact energy	+ 20°C	J	--	180
	-10°C	J	--	120
Hardness	(AW)	HV	--	220
	(PWHT)	HV	--	200

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	350	380	450	450
kg/carton	12.0	15.0	17.7	18.0
pieces/carton	612	399	252	168

CHROMET 1X

1¼Cr-½Mo alloyed MMA electrode for temper embrittlement resistance

Product description

MMA electrode – 1¼Cr-½Mo deposit which meets specific requirements for improved temper embrittlement resistance with prolonged service at 400-600°C. Relevant trace elements (P, Sn, As, Sb) are controlled to ensure low Bruscato (X) and Watanabe (J) factors.

Specifications

AWS A5.5	E8018-B2
BS EN 1599	ECrMo 1 B
BS 2493	1CrMo B H
DIN 8575	ECrMo 1 B 2 6

ASME IX Qualification

QW432 F-No 4, **QW442** A-No 3

Composition (weld metal wt %)

	C	Mn*	Si*	S	P	Cr	Mo	Cu	Sn	As	Sb
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 < 1.10%

Bruscato factor (X) : $\frac{\underline{10P + 5Sb + 4Sn + As}\text{ (ppm)}}{100}$ = 15 max

Watanabe factor (J) : $(Mn+Si)x(P + Sn) \times 10^4$ = 180 max

CHROMET 1X (continued)

All-weld mechanical properties

PWHT 690°C/1h [(1)] (SC = step cooled)			min	typical	690°C/5h typical	690°C/5h + SC 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

(1) BS & AWS PWHT 690°C/1h, DIN 690°C/>30min, BS EN 720°C/1h.
(2) DIN & BS EN minimum average.

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

1CrMo

Solid welding wire for TIG & MIG.

Product description

Copper coated wire for TIG and MIG welding of 1¼Cr-½Mo steels, conforming to European specifications.

Specifications

AWS A5.28	ER80S-G	
BS EN 12070	CrMo1Si	(W = TIG, G = MIG)
BS 2901: Pt1	A32	
DIN 8575	SG CrMo 1	

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 3

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.06	0.80	0.40	--	--	1.10	--	0.45	--
max	0.12	1.20	0.80	0.020	0.020	1.50	--	0.65	0.4
typ	0.1	1	0.6	0.010	0.015	1.2	<0.1	0.5	0.1

All-weld mechanical properties

PWHT 690°C/4h (AWS=1h)			min	typical TIG	typical MIG
Tensile strength		MPa	550	635	590
0.2% Proof stress		MPa	470	520	480
Elongation on 4d		%	19	25	26
Impact energy	-10°C	J	--	> 200	> 115
Hardness		HV(HB)	--	220(215)	195(190)

Typical operating parameters

	TIG	MIG
Shielding	Argon	Ar-5%CO_2
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	280A, 26V

Packaging data

ø mm	TIG	MIG
0.8	--	15kg reel
1.2	--	15kg reel
1.6	5kg tube	--
2.4	5kg tube	--
3.2	5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
55	5	0.4	< 0.1	< 0.5	1.2	5

ER80S-B2

Solid welding wire for TIG & MIG.

Product description

Copper coated wire for TIG and MIG welding 1¼Cr-½Mo creep resisting steels, conforming to the AWS/ASME specification.

Specifications

AWS A5.28	ER80S-B2
BS EN 12070	--
BS 2901: Pt1	A32
DIN 8575	--

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 3

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.07	0.40	0.40	--	--	1.20	--	0.40	--
max	0.12	0.70	0.70	0.020	0.020	1.50	0.20	0.65	0.35
typ	0.1	0.5	0.5	0.010	0.015	1.3	<0.1	0.5	0.1

All-weld mechanical properties

PWHT 690°C/4h (AWS=1h)			min	typical TIG	typical MIG
Tensile strength		MPa	550	635	590
0.2% Proof stress		MPa	470	520	480
Elongation on 4d		%	19	25	26
Hardness		HV(HB)	--	220(215)	195(190)
Impact energy	- 10°C	J	--	> 200	> 115

Typical operating parameters

	TIG	MIG
Shielding	Argon	Ar - 5% CO_2
Current	DC -	DC+
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	280A, 26V

Packaging data

ø mm	TIG	MIG
1.2	--	15kg reel
1.6	5kg tube	--
2.4	5kg tube	--
3.2	5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
55	5	0.4	<0.1	<0.5	1.2	5

LA121 FLUX

Sub-arc flux

Product description

Agglomerated basic flux of high basicity (Boniszewski BI ~3.1) with neutral Si and Mn pick-up/burn-out. Particle size is 0.2 – 2.0mm. Nominal composition of the flux is:

$$40\%(CaO + MgO) + 20\%(Al_2O_3 + MnO) + 15\%(SiO_2 + TiO_2) + 25\%(CaF_2)$$

Specifications

AWS A5.23	F9 P0-EB2 B2
DIN 32522	BFB 155 AC 10 MHP7
BS EN 760	SA FB 1 55 AC H5

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (typical)

	C	Mn	Si	S	P	Cr	Mo
SA 1CrMo wire	0.10	0.8	0.25	0.010	0.012	1.3	0.55
Deposit	0.07	0.8	0.25	0.010	0.015	1.2	0.55

All-weld mechanical properties with SA 1CrMo wire

PWHT 700°C/10h			typical
Tensile strength		MPa	480
0.2% Proof stress		MPa	360
Elongation on 4d		%	40
Impact energy	+20°C	J	80
Hardness cap/mid		HV	160/180

LA121 FLUX (continued)

Typical operating parameters

Current: DC +ve

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

Metrode **LA121 Flux** is supplied in sealed moisture resistant 25kg 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 250-400°C/1-3h.

CORMET 1

All-positional flux cored wire

Product description

Cormet 1 is an all-positional flux cored wire suitable for welding fixed pipework. Made using a high purity steel sheath with a metal recovery of about 90% with respect to the wire.

Specifications

AWS A5.29	E81T1-B2M
BS EN ISO 17634-B	T55T1-1M-1CM

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 3

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Mo	Cu
min	0.05	--	--	--	--	1.00	0.40	--
max	0.12	1.25	0.80	0.030	0.030	1.50	0.65	0.30
typ	0.06	1.0	0.3	0.01	0.01	1.3	0.55	0.05

All-weld mechanical properties

PWHT 690°C/1-2h			min	typical
Tensile strength		MPa	550	650
0.2% Proof stress		MPa	470	550
Elongation on 4d		%	19	24
Elongation on 4d		%	17	22
Impact energy	+ 20°C	J	--	> 40
Hardness		HV	--	220

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 80%. The wire is also suitable for use with 100%CO_2. (Note: for 100%CO_2 shielding gas, voltage should be 1-2V higher.)

Current: DC+ve ranges as below:

ø mm	amp-volt range	typical	stickout
1.2	160 – 260A, 24-30V	190A, 25V	15 – 25mm
1.6	220 – 350A, 26-32V	260A, 28V	15 – 25mm

Packaging data

Spools vacuum-sealed in barrier foil with cardboard carton: 15kg.
The as-packed shelf life is virtually indefinite.
Resistance to moisture absorption is high, but to maintain the high integrity of the wire surface and prevent any possibility of porosity, it is advised that part-used spools are returned to polythene wrappers.
Where possible, preferred storage conditions are 60% RH max, 18°C min.

Fume data

Fume composition (wt %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
20	8	< 0.5	1	< 1	< 1	8	5

Low Alloy Steels

DATA SHEET **A-13**

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2¼Cr-1Mo CREEP RESISTING STEEL

Alloy type

2¼Cr-1Mo alloyed steel consumables for elevated temperature service.

Materials to be welded

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

Also Cr-Mo-V steels	BS
	1501 Gr 622
	1503 Gr 622
BS 1503 Gr 660	1504 Gr 622
BS 1504 Gr 660	3100 Gr B3
BS 3100 Gr B7	3604 Gr 622
BS 3604 Gr 660	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_3 **pressure vessels** operating at up to 450°C. In the as-welded 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.

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
	Cormet 2L	AWS E91T1-B3L

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

General Data for all 2¼Cr-1Mo Electrodes

Description	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	**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_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 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 AC (OCV: 70V min)

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 composition, wt % typical:

Fe	Mn	Cr	Ni	Cu	F	OES (mg/m^3)
15	5	1	< 0.1	< 0.2	18	5

CHROMET 2

2¼Cr-1Mo MMA electrode

Product description

MMA electrode meeting AWS and BS EN national standards suitable for most power generation applications.

Specifications

AWS A5.5	E9018-B3
BS EN 1599	ECrMo 2 B 3 2
BS 2493	2CrMo B H
DIN 8575	ECrMo 2 B 2 6
NATIONAL POWER	Conforms to specification requirements.

ASME IX Qualification

QW432 F-No 4, **QW442** A-No 4

Composition (weld metal wt %)

	C	Mn*	Si	S	P	Cr	Mo	Cu	Sn	As
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	0.07	0.8	0.35	0.012	0.015	2.25	1.05	< 0.10	<0.006	<0.010

* Mn may exceed AWS 0.90% max.

All-weld mechanical properties

PWHT 690°C/1h			min	typical
Tensile strength		MPa	630	700
0.2% Proof stress		MPa	540	620
Elongation on 4d		%	17	22
Elongation on 5d		%	15	19
Reduction of area		%	--	65
Impact energy	+ 20°C	J	47	140
	-10°C	J	--	80
Hardness	(AW)	HV	--	300-320
	(PWHT)	HV	--	220-250

Preheat 200 – 300°C (BS & BS EN), 160 – 190°C (AWS), 200 – 350°C (DIN).

Packaging data

ø mm	2.5	3.2	4.0	5.0	6.0
length mm	350	380	450	450	450
kg/carton	12.0	15.0	16.2	17.1	16.2
pieces/carton	621	396	228	156	105

CHROMET 2L

Low carbon 2¼Cr-1Mo MMA electrode

Product description

MMA electrode – 2¼Cr-1Mo deposit with low carbon which produces lower hardness and residual stresses for resistance to sulphide stress corrosion cracking when operating in wet 'sour' environments. The lower hardness of **Chromet 2L** can also be beneficial for welds that cannot be subsequently PWHT.

Specifications

AWS A5.5	E8015-B3L
BS EN 1599	ECrMo 2 L B 3 2
BS 2493	2CrMo L B H
DIN 8575	ECrMo 2 B 2 6

ASME IX Qualification

QW432 F-No 4, **QW442** A-No 4

Composition (weld metal wt %)

	C	Mn*	Si	S	P	Cr	Mo	Cu
min	0.03	0.50	--	--	--	2.00	0.90	--
max	0.05	0.90	0.50	0.015	0.020	2.50	1.20	0.15
typ	0.04	0.8	0.35	0.012	0.015	2.25	1.05	<0.10

* Mn may exceed AWS 0.90% max.

All-weld mechanical properties

PWHT 690°C/1h			min	typical
Tensile strength		MPa	550	630
0.2% Proof stress		MPa	460	540
Elongation on 4d		%	17	24
Elongation on 5d		%	15	20
Reduction of area		%	--	70
Impact energy	+ 20°C	J	--	160
	-10°C	J	--	90
Hardness	(AW)	HV	--	250-260
	(PWHT)	HV	--	210-220

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	350	380	450	450
kg/carton	12.0	15.0	17.4	17.1
pieces/carton	621	396	228	156

CHROMET 2X

2¼Cr-1Mo alloyed MMA electrode for temper embrittlement resistance

Product description

MMA electrode – 2¼Cr-1Mo deposit which meets specific requirements for improved temper embrittlement resistance after prolonged service at 400-600°C. Relevant trace elements (P, Sn, As, Sb) are controlled to ensure low Bruscato (X) and Watanabe (J) factors.

Specifications

AWS A5.5	E9018-B3
BS EN 1599	ECrMo 2 B
BS 2493	2CrMo B H
DIN 8575	ECrMo 2 B 2 6

ASME IX Qualification

QW432 F-No 4, **QW442** A-No 4

Composition (weld metal wt %)

	C	Mn*	Si*	S	P	Cr	Mo	Cu	Sn	As	Sb
min	0.05	0.50	0.15	--	--	2.00	0.90	--	--	--	--
max	0.10	0.90	0.30	0.015	0.012	2.50	1.20	0.15	0.005	0.010	0.005
typ	0.06	0.7	0.25	0.012	0.010	2.25	1.05	<0.05	0.002	0.003	<0.002

* Mn+Si < 1.10%

Bruscato factor (X) : $\frac{10P + 5Sb + 4Sn + As}{100}$ (ppm) = 15 max

Watanabe factor (J) : $(Mn+Si) x (P + Sn) x 10^4$ = 180 max

CHROMET 2X (continued)

All-weld mechanical properties

PWHT 690°C/1h [1] (SC = step cooled)			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 [2]	140	170	170
	- 30°C	J	--	80	140	110
Hardness	(AW)	HV	--	300-320	--	--
	(PWHT)	HV	--	220-250	195	205

(1) BS & AWS PWHT 690°C/1h, DIN 690°C/>30min, BS EN 720°C/1h.
(2) DIN & BS EN minimum average.

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 welding wire for TIG & MIG.

Product description

Copper coated wire for TIG and MIG welding of 2¼Cr-1Mo steels, conforming to European specifications.

Specifications

AWS A5.28	ER90S-G	
BS EN 12070	CrMo2Si	(W = TIG, G = MIG)
BS 2901: Pt1	A33	
DIN 8575	SG CrMo 2	

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 4

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.06	0.80	0.40	--	--	2.30	--	0.90	--
max	0.12	1.20	0.80	0.020	0.020	2.70	--	1.10	0.4
typ	0.1	1	0.6	0.010	0.015	2.4	<0.1	1	0.15

All-weld mechanical properties

PWHT 690°C/4h (AWS=1h)			min	typical TIG	typical MIG
Tensile strength		MPa	620	660	655
0.2% Proof stress		MPa	540	550	540
Elongation on 4d		%	17	22	23
Impact energy	-10°C	J	--	> 150	> 95
Hardness		HV(HB)	--	225(220)	220(215)

Typical operating parameters

	TIG	MIG
Shielding	Argon	Ar-5%CO_2
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	280A, 26V

Packaging data

ø mm	TIG	MIG
0.8	--	15kg reel
1.2	--	15kg reel
1.6	5kg tube	--
2.0	To order	--
2.4	5kg tube	--
3.2	5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
55	5	1.3	< 0.1	< 0.5	1.2	5

ER90S-B3

Solid welding wire for TIG & MIG.

Product description

Copper coated wire for TIG and MIG welding 2¼Cr-1Mo creep resisting steels, conforming to the AWS/ASME specification.

Specifications

AWS A5.28	ER90S-B3
BS EN 12070	--
BS 2901: Pt1	A33
DIN 8575	--

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 4

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.07	0.40	0.40	--	--	2.30	--	0.90	--
max	0.12	0.70	0.70	0.020	0.020	2.70	0.20	1.20	0.35
typ	0.1	0.5	0.5	0.010	0.015	2.4	<0.1	1	0.1

All-weld mechanical properties

PWHT 690°C/4h (AWS=1h)			min	typical TIG	typical MIG
Tensile strength		MPa	620	660	655
0.2% Proof stress		MPa	540	550	540
Elongation on 4d		%	17	22	23
Hardness		HV(HB)	--	225 (220)	220(215)
Impact energy	- 10°C	J	--	> 150	> 95

Typical operating parameters

	TIG	MIG
Shielding	Argon	Ar - 5% CO_2
Current	DC -	DC+
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	280A, 26V

Packaging data

ø mm	TIG	MIG
1.2	--	15kg reel
1.6	5kg tube	--
2.4	5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
55	5	1.3	<0.1	<0.5	1.2	5

LA121 FLUX

Sub-arc flux

Product description

Agglomerated basic flux of high basicity (Boniszewski BI ~3.1) with neutral Si and Mn pick-up/burn-out. Particle size is 0.2 – 2.0mm. Nominal composition of the flux is:
40%(CaO + MgO) + 20%(Al_2O_3 + MnO) + 15%(SiO_2 + TiO_2) + 25%(CaF_2)

Specifications

AWS A5.23	F9 P0-EB3 B3
DIN 32522	BFB 155 AC 10 MHP7
BS EN 760	SA FB 1 55 AC H5

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 4

Composition (typical)

	C	Mn	Si	S	P	Cr	Mo
SA 2CrMo wire	0.10	0.8	0.25	0.010	0.012	2.5	1.0
Deposit	0.07	0.8	0.25	0.010	0.015	2.2	1.0

All-weld mechanical properties with SA 2CrMo wire

PWHT 690°C/1h			typical
Tensile strength		MPa	590
0.2% Proof stress		MPa	500
Elongation on 4d		%	22
Impact energy	+20°C	J	140
Hardness		HV	200

LA121 FLUX (continued)

Typical operating parameters

Current: DC +ve

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

Metrode **LA121 Flux** is supplied in sealed moisture resistant 25kg 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 250-400°C/1-3h.

CORMET 2 / 2L

All-positional flux cored wires

Product description

Cormet 2 is an all-positional flux cored wire suitable for welding fixed pipework. Made using a high purity steel sheath with a metal recovery of about 90% with respect to the wire.

Cormet 2L, which is the low carbon version, is available to order; this wire finds applications for **as-welded repairs** in **power generation** plant and the lower hardness may provide some benefits in some **petrochemical** applications.

Specifications

	Cormet 2	**Cormet 2L**
AWS A5.29	E91T1-B3M	E91T1-B3LM
BS EN ISO 17634-B	T62T1-1M-2C1M	T62T1-1M-2C1ML

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 4

Composition (weld metal wt %)

	C*	Mn	Si	S	P	Cr	Mo	Cu
min	0.05	--	--	--	--	2.00	0.90	--
max	0.12	1.25	0.80	0.030	0.030	2.50	1.20	0.30
typ	0.06	1.0	0.3	0.01	0.01	2.3	1.0	0.05

* Cormet 2L C ≤ 0.05%, typical 0.04%

All-weld mechanical properties

PWHT 690°C/1-2h			min	Cormet 2 typical	Cormet 2L typical (as-welded)
Tensile strength		MPa	620	725	--
0.2% Proof stress		MPa	540	625	--
Elongation on 4d		%	17	22	--
Elongation on 4d		%	15	20	--
Impact energy	+ 20°C	J	--	> 70	50
Hardness		HV	--	235	280

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 80%. The wire is also suitable for use with 100%CO_2. (Note: for 100%CO_2 shielding gas, voltage should be 1-2V higher.)

Current: DC+ve ranges as below:

ø mm	amp-volt range	typical	stickout
1.2	160 – 260A, 24-30V	190A, 25V	15 – 25mm
1.6	220 – 350A, 26 – 32V	260A, 28V	15 – 25mm

Packaging data

15kg spools vacuum-sealed in barrier foil with cardboard carton.
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^3	Cr^6	Cu	F	OES (mg/m^3)
20	8	< 0.5	1	< 1	< 1	8	5

METRODE
WELDING CONSUMABLES

Low Alloy Steels

CrMoV CREEP RESISTING STEEL

DATA SHEET **A-14**

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Alloy type

1¼Cr-1Mo-¼V 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.

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.

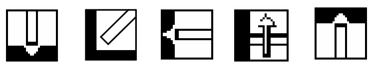
Products available

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	100	140
max A	110	140	180	240

Storage

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_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 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	Pb	F	OES (mg/m^3)
15	5	<0.1	<0.5	<0.2	<0.1	18	5

CHROMET 1V

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.

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

Specifications

DIN 8575	ECrMoV1 B 20
BS EN 1599	ECrMoV1 B 32

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Mo	V
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 properties

Typical PWHT 700°C/1h			Room Temperature		High Temperature		
			min	typical	+350°C	+400°C	+450°C
Tensile strength		MPa	590	800	750	730	695
0.2% Proof stress		MPa	435	745	675	650	620
Elongation on 4d		%	--	20	--	--	--
Elongation on 5d		%	15	16	--	--	--
Impact energy	+ 20°C	J	24	60	--	--	--
Hardness		HV	--	275	--	--	--

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	350	380	450	450
kg/carton	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.

The **13CMV** 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 **13CMV** 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.

Specifications

DIN 8575	(ECrMoV1 B 20)	
BS EN 1599	(ECrMoV1 B 32)	
GE	B50A273	By prior agreement only.

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Mo	V*	Ni
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 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/carton	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 no relevant national standards.
ASME IX Qualification	**QW432** F-No --, **QW442** A-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Mo	V
min	0.05	0.50	0.15	--	--	1.00	0.90	0.10
max	0.15	1.50	0.50	0.025	0.025	1.50	1.30	0.35
typ	0.06	1	0.4	0.01	0.01	1.3	1.1	0.2

All-weld mechanical properties

PWHT 720°C/3h			typical
Tensile strength		MPa	650
0.2% Proof stress		MPa	550
Impact energy	+ 20°C	J	50
Hardness		HV	230

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 80%. The wire is also suitable for use with 100%CO_2.
Current: DC+ve ranges as below (when using 100%CO_2 increase voltage by about 2V):

ø mm	amp-volt range	typical	stickout
1.2	160-260A, 24-30V	190A, 25V	15-25mm

Packaging data

Spools vacuum-sealed in barrier foil with cardboard carton: 15kg
The as-packed shelf life is virtually indefinite.
Resistance to moisture absorption is high, but to maintain the high integrity of the wire surface and prevent any possibility of porosity, it is advised that part-used spools are returned to polythene wrappers.
Where possible, preferred storage conditions are 60% RH max, 18°C min.

Fume data

Fume composition (wt %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
20	8	<0.5	1	<1	<1	8	5

Low Alloy Steels

DATA SHEET A-15

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5CrMo FOR ELEVATED TEMPERATURE

Alloy type

5%Cr-½%Mo steel for elevated temperature service up to 600°C.

Materials to be welded

plates:

ASTM	A387 grade 5

pipe/tube:

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:

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 600ºC, 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 martensitc 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.

Products available

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

METRODE
WELDING CONSUMABLES

CHROMET 5

5%Cr-0.5%Mo MMA electrode

Product description

Basic metal powder type made on high purity low carbon core wire. Moisture resistant coating gives 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	E8015-B6	
AWS A5.4	E502-15	This classification has now been withdrawn from A5.4
BS EN 1599	E CrMo5 B 32 H5	
BS 2493	5CrMoBH	
DIN 8575	ECrMo5 B26	

ASME IX Qualification

QW432 F-No 4, **QW442** A-No 4

Composition (weld metal wt %)

	C *	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.05	0.50	--	--	--	4.0	--	0.45	--
max	0.10	1.00	0.50	0.025	0.025	6.0	0.40	0.65	0.50
typ	0.06	0.8	0.35	0.01	0.015	5	0.2	0.55	0.05

* Carbon 0.05-0.10% for E8015-B6 (<0.05% for E8015-B6L made to order).

All-weld mechanical properties

Typical properties after PWHT *			745°C/1h ** min.	745°C/1h ** typical	740°C/2h typical	745°C/3h typical
Tensile strength		MPa	550 ***	610	610	540
0.2% Proof stress		MPa	460	500	480	360
Elongation on 4d		%	19	25	23	28
Elongation on 5d		%	18	22	20	25
Reduction of area		%	--	69	71	74
Impact energy	+ 20°C	J	--	150	130	140
	- 10°C	J	--	80	50	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 is not shown).

** This is the AWS A5.5 PWHT (732-760°C/1h). BS is 725-745°C/2h, BS EN & DIN is 730-760°C/1h.

*** BS EN and DIN minimum is 590MPa. There are no base material grades requiring such a high tensile strength ASTM is 414-552MPa dependent on grade.

Operating parameters

DC +ve or AC (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	14.4	17.1	16.8
pieces/carton	636	366	246	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, 300-350ºC/1-2h to ensure H_2 < 5ml/100g. Maximum 420°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	Pb	F	OES (mg/m^3)
15	5	<0.1	1.5	<0.2	<0.1	18	3

5CrMo

Solid TIG and MIG wire for 5%Cr-0.5%Mo creep resisting steels

Product description

Solid copper coated wire for TIG and MIG, alloyed with 5%Cr-0.5%Mo.

Specifications

AWS A5.28	ER80S-B6	
AWS A5.9	ER502	This classification has now been withdrawn from A5.9
BS EN 12070	CrMo5Si	
BS 2901: Pt2	A34	
DIN 8575	SG CrMo5 (1.7373)	

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 4

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	V
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 properties

Typical values after PWHT:			min. *	TIG 745ºC/1h	TIG 740ºC/2h
Tensile strength		MPa	590	660	570
0.2% Proof stress		MPa	470	560	440
Elongation on 4d		%	17	28	25
Elongation on 5d		%	17	25	20
Reduction of area		%	--	72	78
Impact energy	+ 20°C	J	--	240	--
Hardness cap/mid		HV10	--	195/215	--

* Minimum values after PWHT 745ºC (730-760ºC) for 1h according to AWS A5.28 for ER80S-B6 and BS EN 12070.

Typical operating parameters

	TIG	MIG
Shielding	Argon *	Ar + 1-3%O_2 or 5-20% CO_2
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	140A, 14V	260A, 26V

* Also required as a purge for root runs.

Packaging data

ø mm	TIG	MIG
1.2	--	15kg spool
1.6	5kg tube	--
2.4	5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m^3)
50	5	3	<0.1	<0.5	1.2	5

CORMET 5

All-positional flux cored wire

Product description

Cormet 5 is an all-positional flux cored wire suitable for welding fixed pipework. Made using a high purity steel sheath with a metal recovery of about 90% with respect to the wire.

Specifications

AWS A5.29	E81T1-B6M	Concurrent specifications – E502T1-4 will be withdrawn at the next revision of AWS A5.22
AWS A5.22	E502T1-4	
BS EN ISO 17634-B	T55T1-1M-5CM	

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 4

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Mo	Cu	Ni
min	0.05	--	--	--	--	4.00	0.45	--	--
max	0.10	1.20	0.50	0.030	0.030	6.00	0.65	0.3	0.40
typ	0.06	0.8	0.3	0.01	0.01	5	0.5	0.05	0.01

All-weld mechanical properties

PWHT 745°C/2h *		min	typical
Tensile strength	MPa	550	690
0.2% Proof stress	MPa	470	600
Elongation on 4d	%	19	22
Elongation on 5d	%	17	19
Reduction of area	%	--	67

* BS EN ISO requires 1 hour PWHT. AWS requires 2 hour PWHT.

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 80%. The wire is also suitable for use with 100%CO_2. (Note: for 100%CO_2 shielding gas, voltage should be 1-2V higher.)

Current: DC+ve ranges as below:

ø mm	amp-volt range	typical	stickout
1.2	160 – 260A, 24-30V	190A, 25V	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 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^3	Cr^6	Cu	F	OES (mg/m^3)
20	8	< 0.5	1.5	1.5	< 1	8	3.3

Low Alloy Steels

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	A217 grade C12
BS	1504 grade 629 3100 grade B6
DIN	GS-12CrMo 10 1 (1.7389)

Applications

For elevated temperature service up to 600ºC, 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.

Products available

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

CHROMET 9

9%Cr-1%Mo MMA electrode

Product description

Basic metal powder type made on high purity low carbon core wire. 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	E8015-B8	
AWS A5.4	E505-15	This classification has now been withdrawn from A5.4
BS EN 1599	E CrMo9 B 32 H5	
BS 2493	9CrMoBH	
DIN 8575	ECrMo9 B26	

ASME IX Qualification

QW432 F-No 4, **QW442** A-No 5

Composition (weld metal wt %)

	C *	Mn	Si	S	P	Cr	Ni	Mo	Cu
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

* Carbon 0.05-0.10% for E8015-B8 (<0.05% for E8015-B8L, made to order).

All-weld mechanical properties

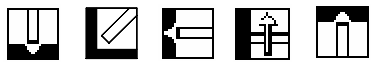
Typical PWHT			min *	740°C/2h typical	746°/3h typical
Tensile strength		MPa	590	710	680
0.2% Proof stress		MPa	460	600	550
Elongation on 4d		%	19	22	26
Elongation on 5d		%	18	20	25
Reduction of area		%	--	70	70
Impact energy	+ 20°C	J	34	90	130
	0ºC	J	--	50	--
	-10ºC	J	--	25	90
Hardness		HV	--	235	220

AWS PWHT is 732-760°C /1 hour. BS EN PWHT is 740-780°C/2 hours. See front page under PWHT for normal fabrication practice.

* ASTM base material minimum varies in the range 414-586MPa depending on grade.

Operating parameters

DC +ve or AC (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	11.7	15.0	17.4	16.5
pieces/carton	612	399	249	150

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, 300-350ºC/1-2h to ensure H_2 < 5ml/100g. Maximum 420°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	Pb	F	OES (mg/m³)
15	5	<0.1	2.5	<0.2	<0.1	18	2

9CrMo

TIG and MIG copper coated wire for 9%Cr-1%Mo

Product description

Solid copper coated wire for TIG and MIG.

Specifications

AWS A5.28	ER80S-B8	
AWS A5.9	ER505	This classification has now been withdrawn from A5.9
BS EN 12070	CrMo9Si	
BS 2901: Pt1	A35	
DIN 8556	SG CrMo9 (1.7388)	

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 5

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.03	0.40	--	--	--	8.5	--	0.8	--
max	0.10	0.60	0.50	0.020	0.020	10.0	0.5	1.2	0.35
typ	0.07	0.5	0.3	0.01	0.015	9	0.1	0.9	0.1

All-weld mechanical properties

Typical values after 745°C/1h:			min	TIG
Tensile strength		MPa	550	729
0.2% Proof stress		MPa	470	612
Elongation on 4d		%	17	25
Impact energy	+ 20°C	J	--	80
Hardness cap/mid		HV	--	225/230

Typical operating parameters

	TIG	MIG
Shielding	Argon *	Ar + 1-3%O_2 or 5-20% CO_2
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	140A, 14V	260A, 26V

* Also required as a purge for root runs.

Packaging data

ø mm	TIG	MIG
1.2	--	To order
1.6	5kg tube	--
2.4	5kg tube	--
3.2	To order	--

Fume data

MIG fume composition (wt %) (TIG fume negligible):

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m^3)
50	4	6	<0.1	<0.5	1.2	5

CORMET 9

All-positional flux cored wire

Product description	**Cormet 9** is an all-positional flux cored wire suitable for welding fixed pipework. Made using a high purity steel sheath with a metal recovery of about 90% with respect to the wire.
Specifications	**AWS A5.29** E81T1-B8M **AWS A5.22** E505T1-4 **BS EN ISO 17634-B** T55T1-1M-9C1M Concurrent AWS specifications – E505T1-4 will be withdrawn at the next revision of A5.22.
ASME IX Qualification	**QW432** F-No 6, **QW442** A-No 5

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Mo	Cu	Ni
min	0.05	--	--	--	--	8.0	0.85	--	--
max	0.12	1.25	1.00	0.030	0.040	10.5	1.20	0.5	0.4
typ	0.06	0.8	0.3	0.01	0.01	9	1.0	0.05	0.3

All-weld mechanical properties

PWHT 745°C/2h *		min	typical
Tensile strength	MPa	550	640
0.2% Proof stress	MPa	470	500
Elongation on 4d	%	19	24
Elongation on 5d	%	17	21
Reduction of area	%	--	65

* BS EN ISO-B requires 1 hour PWHT. AWS Requires 2 hour PWHT.

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 80%. The wire is also suitable for use with 100%CO_2. (Note: for 100%CO_2 shielding gas, voltage should be 1-2V higher.)

Current: DC+ve ranges as below:

ø mm	amp-volt range	typical	stickout
1.2	160 – 260A, 24-30V	190A, 25V	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 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^3	Cr^6	Cu	F	OES (mg/m^3)
20	8	< 0.5	3	3	< 1	8	1.7

Low Alloy Steels

DATA SHEET **A-17**

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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.

PWHT

Minimum preheat temperature 150°C with maximum interpass temperature of 300°C; in practice a preheat-interpass range of 200 – 300°C is normal. To ensure full martensite transformation, welds should be cooled to ~100°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^{-3}. 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°C. PWHT above 765°C is not generally recommended for Ni-containing consumables, because some re-hardening could occur due to the proximity of Ac_1. Some authorities specify weld metal Ni + Mn < 1.5% to keep Ac_1 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.

Products available

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 powder types made on high purity steel core wire.

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

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	100	140
max A	110	140	180	240

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 quivers: no limit, but maximum 6 weeks recommended.

Fume data

Fume composition (wt %)

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

Chromet 9MV-N

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

Product description

MMA electrode – with Ni addition and lower Nb for improved toughness, conforming to BS EN 1599

Specifications

AWS A5.5 E9015-B9
BS EN 1599 E CrMo91 B 3 2

ASME IX Qualification

QW422 P-No 5B group 2, **QW432** F-No 4, **QW442** A-No 5

Composition (weld metal wt %)

	C	Mn	Si	S*	P*	Cr	Ni	Mo	Nb	V	N	Cu	Sn	Ni+Mn
min	0.08	0.50	--	--	--	8.0	0.4	0.85	0.04	0.15	0.03	--	--	--
max	0.12	1.20	0.50	0.01	0.01	10.0	0.8	1.2	0.07	0.25	0.07	0.25	<0.008	1.5
typ	0.1	0.6	0.25	0.008	0.01	9	0.7	1	0.05	0.2	0.05	0.05	0.003	1.3

* Low Ni variant is available, **Chromet 9-B9**.

All-weld mechanical properties

PWHT 755°C / 3h			min(1)	typical	550°C	600°C	650°C
Tensile strength		MPa	620	770	>450	>375	>285
0.2% Proof stress		MPa	530	640	>360	>255	>175
Elongation on 4d		%	17	22	--	--	--
Elongation on 5d		%	15	19	>15	>17	>21
Reduction of area		%	--	60	>68	>75	>80
Impact energy	+ 20°C	J	47	65	--	--	--
Lateral expansion	+ 20°C	mm	--	1.00	--	--	--
Hardness after PWHT		HV	--	250	--	--	--
Hardness as-welded		HV	--	450	--	--	--

(1) Minimum strength for parent material is lower than AWS requirement shown.

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	350	380	450	450
kg/carton	12.9	15.0	17.4	16.5
pieces/carton	651	405	234	150

Chromet 9-B9

MMA electrode meeting AWS/ASME

Product description

MMA electrode – manufactured to the requirements of AWS A5.5 E9015-B9

Specifications

AWS A5.5 E9015-B9
BS EN 1599 (E CrMo91 B 3 2)

ASME IX Qualification

QW422 P-No 5B group 2, **QW432** F-No 4, **QW442** A-No 5

Composition (weld metal wt %)

	C	Mn*	Si	S	P	Cr	Ni*	Mo	Nb	V	N	Cu	Al
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%. Nickel is below 0.4% (as parent material) although AWS allows up to 1.0%Ni. See **Chromet 9MV-N** for variant with 0.4 – 1.0%Ni conforming to BS EN specification.

All-weld mechanical properties

PWHT 760°C / 2h			min(1)	typical	550°C	600°C	650°C
Tensile strength		MPa	620	710	>450	>375	>285
0.2% Proof stress		MPa	530	590	>360	>255	>175
Elongation on 4d		%	17	22.5	--	--	--
Elongation on 5d		%	15	19	>15	>17	>21
Reduction of area		%	--	63	>68	>75	>80
Impact energy	+ 20°C	J	--	75	--	--	--
Lateral expansion	+ 20°C	mm	--	1.10	--	--	--
Hardness after PWHT		HV	--	240	--	--	--
Hardness as-welded		HV	--	450	--	--	--

(1) Minimum strength for parent material is lower than AWS requirement shown.

Packaging data

ø mm	2.5	3.2	4.0*	5.0
length mm	350	380	380/450	450
kg/carton	13.5	15	15/17.1	16.5
pieces/carton	657	378	264/249	150

* 450mm is standard length for 4.0mm, 380mm produced to order.

Chromet 91VNR

MMA electrode for root welding

Product description

MMA electrode for root welding applications.

Specifications

AWS A5.5 E9016-B9
BS EN 1599 E CrMo91 R 3 2

ASME IX Qualification

QW422 P-No 5B group 2, **QW432** F-No 4, **QW442** A-No 5

Composition (weld metal wt %)

	C	Mn*	Si	S	P	Cr	Ni*	Mo	Nb	V	N	Cu
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 + Mn <1.50

All-weld mechanical properties

PWHT 760°C / 2h			min(1)	typical
Tensile strength		MPa	620	750
0.2% Proof stress		MPa	530	600
Elongation on 4d		%	17	20
Elongation on 5d		%	16	18
Impact energy	+ 20°C	J	--	55
Hardness		HV	--	250

(1) Minimum strength for parent material is lower than AWS requirement shown.

Packaging data

ø mm	2.5	3.2
length mm	350	380
kg/carton	14.1	13.5
pieces/carton	714	408

Chromet 91VNB

MMA electrode for root welding

Product description

Basic coated MMA electrode for root welding applications made on high purity steel core wire. Recovery is approx 120% with respect to core wire, 65% with respect to whole electrode. Moisture resistant coatings giving very low weld metal hydrogen levels.

Specifications

AWS A5.5	E9015-B9
BS EN 1599	E CrMo91 B 3 2

ASME IX Qualification

QW422 P-No 5B group 2, **QW432** F-No 4, **QW442** A-No 5

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	V	N	Cu	Al
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

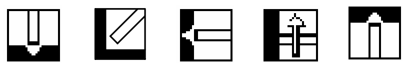
All-weld mechanical properties

PWHT 760°C / 2h			min [1]	typical
Tensile strength		MPa	620	750
0.2% Proof stress		MPa	530	600
Elongation on 4d		%	17	20
Elongation on 5d		%	16	18
Impact energy	+ 20°C	J	--	55

[1] Minimum strength for parent material is lower than AWS requirement shown.

Operating parameters

DC +ve, DC –ve or AC (OCV 70V min)



ø mm	2.5
min A	60
max A	110

Fume data

Fume composition (wt %)

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

9CrMoV-N

Solid wire for TIG and SAW

Product description

Solid wire, non-copper coated, for TIG and SAW

Specifications

	TIG	SAW
AWS A5.23	N/A	EB9
AWS A5.28	ER90S-B9	N/A
BS EN 12070	WCrMo91	(SCrMo91)

ASME IX Qualification

QW422 P-No 5B group 2, **QW432** F-No 6, **QW442** A-No 5

Composition (wire wt %)

	C	Mn	Si *	S	P	Cr	Ni	Mo	Nb	V	N	Cu	Al
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 properties

PWHT 750 – 760°C / 2 – 3h			min	TIG typical	SAW typical LA491 flux	SAW typical L2N flux
Tensile strength		MPa	620	800	750	750
0.2% Proof stress		MPa	415	700	630	630
Elongation on 4d		%	16	22	25	25
Elongation on 5d		%	17	19	23	23
Reduction of area		%	--	70	70	70
Impact energy	+ 20°C	J	-- *	220	45	35
Hardness		HV (mid)	--	265	250	250

* Minimum impact required by BS EN is 47 J.

9CrMoV-N (continued)

Parameters

	TIG	SAW	MIG
Shielding	Argon	LA491 or L2N flux	9CrMoV-N not recommended for MIG, Cormet M91 or Supercore F91 should be used.
Current	DC-	DC+	
Typical parameters 2.4mm ø	100A, 12V	450A, 30V, 450mm/min	

Packaging data

ø mm	TIG	SAW	MIG
0.8/0.9	Spool to order	--	Not recommended - see Supercore F91 or Cormet M91.
1.2	--	--	
1.6	5kg tube	--	
2.4	5kg tube	25kg coil	
3.2	5kg tube	25kg coil	

Fume data

Fume composition (wt %); TIG and SAW fume are negligible:

Fe	Mn	Ni	Cr[3]	Mo	Cu	OES (mg/m^3)
50	4	< 0.4	6	0.5	< 0.5	5

Cormet M91

Metal cored wire for MIG welding

Product description

Metal cored wire for MIG welding. High purity steel sheath with 96% metal recovery with respect to wire.

Specifications

AWS A5.28	E90C-G (B9)
BS EN ISO 17634-B	T69T15-0M-9C1MV

ASME IX Qualification

QW422 P-No 5B group 2, **QW432** F-No 6, **QW442** A-No 5

Composition (weld metal wt %)

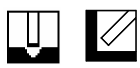
	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	V	N	Cu	Al
min	0.08	0.60	--	--	--	8.0	--	0.85	0.03	0.18	0.03	--	--
max	0.13	1.20	0.40	0.015	0.020	10.0	0.80	1.20	0.07	0.25	0.07	0.15	0.04
typ	0.1	1	0.3	0.01	0.01	9	0.3	1	0.05	0.2	0.05	0.05	0.03

All-weld mechanical properties

PWHT 760°C / 2h			min	typical		
				Ar-2½%CO_2	80/20	Ar-He-CO_2
Tensile strength		MPa	620	780	780	780
0.2% Proof stress		MPa	565	650	650	650
Elongation on 4d		%	16	17	17	17
Elongation on 5d		%	14	16	16	16
Impact energy	+ 20°C	J	--	30	25	35
Lateral expansion	+ 20°C	mm	--	0.30	0.28	0.45
Hardness		HV	--	260	260	260

Parameters

Operability is influenced by the type of shielding gas; higher CO_2 levels, up to 20%, give better arc characteristics but lower CO_2 and O_2 levels produce better impact properties. The best compromise is considered to be obtained from Ar-2½%CO_2 although if impact properties are not a major concern, higher CO_2 levels can be used to obtain optimum arc characteristics.



ø mm	Gas flow	Optimum	Stickout
1.2	15 – 25 l/min	DC+ 260A 28V	10 – 20mm
1.6	15 – 25 l/min	DC+ 330A 29V	15 – 25mm

Packaging data

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. 15kg spools. Where possible, preferred storage conditions are 60% RH max, 18°C min.

Fume data

Fume composition (wt %)

Fe	Mn	Ni	Cr[3]	Mo	Cu	OES (mg/m^3)
60	5	< 0.5	5	<0.1	<0.1	5

LA491 and L2N

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

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 (flux wt %)

	LA491	L2N
$SiO_2 + TiO_2$	15%	30%
CaO + Mg O	40%	35%
AlO_3 + MnO	20%	5%
CaF_2	25%	20%
Basicity index (Boniszewski)	~2.7	~1.3

Analysis deposit (typical)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	V	N
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	0.08	0.8	0.35	0.005	0.010	8.6	0.6	1	0.05	0.17	0.05
Deposit with L2N	0.09	0.5	0.6	0.005	0.012	8.3	0.6	1	0.04	0.16	0.05

All-weld mechanical properties

PWHT 750–760°C / 2–3h			min	SAW typical LA491 flux	SAW typical L2N flux
Tensile strength		MPa	620	750	750
0.2% Proof stress		MPa	415	630	630
Elongation on 4d		%	16	25	25
Elongation on 5d		%	17	23	23
Reduction of area		%	--	70	70
Impact energy	+ 20°C	J	--*	40	35
Hardness		HV (mid)	--	250	250

* 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 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 <5ml H_2/100g.	Packaging: 20kg sealed drums Preferred storage <60%RH, > 18°C. If flux becomes damp, rebake at 150-250°C/1–2hours to restore to as-packed condition.

Supercore F91

All-positional flux cored wire

Product description

All-positional flux cored wire designed to weld equivalent modified 9CrMo steels (P91). Rutile flux system with an alloyed strip producing weld metal recovery of about 90%.

Specifications

AWS A5.29	E91T1-B9M
BS EN ISO 17634-B	T69T1-1M-9C1MV

ASME IX Qualification

QW432 F-No -, **QW442** A-No -

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	V	N	Cu	Al	Ni+Mn
min	0.08	0.60	--	--	--	8.0	--	0.85	0.02	0.15	0.02	--	--	--
max	0.13	1.20	0.50	0.015	0.020	10.0	0.80	1.2	0.07	0.25	0.07	0.15	0.04	1.5
typ	0.1	0.8	0.3	0.010	0.016	9	0.5	1	0.04	0.2	0.05	0.05	0.01	1.3

All-weld mechanical properties

PWHT 760°C / 2h			min	typical	High Temperature +566°C	+600°C	+650°C
Tensile strength		MPa	620	790	450	420	396
0.2% Proof stress		MPa	565	660	360	288	245
Elongation on 4d		%	16	20	21	27	29
Elongation on 5d		%	14	18	20	25	26
Reduction of area		%	--	55	73	81	85
Impact energy	+ 20°C	J	--	25	--	--	--
Hardness		HV	--	260	--	--	--

Operating parameters

Shielding gas: 80%Ar-20%CO_2 (or 15 – 25%CO_2) or 100% CO_2 at 20-25l/min.

Current: DC+ve ranges as below:

ø	welding position	amp-volt range *	typical	stickout
1.2mm (0.045in)	Positional	140-170A, 24-26V	160A, 25V	15-25mm

* Using 100%CO_2 the voltage should be increased by 1-2V

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_2:

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
18	8	< 0.5	3	3	< 1	8	1.7

Low Alloy Steels

DATA SHEET **A-18**

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CONSUMABLES FOR E911 CrMo STEEL

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.

$P = °C+273(20+\log t) \times 10^{-3}$ (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).

Products available

Process	Product	Specification
MMA	**Chromet 10MW**	--
FCW	**Cormet 10MW**	--

CHROMET 10MW

MMA electrode for E911 creep-resisting 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 E9015-G (E9015-B9 modified)

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Nb	V	N	Al
min	0.08	0.50	0.15	--	--	9.0	0.40	0.9	0.9	0.04	0.18	0.04	--
max	0.13	1.20	0.50	0.01	0.02	10.0	0.80	1.1	1.1	0.07	0.25	0.07	0.02
typ	0.1	0.8	0.25	0.008	0.010	9.5	0.5	1	1	0.05	0.22	0.05	0.01

All-weld mechanical properties

Typical after PWHT: 730°C/12h			typical
Tensile strength		MPa	760
0.2% Proof stress		MPa	620
Elongation on 5d		%	19
Reduction of area		%	62
Impact energy	+ 20°C	J	60
Hardness		HV	250

Operating parameters

DC +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	14.4	16.5	16.8
pieces/carton	393	225	159

Storage

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_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 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	Pb	F	OES (mg/m^3)
15	5	<0.2	<3	<0.1	<0.1	18	1.7

Cormet 10MW

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 -

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Nb	V	N	B	Al	Cu
min	0.08	0.50	--	--	--	9.0	0.40	0.9	0.9	0.04	0.18	0.04	--	--	--
max	0.13	1.20	0.40	0.015	0.020	10.0	0.85	1.1	1.1	0.07	0.25	0.07	0.0015	0.04	0.1
Typ	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	0.05

All-weld mechanical properties

PWHT 755°C / 3h		typical
Tensile strength		770
0.2% Proof stress		650
Elongation on 4d		11
Elongation on 5d		9
Reduction of area		20
Impact energy	+ 20°C	14
Hardness		260

Operating parameters

Shielding gas: Ar + 2.5-20%CO_2 at 20-25l/min (operability is improved at higher CO_2 contents but impact properties are better with lower CO_2 contents).

Current: DC+ve ranges as below:

ø	amp-volt range	stickout
1.2mm (0.045in)	260A, 28V	15-25mm

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_2:

Fe	Mn	Ni	Cr[3]	Cu	Pb	OES (mg/m^3)
60	5	< 0.5	5	< 0.1	< 0.1	5.0

Low Alloy Steels

DATA SHEET **A-19**

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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	Type 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.

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).

Products available

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

METRODE WELDING CONSUMABLES

CHROMET 12MV

Basic all-positional MMA electrode for 12%Cr creep resisting steel

Product description

Basic low hydrogen metal powder type made on high purity core wire. Moisture resistant coating giving very low weld metal hydrogen levels.

Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.

Specifications

BS EN 1599	E CrMoWV12 B 3 2
DIN 8575	E CrMoWV 12 B 26

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	V
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

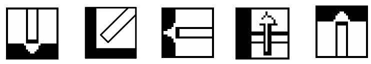
All-weld mechanical properties

PWHT 760ºC / 3 hrs			Room temperature		Elevated temperature 350°C		400°C		450°C	
			min *	typical	min	typ	min	typ	min	typ
Tensile strength		MPa	690	750	--	590	--	560	--	520
0.2% Proof stress		MPa	550	550	370	450	355	420	325	410
Elongation on 4d		%	--	24	--	18	--	20	--	17
Elongation on 5d		%	15	21	--	16	--	16	--	14
Reduction of area		%	--	55	--	50	--	48	--	48
Impact energy	+ 20°C	J	34	40	--	--	--	--	--	--
	0ºC		--	33	--	--	--	--	--	--
Hardness		HV	--	235	--	--	--	--	--	--

* Minimum requirements after PWHT of 740-780°C/2 hours.

Operating parameters

DC +ve or AC (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	12.6	13.8	16.8	16.8
pieces/carton	600	339	234	150

Storage

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_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 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)
20	4	0.1	3	<0.2	0.1	0.1	16	1.7

12CrMoV

Solid TIG wire for 12%Cr creep resisting steel

Product description

Solid wire for TIG.

Specifications

BS EN 12070	W CrMoWV 12 Si
DIN 8575	SG CrMoWV12

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	V	W
min	0.17	0.40	0.20	--	--	10.5	--	0.80	0.20	0.35
max	0.24	1.00	0.60	0.020	0.025	12.0	0.80	1.20	0.40	0.80
typ	0.2	0.6	0.4	0.005	0.01	11	0.6	1	0.3	0.5

All-weld mechanical properties

Typical values after PWHT 760ºC/2h:			min	typical
Tensile strength		MPa	690	750
0.2% Proof stress		MPa	550	600
Elongation on 5d		%	15	20
Impact energy	+ 20°C	J	34	50

Operating parameters

	TIG
Shielding	Argon *
Current	DC-
Diameter	2.4
Voltage	100A, 12V

Packaging data

ø mm	TIG
2.4	5kg tube

Fume data

Fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m^3)
55	4	8	<0.5	<0.5	<0.5	5

Low Alloy Steels

DATA SHEET A-20

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Fax: +44(0)1932 569449 Technical
Fax: +44(0)1932 566199 Export
Email: info@metrode.com
Internet: http//www.metrode.com

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)

EN
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.

PWHT

Minimum preheat temperature 200°C with maximum interpass temperature of 350°C; in practice a preheat-interpass range of 200 – 300°C is normal. To ensure full martensite transformation welds should be cooled to ~100°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°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.

Products available

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

Chromet 92

MMA all-positional electrode for joining P92 creep resisting steel

Product description

Basic coated MMA electrode made on pure low carbon core wire. Moisture resistant coatings giving very low weld metal hydrogen levels.

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

Specifications

None applicable.

ASME IX Qualification

QW422 P-No 5B group 2, **QW432** F-No --, **QW442** A-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Nb	V	N	B	**Al**	Cu
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 properties

PWHT 760°C / 2-4h			min	typical	----- High Temperature -----		
					+550°C	+600°C	+650°C
Tensile strength		MPa	620	740	511	422	340
0.2% Proof stress		MPa	440	630	419	320	229
Elongation on 4d		%	17	22	15	19.5	19.5
Elongation on 5d		%	16	19	14	18	18
Reduction of area		%	--	50	64	73	80
Impact energy	+ 20°C	J	--	60	--	--	--
Hardness		HV	--	230-260	--	--	--

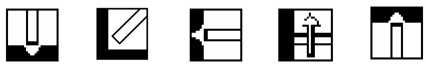
Packaging data

ø mm	2.5	3.2	4.0*	5.0
length mm	350	380	380/450	450
kg/carton	13.5	15.0	15.0/17.1	16.5
pieces/carton	657	378	264/249	150

* 450mm is the standard length for 4.0mm, 380mm produced to order.

Operating parameters

DC +ve. AC (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

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 quivers: no limit, but maximum 6 weeks recommended.

Fume data

Fume composition (wt %)

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

9CrWV

Solid wire for TIG and SAW

Product description

Solid wire, non-copper coated, for TIG and SAW welding.

Specifications

None applicable.

ASME IX Qualification

QW422 P-No 5B group 2, **QW432** F-No --, **QW442** A-No --

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Nb	V	N	B	Al	Cu
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	0.015	9.5	0.80	0.60	2.0	0.07	0.25	0.07	0.005	0.03	0.15
Typ	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

PWHT 760°C / 2 – 4h			min	TIG typical	----- High Temperature TIG ----- +550°C	+600°C	+650°C
Tensile strength		MPa	620	800	455	387	312
0.2% Proof stress		MPa	440	700	374	282	200
Elongation on 4d		%	16	22	24.5	20.5	28
Elongation on 5d		%	--	19	22.5	19	25.5
Reduction of area		%	--	70	82	85	89
Impact energy	+ 20°C	J	--	220	--	--	--
Hardness		HV (mid)	--	265	--	--	--

Parameters

	TIG	SAW	MIG
Shielding	Argon	LA491 flux	9CrWV is not recommended
Diameter, mm	2.4	2.4	for MIG welding.
Current	DC-	DC+	Supercore F92 should be used.
Typical parameters	100A, 12V	450A, 30V, 450mm/min	

Packaging data

ø mm	TIG	SAW
2.4	5kg tube	25kg coil

Fume data

Fume composition (wt %); TIG and SAW fume is negligible:

Fe	Mn	Ni	Cr	Mo	Cu	OES (mg/m^3)
50	4	< 0.4	6	0.5	< 0.5	5

LA491 Flux

Sub-arc flux for use with 9CrWV solid wire

Product description

Agglomerated fluoride-basic submerged arc welding flux

Specifications

Flux: **BS EN 760** SA FB 255 AC

Composition (weld metal wt %)

15% SiO_2 + Ti O_2
40% CaO + Mg O
20% AlO_3 + MnO
25% CaF_2
Basicity index ~2.7 (Boniszewski)

Analysis deposit (typical)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Nb	V	N	B
9CrWV Wire	0.11	0.7	0.3	0.01	0.01	9.0	0.5	0.4	1.7	0.06	0.19	0.05	0.003
Deposit	0.09	0.7	0.3	0.01	0.01	8.5	0.5	0.4	1.7	0.04	0.16	0.04	0.001

LA491 Flux (continued)

Sub-arc flux for use with 9CrWV solid wire

All-weld mechanical properties

PWHT 760°C / 2 – 4h			SAW & LA491 min	SAW & LA491 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 <5ml H_2/100g.

Supercore F92

All-positional flux cored wire

Product description

All-positional flux cored wire designed to weld equivalent P92 steels. Rutile flux system with an alloyed strip producing weld metal recovery of about 90%.

Specifications

AWS A5.29 No current national standards.

ASME IX Qualification

QW432 F-No -, **QW442** A-No -

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Nb	V	N	B	Al	Cu
min	0.08	0.40	--	--	--	8.5	0.30	0.30	1.5	0.03	0.15	0.03	0.001	--	--
max	0.13	1.20	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	0.8	0.30	0.01	0.017	9	0.5	0.45	1.7	0.04	0.2	0.04	0.003	<0.01	<0.05

All-weld mechanical properties

PWHT 760°C / 4-6h		typical	High Temperature +550°C	+600°C	+650°C	+700°C
Tensile strength		775	471	400	308	215
0.2% Proof stress		650	385	294	194	125
Elongation on 4d		21	18.5	25	26.5	25.5
Elongation on 5d		18	17	22.5	24.5	23.5
Reduction of area		50	68	77	81	86
Impact energy	+ 20°C	25	--	--	--	--
Hardness		260	--	--	--	--

Operating parameters

Shielding gas: 80%Ar-20%CO_2 (or 15 – 25%CO_2) or 100% CO_2 at 20-25l/min.
Current: DC+ve ranges as below:

ø	welding position	amp-volt range *	typical	stickout
1.2mm (0.045in)	Positional	140-170A, 24-26V	160A, 25V	15-25mm

***** Using 100%CO_2 the voltage should be increased by 1-2V

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_2:

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
18	8	< 0.5	3	3	< 1	8	1.7

Low Alloy Steels

T23 CONSUMABLES

DATA SHEET **A-21**

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

Alloy type

2¼%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' 2¼%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.

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°C/30 minutes; the ASME code case specifies a minimum tempering temperature of 730°C for base material. When it has been applied PWHT in the range 715-740˚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.

Products available

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

Chromet 23L

MMA all-positional electrode for joining T23 creep resisting steel

Product description

Basic coated MMA electrode made on pure low carbon core wire. Moisture resistant coatings giving very low weld metal hydrogen levels.

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

Specifications

None applicable.

ASME IX Qualification

QW422 P-No 5B group 2, **QW432** F-No --, **QW442** A-No --

Composition (weld metal wt %)

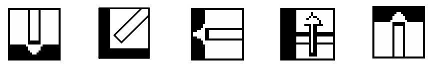
	C	Mn	Si	S	P	Cr	Ni	Mo	W	Nb	V	N	B	Al	Cu
min	0.04	0.10	--	--	--	1.9	--	0.05	1.45	0.02	0.20	--	0.0005	--	--
max	0.10	1.00	0.50	0.015	0.020	2.6	0.80	0.30	1.75	0.08	0.30	0.03	0.0060	0.03	0.15
typ	0.05	0.5	0.25	0.01	0.01	2.2	0.6	0.2	1.6	0.03	0.23	0.02	0.001	<0.01	<0.05

All-weld mechanical properties

			typical as-welded	typical 715°C/1
Tensile strength		MPa	940	700
0.2% Proof stress		MPa	870	625
Elongation on 4d		%	19	22
Elongation on 5d		%	16	20
Reduction of area		%	50	60
Impact energy	+ 20°C	J	22	70
Hardness		HV	290-350	220-260

Operating parameters

DC +ve. 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	350	380	450
kg/carton	12.0	15.0	16.2
pieces/carton	621	396	228

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 quivers: no limit, but maximum 6 weeks recommended.

Fume data

Fume composition (wt %)

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

2CrWV

Solid T23 wire for TIG welding

Product description

Solid wire, copper coated, for TIG welding.

Specifications

None applicable.

ASME IX Qualification

QW422 P-No 5B group 2, **QW432** F-No --, **QW442** A-No --

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Nb	V	B	Al	Cu
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
Typ	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

			typical as-welded	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
Shielding	Argon
Diameter, mm	2.4
Current	DC-
Typical parameters	100A, 12V

Packaging data

ø mm	TIG
2.4	5kg tube

Fume data

Fume composition (wt %); TIG and SAW fume is negligible:

Fe	Mn	Ni	Cr	Mo	Cu	OES (mg/m^3)
55	5	1.3	<0.5	<0.5	1.2	5

LA491 FLUX

Sub-arc flux

Product description

Agglomerated fluoride-basic non-alloying flux for submerged arc welding.

Specifications

DIN 32522	B FB 6 55455 AC 8
BS EN 760	SA FB 255 AC

ASME IX Qualification

QW432 F-No -, **QW442** A-No -

Composition (typical wt%)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Nb	V	Cu	B
2CrWV wire	0.06	0.6	0.30	<0.01	0.01	2.4	0.5	0.2	1.6	0.05	0.25	0.1	0.003
Deposit	0.05	0.6	0.35	<0.01	0.01	2.3	0.5	0.2	1.5	0.04	0.22	0.1	0.002

All-weld mechanical properties with 2CrWV wire

			740°C/2h
Tensile strength		MPa	645
0.2% Proof stress		MPa	570
Elongation on 4d		%	22
Elongation on 5d		%	18
Reduction of area		%	55
Impact energy	+20°C	J	175
Hardness		HV (mid)	245

Operating parameters

Current: DC +ve ranges as below:

ø mm	amp-volt range	typical	stickout
2.4	250-450A, 28-32V	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

DATA SHEET A-23

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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:

DIN	15NiCuMoNb5
	1.6368
BS EN 10216-2	15NiCuMoNb5-6-4
	1.6368
BS 3604	Grade 591
ASTM	Code Case 2353
	A335 P36
Proprietary	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.

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°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±30°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.

Products available

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-positional NiMo low alloy steel MMA electrode

Product description

MMA electrode with a basic flux coating on high purity mild steel core wire. Moisture resistant coating provides 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 E9018-G

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.07	0.8	--	--	--	--	0.8	0.20	--
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/1-2h:		min	typical	High Temperature 250°C	350°C	450°C
Tensile strength	MPa	620	720	650	640	545
0.2% Proof stress	MPa	530	645	505	445	432
Elongation on 4d	%	17	26	22	28	24
Elongation on 5d	%	--	23	--	--	--
Reduction of area	%	--	65	57	69	73

Operating parameters

DC +ve or AC (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

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_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 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 composition, wt % typical:

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

MnMo

Solid MnMo low alloyed wire for TIG and MIG

Product description

Solid copper coated wire for TIG and MIG.

Specifications

AWS A5.28	ER80S-D2, ER90S-D2
BS EN 440	(G4Mo)
BS 2901: Pt1	A31

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 11

Composition (wire wt %)

	C	Mn	Si	S	P	Ni	Mo	Cu
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

Typical values PWHT 590-620°C/1-2h			min *	TIG	MIG		High Temperature (TIG)		
					Ar + 5%CO_2	Ar + 20%CO_2	250°C	350°C	450°C
Tensile strength		MPa	550	640	725	605	650	665	585
0.2% Proof stress		MPa	470	530	625	490	525	490	460
Elongation on 4d		%	17	32	28	25	24	27	25
Impact energy	- 30°C	J	27	200	>100	>100	--	--	--
Hardness cap/mid		HV	--	235/210	235/220	220/205	--	--	--

* Minimum as-welded values are for AWS **ER80S-D2**. As shown MAG welds using more oxidising shielding gas (higher CO_2 + O_2) have lower strength. The AWS classification for ER80S-D2 is based on 100%CO_2 which is seldom used; alternatively this wire can also be classified as **ER90S-D2** using low CO_2 gas mixtures.

Typical operating parameters

	TIG	MIG
Shielding	Argon	Ar + 5-20%CO_2 *
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	120A, 14V	280A, 26V

* Ar + 5%CO_2 provides the highest strength and best impact properties, see above. Other proprietary gas mixtures also suitable.

Packaging data

ø mm	TIG	MIG
1.2	--	15kg spool
1.6	5kg tube	--
2.4	5kg tube	--
3.2	To order	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
55	10	<0.1	<0.1	<0.5	1.2	5

SA1NiMo

Solid NiMo alloyed wire for SAW

Product description	Solid copper coated wire for submerged arc welding. Nominal composition of 1%Ni-0.5%Mo capable of achieving 90ksi (620MPa) tensile strength. Supplied to NACE MR0175 1.0%Ni maximum on request..
Specifications	**AWS A5.23** EF3 **BS EN 756** S3Ni1Mo
ASME IX Qualification	**QW432** F-No 6, **QW442** A-No 10 (Nearest)

Composition (wire wt %)

	C	Mn	Si	S	P	Ni *	Mo	Cr	Cu
min	0.08	1.30	0.05	--	--	0.8	0.45	--	--
max	0.15	2.40	0.25	0.020	0.020	1.2	0.65	0.20	0.30
typ	0.10	1.75	0.2	0.005	0.01	0.9	0.55	0.05	0.1

* Ni supplied to 1.0% maximum (NACE MR0175) on request.

All-weld mechanical properties

Typical values as-welded & PWHT			AW	600°C/1h
Tensile strength		MPa	700	680
0.2% Proof stress		MPa	600	580
Elongation on 4d		%	20	22
Impact energy	- 20°C	J	90	120

Typical operating parameters

	SAW
Shielding	LA121 flux
Current	DC+
Diameter	2.4mm
Parameters	450A, 30V, 450mm/min

Packaging data

ø mm	SAW
2.4	25kg coil

Fume data

Fume composition (wt %) (SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
50	10	<0.5	<0.5	<1.5	1.2	5

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METRODE WELDING CONSUMABLES

CHROMET 921

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 ~3kJ/mm. Cooling to ~100°C before PWHT is advisable to ensure full transformation to martensite. PWHT (for >27J): 730°C/16-24h or preferably 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: 70V)

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°C in holding oven, or 50 – 150°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^3)
15	5	<0.1	<3	0.1	<0.1	18	1.7

All-weld mechanical properties

PWHT 760°C 4h or equivalent			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 %)

	C	Mn	Si	S	P	Cr	Ni	Mo	V	Nb	N	B	Co
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

DATA SHEET A-40

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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°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°C eg. **offshore construction**, **pipelines** and **pressure vessels**.

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.

Products available

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

TUFMET 1Ni.B

1%Ni MMA electrode for good low temperature toughness

Product description

MMA electrode with a basic, metal powder, type flux on high purity low carbon core wire. 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	E8018-C3
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
Conforms with	NACE MR0175

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	V	Nb	Cu
min	--	0.80	0.20	--	--	--	0.80	--	--	--	--
max	0.10	1.20	0.50	0.030	0.030	0.15	1.00*	0.2	0.05	0.05	0.3
typ	0.05	1	0.3	0.015	0.015	0.05	0.9	0.1	0.01	<0.05	0.05

* BS and AWS 1.10%Ni max.

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	550-680	610
0.2% Proof stress		MPa	470-550	520
Elongation on 4d		%	24	27
Elongation on 5d		%	17	25
Reduction of area		%	--	70
Impact energy	- 20°C	J	--	150
	- 40°C	J	47	120
	- 50°C	J	--	80
	- 60°C	J	--	65

Operating parameters

DC +ve or AC (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	13.5	16.8	16.2
pieces/carton	627	390	243	162

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 working shift of 8h.
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 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	Pb	F	OES (mg/m^3)
14	5	< 0.5	< 0.1	0.2	< 0.1	18	5

1Ni

1%Ni wire for improved toughness

Product description

Solid copper coated wire for TIG and MIG.

Specifications

AWS A5.28	ER80S-Ni1
BS EN 440 & 1668	(G3Ni1 – MIG; W3Ni1 – TIG)

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 10

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo *	Cu	V
min	0.06	0.80	0.40	--	--	--	0.80	--	--	--
max	0.12	1.25	0.80	0.015	0.020	0.15	1.00	0.35	0.35	0.05
typ	0.10	1	0.5	0.010	0.010	0.05	0.9	0.02	0.2	0.01

* Most wire has a typical Mo of 0.02% but some batches will have typically 0.3% Mo.

All-weld mechanical properties

Typical values as welded			min *	TIG	MAG Ar + 5%CO_2
Tensile strength		MPa	550	550-650	571
0.2% Proof stress		MPa	470	460-510	475
Yield strength		MPa	--	472	498
Elongation on 4d		%	24	32	35
Impact energy	- 50°C	J	27	> 120	> 130
	- 75°C	J	--	> 110	> 50
Hardness cap/mid		HV	--	195/240	190/205

* Minimum as-welded properties according to AWS. All-weld tests show actual proof stress values close to minimum or slightly lower, depending on process, shielding gas and Mo content (higher Mo wires produce the higher typical strengths reported). However, note that yield point is typically 10-20MPa above the 0.2% proof stress, and in either case, exceeds 450MPa (65ksi).

Typical operating parameters

	TIG	MIG
Shielding	Argon	Ar + 5-20%CO_2 *
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Voltage	120A, 14V	280A, 26V

* Ar + 1-5%O_2 and proprietary mixtures also suitable.

Packaging data

ø mm	TIG	MIG
1.0	--	15kg spool
1.2	--	15kg spool
1.6	5kg tube	--
2.0	to order	--
2.4	5kg tube	--
3.0 (not 3.2)	5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
55	6	< 0.1	0.5	< 0.1	1.2	5

METCORE DWA 55E

Ni alloyed all-positional flux cored wire

Product description

Flux cored wire with a rutile flux system for spray transfer at low currents and easy operation in all welding positions. The wire is alloyed with about 0.4%Ni and provides good as-welded ed toughness down to –40°C. Low moisture potential giving weld metal hydrogen content of typically < 5ml/100g.

Metal recovery 90% with respect to wire.

Specifications

AWS A5.20	E71T-5 (MJ)*
BS EN 758	T424PM1 H5
BS 7084	T541 GPH

* Meets suffix M (Ar+20%CO_2) and J (27J at –40°C) requirements. Note that the new classification E71T-9MJ introduced in AWS A5.20-95 is strictly more appropriate.

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 1

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	V
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 properties

As welded (PWHT with caution)			min *	typical as-welded	typical 600°C/4h **
Tensile strength		MPa	480	580	575
0.2% Proof stress		MPa	400	500	485
Elongation on 4d		%	22	32	29
Impact energy	- 40°C	J	27	115	>27
Hardness		HV	--	190	180

* As specified by AWS A5.20 E71T-5MJ as-welded.
** PWHT has a detrimental effect on impact energy but all batches are impact tested after PWHT of 600°C/4h.

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 80%.

Current: DC+ve ranges as below:

ø mm	amp-volt range	typical	stickout
1.2	130-300A, 16-32V	232A, 26V	15-25mm

Packaging data

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 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	Cr	Ni	Cu	F	OES (mg/m^3)
33	12	< 0.5	< 0.1	< 0.5	2	5

Low Alloy Steels

2%Ni FOR IMPROVED TOUGHNESS

DATA SHEET **A-41**

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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 -60ºC.

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).

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.

Products available

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

METRODE
WELDING CONSUMABLES

TUFMET 2Ni.B

2.5%Ni MMA electrode for good low temperature toughness

Product description

MMA electrode with a basic flux, metal powder type coating on low carbon core wire. 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	E8018-C1
BS EN ISO 2560-A	E 46 6 2Ni B 42
BS EN ISO 2560-B	E5518-N5 P U
BS 2493	2Ni.BH
DIN 8529	EY 4675 2NiB

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Ni	Cr	Mo	Cu	V	Nb
min	--	0.50	--	--	--	2.00	--	--	--	--	--
max	0.10	1.25	0.80	0.030	0.030	2.75	0.2	0.2	0.3	0.05	0.05
typ	0.05	0.75	0.3	0.015	0.010	2.4	0.05	0.05	0.05	0.01	<0.01

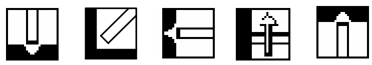
All-weld mechanical properties

As welded or PWHT 605ºC/1h *			min	typical
Tensile strength		MPa	550-680 **	600
0.2% Proof stress		MPa	460	520
Elongation on 4d		%	19	25
Elongation on 5d		%	20	23
Reduction of area		%	--	70
Impact energy	- 60°C	J	47	100
	- 75°C	J	-- ***	65

* BS & BS EN ISO-A properties are as-welded, AWS & BS EN ISO-B after PWHT.
** Maximum according to DIN 8529 is optional.
*** Typically >30J as-welded, meeting BS 2Ni.LB/AWS E7018-C1L properties.

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	350	380	450
kg/carton	12.0	13.8	16.8
pieces/carton	609	405	270

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, 300-350ºC/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 ovens, or 50-150ºC in heated quivers: 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^3)
14	5	<0.5	<0.1	0.2	<0.1	18	5

2Ni

Solid wire for TIG and MIG welding

Product description

Solid copper coated wire for TIG and MIG.

Specifications

AWS A5.28	ER80S-Ni2
BS EN 440 and 1668	(G 2Ni2 - MIG: W 2Ni2 - TIG)

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 10

Composition (wire wt %)

	C	Mn	Si	S	P	Ni	Cu
min	0.06	0.8	0.40	--	--	2.00	--
max	0.12	1.25	0.80	0.025	0.025	2.75	0.35
typ	0.08	1	0.5	0.010	0.010	2.5	0.10

All-weld mechanical properties

Typical values as welded (AW) and PWHT 605ºC/1h:				TIG		MAG: Ar + 5%CO_2		MAG: Ar + 20%$C0_2$	
			min*	AW	PWHT	AW	PWHT	AW	PWHT
Tensile strength		MPa	550	580	556	650	585	580	555
0.2% Proof stress		MPa	470	470	452	540	460	470	425
Elongation on 4d		%	24	32	35	28	32	28	32
Impact energy	- 60°C	J	27	175	200	45	140	40	100
	-101ºC	J	--	--	34	--	50	--	30
Hardness cap/mid		HV	--	220/190	185/220	240/230	195/185	220/195	185/175

* Minimum properties after PWHT 620ºC/1h according to AWS. Actual tests show conformance as-welded, as required for most fabrications. Proof stress values below AWS are found after PWHT at 605ºC/1h (=typical practice and PWHT for AWS E8018-C1/Tufmet 2Ni.B).

Note that superior as-welded toughness may be obtained with Metrode 1Ni.

Typical operating parameters

	TIG	MIG
Shielding	Argon	Ar + 5-20%CO_2 *
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	120A, 14V	280A, 26V

* Ar + 1-5%O_2 and proprietary mixtures also suitable.
Less oxidising shielding gas such as Ar + 5%CO_2 produced the best mechanical properties, see above.

Packaging data

ø mm	TIG	MIG
1.2	--	15kg spool
1.6	5kg tube	--
2.0	To order	--
2.4	5kg tube	--
3.2	To order	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
54	6	<0.1	1.5	<0.1	1.2	5

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METRODE WELDING CONSUMABLES

DATA SHEET A-42

TUFMET 3Ni.B

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.

Plate	BS1501Grade 503 and A203 Grades D,E,F
Forgings	BS1503 Grade 503 and ASTM A350 Grade LF3
Castings	BS1504 Grade 503 LT60 and ASTM A352 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 thin-wall 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.

Composition (weld metal wt %)

	C	Mn	Si	S	P	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

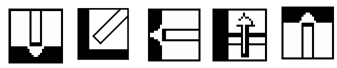
All-weld mechanical properties

As welded or PWHT 605°C/1h[1]			min	typical
Tensile strength		MPa	560-680[2]	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.

Parameters

DC +ve



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_2 <10ml/100g, 300-350°C/1-2h to ensure H_2 <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:

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

Low Alloy Steels

DATA SHEET **A-50**

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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

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°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

General Data for all MMA Electrodes

Storage

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_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 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	F	OES (mg/m^3)
16	7	<0.1	<0.1	<0.2	17	5

E9018-D1

All-positional MnMo low alloy steel MMA electrode

Product description

MMA electrode with a basic flux coating on high purity mild steel core wire. Moisture resistant coating provides 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	E9018-D1
BS 2493	MnMoBH
DIN 8529	(ESY 5564 MnMoB)

ASME IX Qualification

QW432 F-No 4, **QW442** A-No 11

Composition (weld metal wt %)

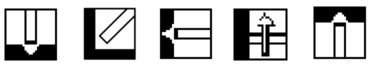
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	--	1.25	--	--	--	--	--	0.25	--
max	0.10	1.75	0.80	0.025	0.025	--	--	0.45	--
typ	0.07	1.5	0.4	0.01	0.015	0.15	0.15	0.35	0.05

All-weld mechanical properties

PWHT 620°C/1h:			min	typical
Tensile strength		MPa	630	670
0.2% Proof stress		MPa	550	605
Elongation on 4d		%	17	25
Elongation on 5d		%	15	20
Reduction of area		%	--	50
Impact energy	- 30°C	J	47	90
	- 50°C	J	30	55
Hardness		HV	--	210

Operating parameters

DC +ve or AC (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	13.8	15.9	16.8
pieces/carton	621	387	228	153

E10018-D2

MnMo low alloy steel MMA electrode

Product description

MMA electrode with a basic flux coating on high purity mild steel core wire. Moisture resistant coating provides 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	E10018-D2
BS 2493	(2MnMoBH)
BS EN 757	(E 624 MnMoB)
DIN 8529	(ESY 6264 MnMoB)

ASME IX Qualification

QW432 F-No 4, **QW442** A-No 11

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.07	1.65	0.20	--	--	--	--	0.25	--
max	0.15	2.00	0.60	0.025	0.025	--	0.9	0.45	--
typ	0.10	1.8	0.4	0.01	0.015	0.15	0.6	0.35	0.05

All-weld mechanical properties

typical after PWHT:			min	620°C/1h *	645°C/4h **
Tensile strength		MPa	690	760	700
0.2% Proof stress		MPa	620	690	620
Elongation on 4d		%	16	25	26
Elongation on 5d		%	18	21	22
Reduction of area		%	--	65	67
Impact energy	0°C	J	--	--	>100
	- 40°C	J	27	>27	>60
Hardness		HV	--	250	230
		HRC	--	--	<22

* PWHT according to AWS.

** PWHT typically applied to weldments in alloy 4130 to meet <22HRC in HAZ for oilfield sour service (NACE MR0175).

Operating parameters

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

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

Packaging data

ø mm	2.5	3.2	4.0	5.0	6.0
length mm	350	380	450	450	450
kg/carton	12.0	12.6	16.8	17.1	16.5
pieces/carton	633	351	243	159	105

MnMo

Solid MnMo alloyed wire for TIG and MIG

Product description

Solid copper coated wire for TIG and MIG.

Specifications

AWS A5.28	ER80S-D2, ER90S-D2
BS EN ISO 16834-B	4M31
BS EN 440	(G4Mo)
BS 2901: Pt1	A31

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 11

Composition (wire wt %)

	C	Mn	Si	S	P	Ni	Mo	Cu
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

Typical values as-welded (AW) & PWHT				TIG			MAG Ar + 5%CO_2		MAG Ar + 20%CO_2	
			min *	AW	620°C/1	645°C/4	AW	620°C/1	AW	620°C/1
Tensile strength		MPa	550	720	640	610	725	>635	625	605
0.2% Proof stress		MPa	470	610	530	530	625	>525	510	490
Elongation on 4d		%	17	27	32	31	29	>25	28	25
Impact energy	- 30°C	J	27	>80	>200	--	>100	--	>55	>100
	- 45°C	J	--	>50	>100	>130	>70	>110	--	--
Hardness		HV	--	250	220	220	235	220	215	205

* Minimum as-welded values are for AWS **ER80S-D2**. As shown MAG welds using more oxidising shielding gas (higher CO_2 + O_2) have lower strength. The AWS classification for ER80S-D2 is based on 100%CO_2 which is seldom used; alternatively this wire can also be classified as **ER90S-D2** using low CO_2 gas mixtures. Maximum strength is found with Ar + 5%CO_2, an economic procedure to obtain as-welded properties equivalent to AWS **ER100S-G** (and the closest approximation to electrode E10018-D2).

Typical operating parameters

	TIG	MIG
Shielding	Argon	Ar + 5-20%CO_2 *
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	120A, 14V	280A, 26V

* Ar + 5%CO_2 provides the highest strength and best impact properties, see above. Other proprietary gas mixtures also suitable.

Packaging data

ø mm	TIG	MIG
1.2	--	15kg spool
1.6	5kg tube	--
2.4	5kg tube	--
3.2	To order	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
55	10	<0.1	<0.1	<0.5	1.2	5

Low Alloy Steels

HIGH STRENGTH Ni-Mo LOW ALLOY

DATA SHEET **A-60**

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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 Q1(N).
E11018-M	Q1(N); HY80; RQT 701 (Corus); QT445; NAXTRA 70; Hystal77.
Tufmet 3NiMo	HY80 & Q1(N); 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

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.

Products available

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	**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 quivers: no limit, but maximum 6 weeks recommended.
Fume data	Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	F	OES (mg/m³)
14	<7	<0.5	<0.5	0.2	18	5

TUFMET 1NiMo

All-positional MMA electrode with high strength and toughness

Product description

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 Mn1NiMo B
Approval:	Statoil R-SF-163

ASME IX Qualification

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

Composition (weld metal wt %)

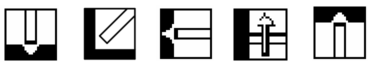
	C	Mn	Si	S	P	Ni	Mo
min	0.030	1.30	0.25	--	--	0.6	--
max	0.075	1.80	0.60	0.02	0.02	1.0	0.3
typ	0.05	1.5	0.35	0.008	0.01	0.85	0.15

All-weld mechanical properties

Typical values as-welded and PWHT			min	As-welded	PWHT 600°C/4-8h
Tensile strength		MPa	620-730	670	630
0.2% Proof stress		MPa	550-660	600	525
Elongation on 4d		%	20	28	--
Elongation on 5d		%	20	25	--
Impact energy	0°C	J	--	--	130
	- 50°C	J	60	>100	>100

Operating parameters

AC (OCV: 60V min) or DC -ve
Operation on DC+ve is not as favourable as above,



ø mm	2.5	3.2	4.0	5.0	6.0
min A	60	80	100	140	200
max A	100	140	180	240	300

Packaging data

ø mm	2.5	3.2	4.0	5.0	6.0
length mm	350	450	450	450	450
kg/carton	13.5	15.0	18.0	16.8	18.0
pieces/carton	663	447	300	180	135

E11018-M

All-positional MMA electrode with high strength and toughness

Product description

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

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.

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

Specifications

AWS A5.5	E11018-M
BS 2493	2NiMo.BH
DIN 8529	(EY 6965 Mn2NiCrMo B)

ASME IX Qualification

QW432 F-No 4, **QW442** A-No 12

Composition (weld metal wt %)

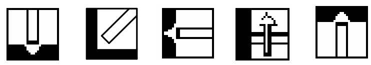
	C	Mn	Si	S	P	Cr	Ni	Mo	V
min	--	1.30	--	--	--	--	1.50	0.25	--
max	0.10	1.80	0.60	0.030	0.030	0.40	2.50	0.50	0.05
typ	0.05	1.7	0.35	0.012	0.012	0.2	2.2	0.4	0.02

All-weld mechanical properties

Typical as welded and PWHT			min	As-welded	PWHT 620°C/2h
Tensile strength		MPa	760	820	830
0.2% Proof stress		MPa	680-760	730	760
Elongation on 4d		%	20	23	--
Elongation on 5d		%	20	22	16
Reduction of area		%	--	65	--
Impact energy	+ 20°C	J	--	125	--
	- 50°C	J	30	80	40
Lateral expansion	- 50°C	mm (mils)	--	0.9 (37)	--

Operating parameters

DC +ve or AC (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	14.1	16.2	16.8
pieces/carton	582	381	234	153

TUFMET 3NiMo

All-positional MMA electrode with high strength and toughness

Product description

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.

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 A5.5 E12016-G
Approvals: MoD NES 769 for Q1(N) in Q+T condition.

ASME IX Qualification

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

Composition (weld metal wt %)

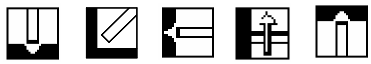
	C	Mn	Si	S	P	Cr	Ni	Mo
min	0.02	0.8	--	--	--	0.6	3.5	0.4
max	0.06	1.5	0.5	0.025	0.025	1.0	4.5	0.8
typ	0.045	1.2	0.4	0.01	0.015	0.8	4	0.5

All -weld mechanical properties

Typical values:			min	As-welded	Stress relieved 600-620°C/1h	Q+T 900°C/1-6h WQ + 635-650°C/1-6h WQ
Tensile strength		MPa	830	950	920	710-770
0.2% Proof stress		MPa	740	870	870	590-660
Elongation on 4d		%	14	20	22	--
Elongation on 5d		%	--	18	20	20-25
Reduction of area		%	--	55	58	65-70
Impact energy	0°C	J	--	65	--	--
	- 50°C	J	--	45	30	65-135
CTOD	- 5°C	mm	--	--	--	>0.46

Operating parameters

DC +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	13.8	17.7	16.5
pieces/carton	381	267	156

ER110S-G

High strength solid TIG and MIG wire

Product description	Solid copper wire for TIG and MIG welding of Q+T steels requiring as-welded tensile strength up to about 760MPa (110ksi). It is not recommended for applications requiring PWHT.
Specifications	**AWS A5.28** ER110S-G (Classified on the basis of mechanical properties in the as-welded condition) **BS EN ISO 16834-A** Mn3Ni1CrMo
ASME IX Qualification	**QW432** F-No 6, **QW442** A-No 12

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	V	Cu
min	0.05	1.4	0.4	--	--	0.2	1.2	0.2	0.04	--
max	0.12	1.8	0.8	0.020	0.020	0.4	1.8	0.4	0.13	0.25
typ	0.1	1.6	0.5	0.01	0.01	0.3	1.4	0.3	0.09	0.1

All-weld mechanical properties

Typical values as welded			min	TIG	MAG Ar+5%CO_2	MAG Ar+20%CO_2
Tensile strength		MPa	760	940	835	730
0.2% Proof stress		MPa	660	870	740	660
Elongation on 4d		%	15	23	21	21
Impact energy	- 20°C	J	--	120	60	50
Hardness cap/mid		HV	--	300	280	255

* Minimum values for AWS ER110S-G MAG welds are typically obtained with low CO_2 content shielding gases; more oxidising gases give AWS ER100S-G properties, as shown above.

Typical operating parameters

	TIG	MIG
Shielding	Argon	Ar + 5-20%CO_2 *
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Voltage	120A, 14V	280A, 26V

* Ar + 5%CO_2 provides the highest strength and best impact properties, see above. Other proprietary gas mixtures also suitable.

Packaging data

ø mm	TIG	MIG
1.0	--	20kg spool
1.2	--	15kg spool
2.4	5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr3	Ni	Mo	Cu	OES (mg/m^3)
50	10	1	0.4	<1.5	1.2	5

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METRODE WELDING CONSUMABLES

DATA SHEET **A-61**

1NiMo.B

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.

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni *	Mo	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

* Nickel normally 1.0% max to conform to NACE MR0175.

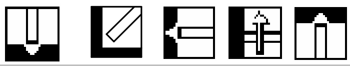
All-weld mechanical properties

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
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^3)
14	5	0.5	<0.1	<0.2	<0.1	18	5

Low Alloy Steels

DATA SHEET **A-70**

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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 three-fold 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 micro-alloyed and CMn steels in ice-breaker vessels and off-shore structures.

Microstructure

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

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.

Products available

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. 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	E8018-W2
BS EN ISO 2560-B	E5518-NCC1 A
DIN 8529	EY 5043 NiCuB

ASME IX Qualification

QW432 F-No 4, **QW442** A-No (not allocated)

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.04	0.50	0.35	--	--	0.45	0.40	--	0.30
max	0.12	1.30	0.80	0.02	0.03	0.70	0.80	--	0.75
typ	0.06	1	0.6	0.01	0.015	0.6	0.6	0.02	0.5

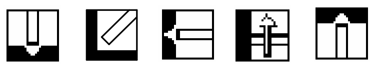
All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	550-720 *	610
0.2% Proof stress		MPa	460	520
Elongation on 4d		%	19	25
Elongation on 5d		%	17	20
Reduction of area		%	--	65
Impact energy	+ 20°C	J	--	150
	-20ºC	J	27	100
	-40ºC	J	--	70
	-60ºC	J	--	40

* Maximum according to DIN 8529 is optional.

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	350	380	450
kg/carton	12.0	15.0	16.5
pieces/carton	420	375	240

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, 300-350ºC/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 50-150ºC in heated quivers:: 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^3)
14	5	0.5	0.5	0.5	0.1	18	5

METRODE WELDING CONSUMABLES

ER80S-W

Solid wire for TIG, MIG and SAW of Corten weathering steels

Product description

Solid copper coated wire for TIG, MIG and SAW.

Specifications

AWS A5.28	ER80S-G
BS EN ISO 16834-A	(Mn3Ni1Cu)

ASME IX Qualification

QW432 F-No 6, **QW442** A-No Not allocated

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Cu
min	0.04	1.0	0.5	--	--	--	0.6	0.2
max	0.12	1.6	1.0	0.025	0.025	0.4	1.2	0.6
typ	0.09	1.4	0.7	0.01	0.01	0.1	0.8	0.4

All-weld mechanical properties

Typical values as welded			min.	Ar-20%CO_2
Tensile strength		MPa	550	610
Yield stress		MPa	--	525
0.2% Proof stress		MPa	470	500
Elongation on 4d		%	24	28
Reduction of Area		%	--	62
Impact energy	- 20°C	J	--	110
	- 50ºC	J	--	75
Hardness mid/cap		HV	--	190/245

Typical operating parameters

	TIG	MIG	SAW
Shielding	Argon	Ar + 5-20%CO_2	LA121
Current	DC-	DC+	DC+
Diameter	2.4mm	1.2mm	2.5mm
Parameters	120A, 14V	280A,26V	350A, 28V

Packaging data

ø mm	TIG	MIG	SAW
1.0	--	15kg spool	--
1.2	--	15kg spool	--
1.6	5kg tube	--	--
2.4	5kg tube	--	--
2.5	--	--	25kg coil

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m^3)
52	8	0.2	0.5	< 0.5	1.6	5

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METRODE WELDING CONSUMABLES

DATA SHEET A-80

RAILROD

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°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 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 sufficientpreheat-interpass range, and to retard cooling.

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo
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

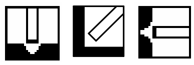
All-weld mechanical properties

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:

Fe	Mn	Ni	Cr	Cu	Pb	F	OES (mg/m^3)
15	5	< 0.2	0.8	< 0.2	< 0.1	18	5

Stainless Steels

DATA SHEET **B-10**

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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) 1.4000, 1.4024	1.4006 (G-X10Cr13)
BS	410S21 (En56A) 403S17	410C21

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 air-hardening 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 550ºC 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 800ºC.

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 as-welded 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-350ºC Mf-100ºC), then temper at 680-760ºC followed by air cool. To ensure <22HRC (NACE) in the weld area, PWHT at 745ºC 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 re-hardening 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

General data for all 410 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 300 – 350°C/1-2h to restore to as-packed condition. Maximum 420° C, 3 cycles, 10h total.
Storage of redried electrodes at 100 – 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/m^3)
20	2	<0.5	3	<0.2	<0.1	<0.1	18	1.7

13.RMP

13%Cr MMA electrode

Product description

Rutile 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

AWS A5.4	E410-26
BS EN 1600	E 13 R 52
BS 2926	13.RMP
DIN 8556	E13 MPR 26 130

ASME IX Qualification

QW432 F-No 1, **QW442** A-No 6

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	--	--	--	--	--	11.0	--	--	--
max	0.08	1.0	0.90	0.025	0.030	13.5	0.60	0.5	0.50
typ	0.06	0.5	0.30	0.010	0.015	11.5	0.4	0.2	0.05

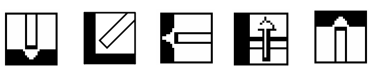
All-weld mechanical properties

After PWHT		850°C/2h (1)		745°C/1h (2)	
		min	typical	min	typical
Tensile strength	MPa	480	520	450	700
0.2% Proof stress	MPa	250	270	--	610
Elongation on 4d	%	--	36	20	21
Elongation on 5d	%	20	34	--	18
Reduction of area	%	--	52	--	59

(1) BS & BS EN PWHT: 840-870ºC for 2 hours, furnace cool to 595ºC at 55ºC/h. max. Air cool to ambient. This gives a relatively low strength condition.
(2) AWS PWHT: 730-760ºC for 1 hour, furnace cool to 315ºC at 60ºC/h max., air cool to ambient. This gives a higher strength tempered condition more representative of normal fabrication welds.

Operating parameters

DC +ve or AC (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	380	450
kg/carton	12.6	14.1	14.1	16.8
pieces/carton	609	378	219	150

13.1.BMP

13%Cr-1.5%Ni MMA electrode

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

AWS A5.4	(E410-15)	Nearest classifications
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 (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo *	Cu
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

* Molybdenum is controlled to satisfy minimum requirements for ASTM A487 CA15M castings (0.15-1.0% Mo).

All-weld mechanical properties

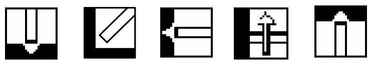
Typical after PWHT			min *	790°C/5h + 700°C/5h	680°C/2h + 620°C/2h
Tensile strength		MPa	620	655	760
0.2% Proof stress		MPa	450	455	685
Elongation on 4d		%	18	26	20
Elongation on 5d		%	15	23	17
Reduction of area		%	--	70	67
Impact energy	+ 20°C	J	--	105	--
	- 10°C	J	--	90	60
Hardness		HRC	<22 **	18	19

* Tensile properties based on ASTM CA15 and CA15M castings. Specifications for wrought grades vary in tensile strength 415-700MPa.

** For conformance to NACE a double temper is mandatory.

Operating parameters

DC +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	16.5
pieces/carton	375	225	144

* 5mm made to order.

12Cr

12%Cr solid wire for TIG & MIG welding of 410 stainless steel

Product description	Solid wire for TIG & MIG.

Specifications

AWS A5.9	ER410
BS 2901: Pt2	410S94
BS EN 12072	13
DIN 8556	SG X 8Cr 14 (1.4009) nearest

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 6

Composition (wire wt %)

	C *	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.06	--	0.25	--	--	12.0	--	--	--
max	0.12	0.6	0.50	0.02	0.03	13.5	0.6	0.3	0.3
typ	0.1	0.4	0.3	0.01	0.02	12.5	0.4	0.03	0.2

* BS 2901: Pt2 requires 0.09-0.25%C.

All-weld mechanical properties

			MAG: Ar+20%CO_2	
Typical values after PWHT			740ºC/1h (AWS)	740ºC/3h
Tensile strength		MPa	695	675
0.2% Proof stress		MPa	530	510
Elongation on 4d		%	22	20
Elongation on 5d		%	19	18
Reduction of area		%	50	50
Impact energy	+ 20°C	J	<20	20
Hardness cap/mid		HV	225/230	215/220
		HRC	--	18/21

Typical operating parameters

	TIG	MIG
Shielding	Argon *	Ar / 1-3%O_2 or Ar / 3-20%CO_2 **
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	220A, 28V

* Also required as a purge for root runs.
** Most economic gas is Ar-20%CO_2. This gas provides the highest resistance to weld metal porosity and carbon content typically not exceeding 0.12%.

Packaging data

ø mm	TIG	MIG
1.2	--	15kg spool
1.6	2.5kg tube	15kg spool
2.4	2.5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Cu	OES (mg/m^3)
55	4	8	<0.1	<0.5	5

Stainless Steels

DATA SHEET **B-11**

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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	
BS EN / DIN	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 precipitation-hardening alloys if corrosion conditions are compatible with lower alloy weld metal, with the advantage of a single PWHT at 450-620ºC 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.

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 675ºC/10h + 605ºC/10h with intermediate air cool to ambient. Recent work indicates 650ºC + 620ºC 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 770ºC/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 650ºC unless a second temper at 590-620ºC 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

Rutile MMA electrode 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

AWS A5.4	E410NiMo-26
BS EN 1600	E 13 4 R 52
BS 2926	13.4.MoRMP
DIN 8556	E13 4 MPR 26 130

ASME IX Qualification

QW432 F-No 1, **QW442** A-No 6

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	--	--	--	--	--	11.0	4.0	0.40	--
max	0.06	1.0	0.90	0.025	0.03	12.5	5.0	0.70	0.50
typ	0.03	0.8	0.25	0.01	0.01	12	4.5	0.6	0.05

All-weld mechanical properties

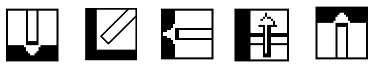
Typical properties			min	PWHT (1)	As-welded (2)
Tensile strength		MPa	760	940	1000
0.2% Proof stress		MPa	500	695	780
Elongation on 4d		%	15	17	4.5
Elongation on 5d		%	10	15	3
Reduction of area		%	--	45	10
Impact energy	+ 20°C	J	--	45	27
	- 40°C	J	--	35	13
	- 60°C	J	--	30	8
Hardness		HV	--	270-300	350

(1) AWS & BS PWHT: 595-620°C for 1 hour, air cooled. See front page for details on PWHT.

(2) This weld metal is not usually recommended for use in the as-welded condition, except for surfacing applications where a hardness of 330-400HV is useful.

Operating parameters

DC +ve or AC (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	12.6	15.0	18.0	16.8
pieces/carton	534	363	240	171

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 300 – 350°C/1-2h to restore to as-packed condition. Maximum 420°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/m^3)
18	2	0.5	3	<0.2	<0.2	<0.2	18	1.7

ER410NiMo

Solid wire for welding 410NiMo martensitic stainless steel

Product description

Solid wire for TIG and MIG.

Specifications

AWS A5.9	(ER410NiMo)	Does not always strictly conform see composition.
BS EN ISO 14343-A	13 4	
BS EN ISO 14343-B	(SS410NiMo)	
DIN 8556	SG X3CrNi 13 4 (1.4351)	

ASME IX Qualification

QW432 F-No 6

Composition (wire wt %)

	C	Mn *	Si *	S	P	Cr	Ni	Mo	Cu
min	--	0.4	--	--	--	11.0	4.0	0.4	--
max	0.05	1.0	0.60	0.02	0.03	12.5	5.0	0.7	0.3
typ	0.02	0.8	0.4	0.005	0.015	12.3	4.5	0.5	0.1

* AWS requires 0.6%Mn max and 0.50%Si max.

All-weld mechanical properties

Typical values after PWHT 610ºC/1h:			TIG
Tensile strength		MPa	890
0.2% Proof stress		MPa	850
Elongation on 4d		%	23
Elongation on 5d		%	20
Impact energy	0°C	J	90
	-50ºC	J	60
Hardness cap/mid		HRC	25-30
		HV	300

Typical operating parameters

	TIG	MIG
Shielding	Argon *	Ar with 1-2%O_2 or 1-5%CO_2 **
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	220A, 28V

* Also required as a purge for root runs.

** Proprietary gas mixtures with <5%CO_2 are also suitable.

Packaging data

ø mm	TIG	MIG
1.0	--	To order
1.2	--	15kg spool
1.6	2.5kg tube	--
2.0	To order	--
2.4	2.5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m^3)
54	5	8	3.2	<0.5	<0.5	5

SUPERCORE 410NiMo

Flux cored wire for welding 410NiMo martensitic stainless steel

Product description

All-positional rutile flux cored wire made on a high purity stainless steel strip

Metal recovery about 90% with respect to wire.

Specifications

AWS A5.22	E410NiMoT1-1/4
BS EN ISO 17633-A	T 13 4 P M 2
BS EN ISO 17633-B	TS410NiMo-FM1

ASME IX Qualification

QW432 F-No 6

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Co
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
Typ	0.03	0.7	0.4	0.005	0.017	11.8	4.5	0.5	0.03	0.03

All-weld mechanical properties

Typical values:			Min	610ºC/1h	610ºC/10h	650ºC/10h +620ºC/10h
Tensile strength		MPa	760	940	870	--
0.2% Proof stress		MPa	500	850	700	--
Elongation on 4d		%	15	20	23	--
Elongation on 5d		%	15	17	19	--
Reduction of area		%	--	50	55	--
Impact energy	+ 20°C	J	--	45	50	50
	- 40°C	J	--	30	40	35
Hardness		HV	--	330	310	310
		HRC	--	31	27	28

AWS PWHT = 593-621°C/1 hour. BS EN PWHT = 580-620°C/2 hours.

Operating parameters

Shielding gas Ar-20%CO_2 or 100% CO_2 at 20-25l/min.
Current DC+ve parameters as below (for 100%CO_2 increase voltage by 1-3V):

ø mm	range	typical	stickout
1.2	150-280A, 25-32V	180A, 28V	15-25mm
1.6	200-350A, 26-34V	260A, 30V	15-25mm

Packaging data

Spools vacuum-sealed in barrier foil with cardboard carton: 15kg
The as-packed shelf life is virtually indefinite.
Resistance to moisture absorption is high, but to maintain the high integrity of the wire surface and prevent any possibility of porosity, it is advised that part-used spools are returned to polythene wrappers.
Where possible, preferred storage conditions are 60% RH max, 18°C min.

Fume data

Fume composition (wt %):

Fe	Mn	Cr^{VI}	Ni	Mo	Cu	OES (mg/m^3)
18	3	2.5	1	0.2	<0.5	2

Stainless Steels

DATA SHEET **B-12**

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MARTENSITIC PRECIPITATION HARDENING STAINLESS STEELS

Alloy type

High strength martensitic precipitation hardening stainless steels.

Materials to be welded

FV520 Types:

ASTM	A564, A693, A705; Grade XM-25
UNS	S45000
BS	3146 Grade ANC 20.
	'S' grades; 2S.143; 3S.144; 3S.145
Proprietary	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.

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 over-aged 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	**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** 300 – 350°C/1-2h to restore to as-packed condition. Maximum 420° 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/m^3)
15	**3**	0.5	4	0.8	0.2	<0.1	18	1.2

FV520-1

MMA electrode for FV520 base material

Product description

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 national specifications for this electrode.

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Nb
min	--	0.4	0.2	--	--	13.0	4.5	1.2	1.2	0.15
max	0.05	1.0	0.5	0.030	0.030	15.5	6.0	2.0	2.0	0.5
typ	0.03	0.6	0.3	0.010	0.015	14	5	1.5	1.6	0.3

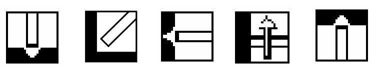
All-weld mechanical properties

Typical properties PWHT		Aged *	Over-aged **
Tensile strength	MPa	1230	980
0.2% Proof stress	MPa	1110	890
Elongation on 4d	%	--	16
Elongation on 5d	%	10	15
Reduction of area	%	30	37
Hardness	HV	420	345

* 850°C/2 hours, air cool to 15°C + 450°C/4 hours, air cool. Not recommended for structural work.
** 750°C/2 hours, air cool to 15°C + 550°C/2 hours, air cool. More commonly applied PWHT.

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	350	380	450
kg/carton	13.5	14.4	17.1
pieces/carton	630	345	246

17.4.Cu.R

MMA electrode for 17-4PH base material

Product description

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 national specifications for this electrode but it is similar to AWS A5.4 E630-26.

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
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

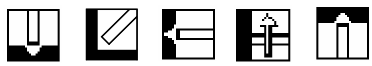
All-weld mechanical properties

Typical properties PWHT		Over-aged *
Tensile strength	MPa	1035
0.2% Proof stress	MPa	635
Elongation on 4d	%	10
Elongation on 5d	%	9
Reduction of area	%	24
Hardness	HV	330

* 750°C/2 hours, air cool to 15°C + 550°C/2 hours, air cool.

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	350	380	450
kg/carton	12.3	15.0	18.6
pieces/carton	528	345	246

FV520B

Solid TIG wire for welding FV520 stainless steel

Product description

Solid wire for TIG.

Specifications

There are no national specifications for this wire.

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Nb
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 properties

Typical PWHT			Aged *	Over-aged **	Over-aged ***	single cycle 550°C
Tensile strength		MPa	1345	1100	1025	1200
0.2% Proof stress		MPa	1240	1050	760	1000
Elongation on 4d		%	5	19	22	19
Elongation on 5d		%	5	16	21	16
Reduction of area		%	15	50	60	50
Impact energy	+ 20°C	J	7	60	125	125
	- 20°C	J	--	20	85	75
Hardness mid		HV	450	380	315	400

* 850°C/2 hours, air cool to 20°C + 450°C/4 hours, air cool. Not recommended for structural work.
** 750°C/2 hours, air cool to 20°C + 550°C/2 hours, air cool. More commonly applied PWHT.
*** 750°C/2 hours, air cool to 20°C + 620°C/2 hours, air cool.

FV520B (continued)

Typical operating parameters

	TIG
Shielding	Argon *
Current	DC-
Diameter	2.4mm
Parameters	120A, 14V

* Also required as a purge for root runs.

Packaging data

ø mm	TIG
1.6	5kg tube
2.4	5kg tube

Fume data

Fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
52	4	11	4	<0.5	2.7	4.5

17-4PH

Solid TIG wire for welding 17-4PH stainless steel

Product description

Solid wire for TIG welding.

Specifications

AWS A5.9 ER630

ASME IX Qualification

QW432 F-No 6

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Nb
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 properties

Typical PWHT		Over-aged *
Tensile strength	MPa	930
0.2% Proof stress	MPa	740
Elongation	%	10

* 750°C/2 hours, air cool to 15°C + 550°C/2 hours, air cool; or 1040°C, air cool + 620°C/4 hours.

Typical operating parameters

	TIG
Shielding	Argon *
Current	DC-
Diameter	2.4mm
Parameters	120A, 14V

* Also required as a purge for root runs.

Packaging data

ø mm	TIG
1.6	2.5kg tube
2.4	2.5kg tube

Fume data

Fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
50	4	13	3.5	<0.5	5.5	3.6

Stainless Steels

DATA SHEET **B-30**

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Email: info@metrode.com
Internet: http//www.metrode.com

308L STAINLESS STEELS

Alloy type

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

Materials to be welded

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

BS	UNS
304S11	S 30403
304S15/16/31	S 30400
304S61	S 30453
304C12	
304C15	

Applications

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.

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	**308S92**	AWS ER308L
MIG	**Supermig 308LSi**	AWS ER308LSi
SAW	**308S92**	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

General Data for all 308L 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°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	Mo	Cu	F *	OES (mg/m^3)
8	5	5	0.8	-	< 0.2	16	1

* F=28% for basic coated Ultramet B308L but this does not affect the OES.

SUPERMET 308L

General purpose rutile 308L MMA electrode

Product description

MMA electrode – rutile aluminosilicate flux on high purity 304L core wire giving very low typical carbon level. 'Low hydrogen' manufacturing technology ensures high resistance to weld metal porosity. 'Supermet Technology' gives acid rutile operability combined with controlled silicon content for maximum cracking/corrosion resistance. Designed for ease of use, exceptional weld bead appearance and high weld metal integrity, primarily in the downhand and HV positions; smaller sizes offer all-positional operability.

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

Specifications

AWS A5.4	E308L-17
BS EN 1600	E 19 9 LR 32
BS 2926	19.9.L.AR
DIN 8556	E 19 9 LR 23

ASME IX Qualification

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

Composition (weld metal wt %)

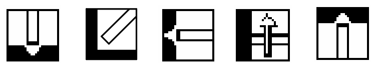
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	18.0	9.0	--	--	3
max	0.04	2.0	0.90	0.025	0.030	21.0	11.0	0.5	0.5	10
typ	0.02	0.8	0.6	0.01	0.02	19.5	10	0.02	0.05	6

All-weld mechanical properties

As-welded			min	typical
Tensile strength		MPa	520	590
0.2% Proof stress		MPa	320	450
Elongation on 4d		%	35	45
Elongation on 5d		%	30	40
Reduction of area		%	--	45
Impact energy *	+ 20°C	J	--	80

Operating parameters

DC +ve or AC (OCV: 50V min)



ø mm	1.6	2.0	2.5	3.2	4.0	5.0
min A	25	50	60	75	100	130
max A	45	70	90	120	155	210

Packaging data

ø mm	1.6	2.0	2.5	3.2	4.0	5.0
length mm	250	300	300	350	450	450
kg/carton	8.7	10.5	11.4	12.0	16.5	16.5
pieces/carton	1350	846	609	333	243	156

ULTRAMET 308L

All-positional rutile MMA electrode for 304L

Product description

MMA electrode – rutile flux coated 308L electrode on high purity 304L core wire. Ultramet has all the benefits of an advanced rutile flux design – this includes optimum versatility for downhand welding with high cosmetic finish and weld metal integrity; and all-positional welding with the 2.5/3.2mm electrodes including fixed pipework.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E308L-16
BS EN 1600	E 19 9 L R 3 2
BS 2926	19.9.LR
DIN 8556	E 19 9 L R 2 3
Approvals	TÜV

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	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	0.6	0.01	0.02	19	9.5	0.1	0.1	6

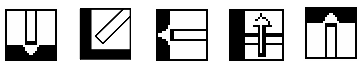
All-weld mechanical properties

As welded			min	typical	1050°C + WQ
Tensile strength		MPa	520	590	540
0.2% Proof stress		MPa	320	450	290
Elongation on 4d		%	35	45	50
Elongation on 5d		%	30	42	48
Reduction of area		%	--	50	64
Impact energy	-100°C	J	--	35	--
	-196°C	J	-- *	--	> 60

* See **Ultramet 308LCF** (data sheet B-37) for as-welded cryogenic applications at –196°C.

Operating parameters

DC +ve or AC (OCV: 50V 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 mm	300	350	350	350
kg/carton	11.4	13.5	13.5	13.5
pieces/carton	618	396	261	165

ULTRAMET B308L

Basic coated MMA pipe-welding electrode for 304L

Product description

MMA electrode – designed and manufactured to give high moisture resistance using a basic flux system and high purity 304L core wire. **Ultramet B308L** is particularly suited to the most demanding vertical and overhead welding applications including fixed pipework in the ASME 5G/6G position. Under site conditions it is tolerant to adverse wind and drafts.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E308L-15
BS EN 1600	E 19 9 L B 4 2
BS 2926	19.9.LB
DIN 8556	E 19 9 L B 20+

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	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

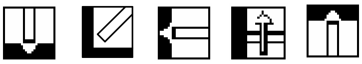
ULTRAMET B308L (continued)

All-weld mechanical properties

As welded			min	typical
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.



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 308LP

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 308LP is a fully all-positional electrode capable of the most demanding fixed pipework applications including ASME 5G/6G. The Ultramet 308LP 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 A5.4	E308L-16
BS EN 1600	E 19 9 L R 11

ASME IX Qualification

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

Composition (weld metal wt %)

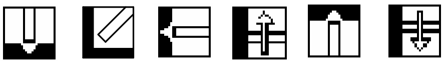
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	18.0	9.0	--	--	3
max	0.04	2.5	0.90	0.025	0.030	21.0	11.0	0.5	0.5	10
typ	0.02	0.8	0.8	0.01	0.02	19	10	0.01	0.1	6

All-weld mechanical properties

As welded		min	typical
Tensile strength	MPa	520	580
0.2% Proof stress	MPa	320	460
Elongation on 4d	%	35	37
Elongation on 5d	%	30	35
Reduction of area	%	--	35

Operating parameters

DC +ve or AC (OCV: 50V min)



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/carton	11.7	12.0	14.1
pieces/carton	1086	702	447

308S92 and SUPERMIG 308LSi

308L solid wire

Product description

Solid wires for TIG, MIG and sub-arc welding.

Specifications

	308S92 (TIG & Sub-arc)	Supermig 308LSi (MIG)
AWS A5.9	ER308L	ER308L Si
BS EN ISO 14343-A	19 9 L	G 19 9 L Si
BS EN ISO 14343-B	SS308L	SS308L Si
BS 2901: Pt2	308S92	308S93
DIN 8556	SG X2CrNi 19 9 (1.4316)	SG X2CrNi 19 9 (1.4316)

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si *	S	P	Cr	Ni	Mo	Cu	FN
min	--	1.0	0.30	--	--	19.5	9.0	--	--	3
max	0.025	2.0	0.65	0.020	0.030	21.0	11.0	0.3	0.3	12
typ	0.01	1.7	0.4	0.01	0.015	20	10	0.1	0.15	10

* **Supermig 308LSi**: Si range is 0.65 – 1.0%, typically 0.8%.

All-weld mechanical properties

As welded			typical TIG	typical MIG	typical SAW + SSB
Tensile strength		MPa	605	570	570
0.2% Proof stress		MPa	465	435	450
Elongation on 4d		%	35	42	41
Elongation on 5d		%	33	40	37
Impact energy	-130°C	J	110	70	50
	-196°C *	J	80	30-60	30
Hardness cap/mid		HV	200/220	200/220	195/215

* For applications requiring cryogenic toughness see data sheet B-37.

Typical operating parameters

	TIG	MIG	SAW
Shielding	Argon	Ar+2%O_2*	SSB**
Current	DC-	DC+	DC+
Diameter	2.4mm	1.2mm	2.4mm
Parameters	100A, 12V	260A, 26V	350A, 28V

* Also proprietary Ar and Ar-He gas mixtures with < 3%CO_2.
****SSCr** (Cr compensating flux), **L2N** and **LA491** also suitable.

Packaging data

ø mm	TIG 308S92	MIG Supermig 308LSi	SAW 308S92
0.8	--	15kg reel	--
1.0	2.5kg tube	15kg reel	--
1.2	2.5kg tube	15kg reel	--
1.6	2.5kg tube	--	--
2.0	2.5kg tube	--	--
2.4	2.5kg tube	--	25kg coil
3.2	2.5kg tube	--	25kg coil

Fume data

MIG fume composition (wt %) (TIG and SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
32	12	16	8	< 0.5	< 0.5	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 system. **Supercore 308L** combines easy operability, high deposit quality and exceptional weld bead appearance for downhand and HV welding. **Supercore 308LP** is designed for all-positional welding including fixed pipework. Metal recovery is about 90% with respect to the wire.

The Supercore 308L wire is not suitable for applications requiring PWHT or solution annealing – for these applications, it is recommended that Supercore 308LP is used.

Specifications & Approvals

	Supercore 308L	Supercore 308LP
AWS A5.22	E308LT0-4	E308LT1-4
BS EN ISO 17633-A	T 19 9 L R M 3	T 19 9 L P M 2
BS EN ISO 17633-B	TS308L-FM0	TS308L-FM1
Approvals	TÜV	TÜV

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	0.2	--	--	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 properties

As welded			min	typical
Tensile strength		MPa	520	560
0.2% Proof stress		MPa	320	400
Elongation on 4d		%	35	43
Elongation on 5d		%	30	42
Reduction of area		%	--	60
Impact energy	+ 20°C	J	--	80
	-110°C	J	--	40
Hardness		HV	--	200

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%. **Supercore 308L** is also suitable for use with 100% CO_2.
Current: DC+ve ranges as below for Ar-20%CO_2 (Supercore 308L with 100%CO_2 requires approx 3V higher):

ø mm	amp-volt range	typical	stickout
1.2	120 – 280A, 21 – 35V	180A, 28V	15 – 20mm
1.2P	120 – 250A, 20 – 32V	160A, 26V	15 – 20mm
1.6	200 – 350A, 26 – 36V	250A, 30V	15 – 25mm

Packaging data

Spools vacuum-sealed in barrier foil with cardboard carton: Supercore 308L (1.2mm) – 12.5kg; Supercore 308L (1.6mm) and Supercore 308LP – 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^3	Cr^6	Cu	F	OES (mg/m^3)
17	10	1.5	3	5	< 1	5	1

Stainless Steels

DATA SHEET **B-31**

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347 STAINLESS STEEL

Alloy type

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

Materials to be welded

ASTM-ASME	BS EN & DIN
321	1.4541
347	1.4543/1.4561/1.4550
CF8C (cast)	1.4552 (cast)

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

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).

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).

Products available

Process	Product	Specification
MMA	**Ultramet 347**	AWS E347-16
	Ultramet B347	AWS E347-15
TIG/MIG/SAW	**347S96**	AWS ER347
SAW flux	**SSB**	BS EN SA AF2
FCW	**Supercore 347**	AWS E347T0-4

General Data for all 347 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°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	F *	OES (mg/m^3)
8	5	0.8	5	<0.2	16	1

* F=28% for basic coated Ultramet B347 but this does not affect the OES.

ULTRAMET 347

All-positional rutile MMA electrode for 321/347

Product description

MMA rutile flux coated 347 electrode on high purity 304L core wire. Ultramet 347 has all the benefits of an advanced rutile flux design, including all-positional fixed pipework welding with the 2.5/3.2mm diameter electrodes.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E347-16
BS EN 1600	E 19 9 Nb R32
BS 2926	19.9.Nb.R
DIN 8556	E 19 9 Nb R 23

ASME IX Qualification

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

Composition (weld metal wt %)

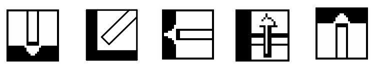
	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	FN
min	--	0.5	--	--	--	18.0	9.0	--	10xC	--	4
max	0.04	2.0	0.9	0.025	0.030	21.0	11.0	0.50	1.00	0.50	12
typ	0.02	0.7	0.7	0.01	0.02	19	9.5	0.05	0.4	0.07	6

All-weld mechanical properties

As welded			min	typical	
Tensile strength		MPa	560	650	
0.2% Proof stress		MPa	350	500	
Elongation on 4d		%	30	40	
Elongation on 5d		%	25	37	
Reduction of area		%	--	52	
Impact energy	+ 20°C	J	--	70	
	-196°C	J	--	20	
	-196°C	J	--	53	(1050°C + WQ)

Operating parameters

DC +ve or AC (OCV: 50V 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 mm	300	350	350	450
kg/carton	11.4	13.5	13.5	16.5
pieces/carton	660	399	261	159

ULTRAMET B347

Basic pipe-welding electrode for 321/347

Product description	MMA electrode with basic carbonate-fluoride flux on high purity 304L core wire. Designed to give good moisture resistance and hence freedom from weld porosity. The electrode is particularly suited to positional welding of fixed pipework qualified in the ASME 5G/6G position and is tolerant to adverse wind and draughts under site conditions. 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 A5.4	E347-15
BS EN 1600	E 19 9 Nb B 42
BS 2926	19.9.Nb.B
DIN 8556	E 19 9 Nb B 20+

ASME IX Qualification — **QW432** F-No 5, **QW442** A-No 8

Composition (weld metal wt %)

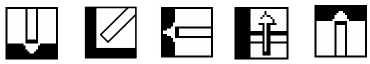
	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	FN
min	--	0.5	--	--	--	18.0	9.0	--	10xC	--	4
max	0.06	2.0	0.9	0.025	0.030	21.0	11.0	0.50	1.00	0.50	12
typ	0.03	1.2	0.3	0.01	0.02	19	9.5	0.05	0.5	0.07	6

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	560	650
0.2% Proof stress		MPa	350	500
Elongation on 4d		%	30	40
Elongation on 5d		%	25	37
Reduction of area		%	--	52
Impact energy	- 50°C	J	--	90

Operating parameters

DC +ve



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	450
kg/carton	12.0	13.5	13.5/17.4	17.4
pieces/carton	669	396	258/267	162

* 350mm is the standard length, 450mm is available to order.

347S96

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

Product description — Solid wire for TIG, MIG and SAW.

Specifications

AWS A5.9	ER347	**BS 2901: PT2**	347S96
BS EN ISO 14343-A	19 9 Nb		
BS EN ISO 14343-B	SS347		
DIN 8556	SG X5CrNiNb 19 9 (1.4551)		

ASME IX Qualification — **QW432** F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	FN
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 properties

Typical values as welded			TIG
Tensile strength		MPa	660
0.2% Proof stress		MPa	450
Elongation on 4d		%	42
Elongation on 5d		%	40
Impact energy	- 50°C	J	150
	- 196°C	J	35
Hardness cap/mid		HV	220/240

347S96 (continued)

Typical operating parameters

	TIG	MIG	SAW
Shielding	Argon *	Ar+2%O_2 **	SSB ***
Current	DC-	DC+	DC+
Diameter	2.4mm	1.2	2.4mm
Parameters	100A, 12V	260A, 26V	350A, 28V

* Also required as a purge for root runs.
** Also proprietary Ar and Ar-He mixtures with <3%CO_{22}.
*** **SSCr** (Cr compensating) also suitable.

Packaging data

ø mm	TIG	MIG	SAW
1.0	--	15kg spool	--
1.2	--	15kg spool	--
1.6	2.5kg tube	--	25kg coil
2.0	To order	--	--
2.4	2.5kg tube	--	25kg coil
3.2	2.5kg tube	--	25kg coil

Fume data

MIG fume composition (wt %) (TIG and SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
32	12	16	8	<0.5	<0.5	3.1

SUPERCORE 347

Downhand rutile flux cored wire for 321/347

Product description

Flux cored wire made with an austenitic stainless steel sheath and rutile flux system. Supercore 347 combines easy operability, high deposit quality and good weld bead appearance for downhand and HV welding. Metal recovery is about 90% with respect to wire.

Specifications

AWS A5.22	E347T0-4
BS EN ISO 17633-A	T19 9 Nb R M 3
BS EN ISO 17633-B	TS347-FM0

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	FN
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 properties

As welded			min	typical
Tensile strength		MPa	550	600
0.2% Proof stress		MPa	350	435
Elongation on 4d		%	30	47
Elongation on 5d		%	25	42
Reduction of area		%	--	50
Impact energy	+ 20°C	J	--	90

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85% argon. The wire is suitable for use on CO_2 but with some loss of cosmetic appearance and increased spatter.

Current: DC+ve ranges as below (for 100%CO_2 increase voltage by 2-3V):

ø mm	amp-volt range	typical	stickout
1.2	120-280A, 22-34V	180A, 26V	15-20mm

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

Fume composition (wt %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
17	11	2	4	5	<1	5	1

METRODE WELDING CONSUMABLES

Stainless Steels

316L STAINLESS STEELS

DATA SHEET B-32

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

Alloy type

316L Mo bearing austenitic stainless.

Materials to be welded

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

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

Applications

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

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

Microstructure

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

Welding guidelines

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

Additional information

There are Technical Profiles available on 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	**316S92**	AWS ER316L
MIG	**Supermig 316LSi**	AWS ER316LSi
SAW	**316S92**	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

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	Cr	Ni	Mo	Cu	F *	OES (mg/m^3)
8	7	5	1	0.5	< 0.2	16	1

* F=28% for basic coated Ultramet B316L but this does not affect the OES.

SUPERMET 316L

General purpose rutile 316L MMA electrode

Product description

MMA electrode – rutile aluminosilicate flux on high purity 304L core wire giving very low typical carbon level. 'Low hydrogen' manufacturing technology ensures high resistance to weld metal porosity. 'Supermet Technology' gives acid rutile operability combined with controlled silicon content for maximum cracking/corrosion resistance. Designed for ease of use, exceptional weld bead appearance and high weld metal integrity, primarily in the downhand and HV positions; smaller sizes offer all-positional operability.

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

Specifications

AWS A5.4	E316L-17
BS EN 1600	E 19 12 3 LR 32
BS 2926	19.12.3.L.AR
DIN 8556	E 19 12 3 LR 23

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo*	Cu	FN
min	--	0.5	--	--	--	17.0	11.0	2.0	--	3
max	0.04	2.0	0.90	0.025	0.030	20.0	13.0	3.0	0.5	10
typ	0.02	0.8	0.6	0.01	0.02	19	12	2.7	0.1	6

* DIN & BS EN require Mo 2.5 – 3.0%.

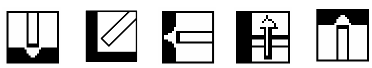
All-weld mechanical properties

As-welded			min	typical	1050°C + WQ
Tensile strength		MPa	520	600	550
0.2% Proof stress		MPa	320	480	320
Elongation on 4d		%	30	42	52
Elongation on 5d		%	25	39	49
Reduction of area		%	--	60	52
Impact energy *	+ 20°C	J	--	70	--
	-196°C	J	--	--	35

* See data sheet B-38 for as-welded cryogenic applications at –196°C

Operating parameters

DC +ve or AC (OCV: 50V min)



ø mm	1.6	2.0	2.5	3.2	4.0	5.0
min A	25	50	60	75	100	130
max A	45	70	90	120	155	210

Packaging data

ø mm	1.6	2.0	2.5	3.2	4.0	5.0
length mm	250	300	300	350	450	450
kg/carton	8.7	10.5	11.4	12.6	17.4	16.8
pieces/carton	1344	846	603	339	249	159

ULTRAMET 316L

All-positional rutile MMA electrode for 316L

Product description

MMA electrode – rutile flux coated 316L electrode on high purity 304L core wire. Ultramet has all the benefits of an advanced rutile flux design – this includes optimum versatility for downhand welding with high cosmetic finish and weld metal integrity; and all-positional welding with the 2.5/3.2mm electrodes including fixed pipework.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E316L-16
BS EN 1600	E 19 12 3 L R 3 2
BS 2926	19.12.3.LR
DIN 8556	E 19 12 3 L R 2 3
Approvals	TÜV, Germanischer Lloyd, LRS

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo*	Cu	FN
min	--	0.5	--	--	--	17.0	11.0	2.0	--	3
max	0.04	2.0	0.90	0.025	0.030	20.0	13.0	3.0	0.5	10
typ	<0.03	1	0.6	0.01	0.02	19	12	2.6	<0.1	6

* DIN & BS EN require Mo 2.5 – 3.0%.

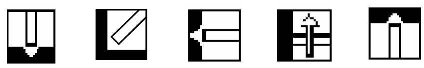
All-weld mechanical properties

As welded			min	typical	1050°C + WQ
Tensile strength		MPa	520	580	540
0.2% Proof stress		MPa	320	480	305
Elongation on 4d		%	30	43	52
Elongation on 5d		%	25	41	50
Reduction of area		%	--	65	58
Impact energy *****	+ 20°C	J	--	70	--
	-100°C	J	--	40	--
	-196°C	J	--	--	40
Hardness		HV	--	230	185

* See data sheet B-38 for as-welded cryogenic applications at –196°C.

Operating parameters

DC +ve or AC (OCV: 50V min)



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	11.4	12.9	13.5	16.5
pieces/carton	618	393	261	159

ULTRAMET B316L

Basic coated MMA pipe-welding electrode for 316L

Product description

MMA electrode – designed and manufactured to give high moisture resistance using a basic flux system and high purity 304L core wire. **Ultramet B316L** is particularly suited to the most demanding vertical and overhead welding applications including fixed pipework in the ASME 5G/6G position. Under site conditions it is tolerant to adverse wind and drafts.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E316L-15
BS EN 1600	E 19 12 3 L B 4 2
BS 2926	19.12.3.LB
DIN 8556	E 19 12 3 L B 20+

ASME IX Qualification

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

ULTRAMET B316L (continued)

Composition (weld metal wt %)

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

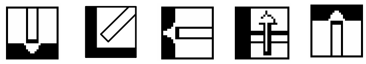
All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	520	600
0.2% Proof stress		MPa	320	470
Elongation on 4d		%	30	37
Elongation on 5d		%	25	33
Reduction of area		%	--	50
Impact energy *	-50°C	J	--	80
	-196°C	J	--	45
Lateral expansion *	-196°C	mm	0.38	0.5

* See data sheet B-38 for as-welded cryogenic applications at –196°C.

Operating parameters

DC +ve only.



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	13.5	13.5	16.5
pieces/carton	681	396	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 A5.4	E316L-16
BS EN 1600	E 19 12 3 L R 11

ASME IX Qualification

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

Composition (weld metal wt %)

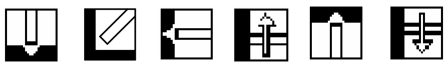
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	17.0	11.0	2.0	--	3
max	0.04	2.5	0.90	0.025	0.030	20.0	13.0	3.0	0.5	10
typ	0.02	0.8	0.8	0.01	0.02	19	12	2.7	0.1	6

All-weld mechanical properties

As welded		min	typical
Tensile strength	MPa	520	600
0.2% Proof stress	MPa	320	485
Elongation on 4d	%	30	37
Elongation on 5d	%	25	35
Reduction of area	%	--	35

Operating parameters

DC +ve or AC (OCV: 50V min)



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/carton	11.7	12.3	14.4
pieces/carton	1089	747	459

316S92 and SUPERMIG 316LSi

Solid 316L wire

Product description	Solid wires for TIG, MIG and sub-arc welding.

Specifications

	316S92 (TIG & sub-arc)	Supermig 316LSi (MIG)	
AWS A5.9	ER316L	ER316L Si	
BS EN ISO 14343-A	19 12 3 L	G 19 12 3 L Si	W=TIG, G=MIG, S=SAW
BS EN ISO 14343-B	SS316L	SS316L Si	
BS 2901: Pt2	316S92	316S93	
DIN 8556	SG X2CrNiMo 19 12 (1.4430)	SG X2CrNiMo 19 12 (1.4430)	
Approvals	TÜV, LRS	TÜV, LRS	

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si *	S	P	Cr	Ni	Mo	Cu	FN
min	--	1.0	0.30	--	--	18.0	11.0	2.5	--	3
max	0.03	2.0	0.65	0.020	0.030	20.0	14.0	3.0	0.3	10
typ	0.01	1.4	0.5	0.01	0.015	18.5	12.8	2.6	0.15	6

* **Supermig 316LSi**: Si range is 0.65 – 1.0%, typically 0.85%.

All-weld mechanical properties

As welded			min	typical TIG	typical MIG	typical SAW + SSB
Tensile strength		MPa	510	605	570	570
0.2% Proof stress		MPa	320	465	435	450
Elongation on 4d		%	30	35	42	41
Elongation on 5d		%	30	33	40	37
Impact energy *	-130°C	J	--	> 100	> 70	> 45
	-196°C	J	--	> 60	30-60	30
Hardness cap/mid		HV	--	200/220	200/220	195/215

* See data sheet B-38 for as-welded cryogenic applications at –196°C.

Typical operating parameters

	TIG	MIG	SAW
Shielding	Argon	Ar+2%O_2*	SSB**
Current	DC-	DC+	DC+
Diameter	2.4mm	1.2mm	2.4mm
Voltage	100A, 12V	260A, 26V	350A, 28V

* Also proprietary Ar and Ar-He gas mixtures with < 3%CO_2.
** **SSCr** (Cr compensating flux), **L2N** and **LA491** also suitable.

Packaging data

ø mm	TIG 316S92	MIG Supermig 316LSi	SAW 316S92
0.8	To order	15kg reel	--
1.0	2.5kg tube	15kg reel	--
1.2	2.5kg tube	15kg reel	--
1.6	2.5kg tube	--	--
2.0	2.5kg tube	--	--
2.4	2.5kg tube	--	25kg coil
3.2	2.5kg tube	--	25kg coil

Fume data

MIG fume composition (wt %) (TIG and SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
30	12	15	11	1.5	< 0.5	3.3

SUPERCORE 316L, 316LP

Rutile flux cored wires

Product description

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 & Approvals

	Supercore 316L	Supercore 316LP
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
Approvals (1.2 & 1.6mm)	TÜV, Germanischer Lloyd	TÜV, Germanischer Lloyd

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	0.2	--	--	17.0	11.0	2.5	--	3
max	0.04	2.0	1.0	0.025	0.030	20.0	13.0	3.0	0.3	12
typ	0.03	1.3	0.5	0.02	0.02	19	12	2.7	0.1	8

* 0.9mm diameter Supercore 316L is typically 2.3%Mo and does not conform to BS EN ISO 17633-A.

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	510	580
0.2% Proof stress		MPa	320	440
Elongation on 4d		%	30	40
Elongation on 5d		%	25	38
Reduction of area		%	--	50
Impact energy	+ 20°C	J	--	70
	-110°C	J	--	40
Hardness	cap/mid	HV	--	200/210

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%. **Supercore 316L** is also suitable for use with 100% CO_2.

Current: DC+ve ranges as below for Ar-20%CO_2 (Supercore 316L with 100%CO_2 requires approx 3V higher):

ø mm	amp-volt range	typical	stickout
0.9 (Supercore 316L only)	75 – 170A, 20 – 30V	120A, 26V	15 – 20mm
1.2	120 – 280A, 21 – 35V	180A, 28V	15 – 20mm
1.2P	120 – 250A, 20 – 32V	160A, 26V	15 – 20mm
1.6	200 – 350A, 26 – 36V	250A, 30V	15 – 25mm

Packaging data

Spools vacuum-sealed in barrier foil with cardboard carton: 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^3	Cr^6	Cu	F	OES (mg/m^3)
14	12	2.5	4	4	< 1	5	1.2

SUPEROOT 316L

Flux cored TIG wire for root welds without back purge

Product description

Flux cored TIG wire **Superoot 316L** is made with a seamless austenitic stainless steel sheath, which results in a robust moisture resistant wire and rutile flux system. Superoot 316L is designed specifically for situations where it is impractical to apply back-purge for the TIG root run, or to gain the economic benefit of eliminating back-purge. For most applications, the use of a 316L root bead is considered compatible with subsequent filling with 308L, 347 or 316L as appropriate.

Metal recovery is 90% with respect to the whole wire.

Specifications

AWS A5.22	R316LT1-5
BS EN ISO 17633-B	TS316L-RI1

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	--	1.0	0.2	--	--	17.0	11.0	2.0	--
max	0.03	2.0	1.0	0.025	0.03	20.0	14.0	3.0	0.5
typ	0.01	1.6	0.8	0.005	0.020	19.2	12.5	2.2	0.05

Typically 5FN.

All-weld mechanical properties

As welded		typical
Tensile strength	MPa	605
0.2% Proof stress	MPa	450
Elongation on 4d	%	38

Note: In practice, mechanical properties of the root bead are assessed with the whole joint and subsequent filler.

Typical operating parameters

	TIG
Shielding	Argon*
Current	DC-
Diameter	2.2mm
Voltage	90A, 12V

* No back-purge is required.

Satisfactory application of **Superoot 316L** requires the use of a keyhole welding technique. Further details are available on request.

Packaging data

ø mm	TIG
2.2	1kg tube

Fume data

Fume composition (wt %)

Fe	Mn	Ni	Cr[3]	Cu	F	OES (mg/m^3)
30	12	11	15	< 0.5	--	3.3

Stainless Steels

NON-MAGNETIC 316L

DATA SHEET **B-33**

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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 micro-fissuring 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 applications. Impact testing procedures at this 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°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**.

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)

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°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	F *	OES (mg/m^3)
8	10	1.5	5	<0.2	16	1

* F=28% for basic coated Ultramet B316NF but this does not affect OES.

ULTRAMET 316NF

All-positional rutile MMA electrode

Product description

Rutile (low silica) flux on high purity 304L core wire. Special control of residuals coupled with a high manganese content ensures freedom from microfissuring.

Recovery is about 120% with respect to core wire, 65% with respect to whole 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 %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N
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	< 0.03	3.0	0.4	0.01	0.02	18	16	2.8	< 0.1	0.15

Maximum magnetic permeability 1.01.

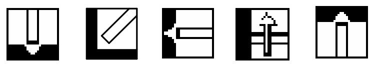
All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	560	610
0.2% Proof stress		MPa	--	430
Elongation on 4d		%	--	38
Elongation on 5d		%	30	35
Reduction of area		%	--	54
Impact energy	- 196°C *	J	--	60
Lateral expansion	- 196°C *	mm (mils)	--	0.7mm (28mils)

* Useful impact properties are maintained down to 4°K (-269°C) and exceeds proposed ASME Code recommendation.

Operating parameters

DC +ve or AC (OCV: 50V 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 mm	300	350	350	350
kg/carton	13.5	15.0	15.0	16.5
pieces/carton	684	402	267	189

ULTRAMET B316NF

Basic all-positional MMA pipe welding electrode

Product description

Basic carbonate-fluoride flux on high purity 304L core wire. Special control of residuals coupled with a high manganese to ensure freedom from microfissuring.

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

Specifications

BS EN 1600	E 18 15 3 L B 4 2	
BS 2926	18.15.3.LMnB	
DIN 8556	E 18 15 3 L B 20+	
AWS A5.4	(E316LMn-15)	Nearest classification

ASME IX Qualification

QW432 F-No -, **QW442** A-No -

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N
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	< 0.03	3.5	0.4	0.01	0.02	18	16	2.8	< 0.1	0.15

Maximum magnetic permeability 1.01.

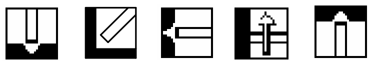
All-weld mechanical properties

As welded			min	typical	
Tensile strength		MPa	560	610	
0.2% Proof stress		MPa	300	440	
Elongation on 4d		%	--	38	
Elongation on 5d		%	30	35	
Reduction of area		%	--	50	
Impact energy	- 196°C *	J	--	50	
Lateral expansion	- 196°C *	mm (mils)	--	0.6	(24mils)

* Useful impact properties are maintained down to 4°K (-269°C) and exceeds proposed ASME Code recommendation.

Operating parameters

DC +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
length mm	300	350	350
kg/carton	12.0	13.5	13.5
pieces/carton	678	393	252

ER316MnNF

Non-magnetic solid wire for TIG and MIG

Product description

Solid wire for TIG and MIG.

Specifications

AWS A5.9	ER316LMn
BS EN ISO 14343-A	20 16 3 Mn L
DIN 8556	SG-X2CrNiMnMoN 20 16 (1.4455)

ASME IX Qualification

QW432 F-No - **QW442** A-No -

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N
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 properties

Typical values as welded			TIG
Tensile strength		MPa	732
0.2% Proof stress		MPa	527
Elongation on 4d		%	39
Elongation on 5d		%	34
Reduction of area		%	68
Impact energy	- 100°C	J	140
Impact energy	- 196°C *	J	95
Lateral expansion	- 196°C *	mm (mils)	1.0 (40)
Hardness cap/mid		HV	175/220

* Useful impact properties are maintained down to 4°K (-269°C) and exceeds proposed ASME Code recommendation.

Typical operating parameters

	TIG	MIG
Shielding	Argon	Ar+2%O_2 *
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	260A, 26V

* Proprietary Ar and Ar-He gas mixtures with <3%CO_2 also suitable.

Packaging data

ø mm	TIG	MIG
1.0	--	15kg spool
1.2	--	15kg spool
1.6	2.5kg tube	--
2.4	2.5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
26	22	15	13	1.5	< 0.5	3.3

SUPERCORE 316NF

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 recovery is about 90% with respect to the wire.

Specifications

AWS A5.22	(E316LT0-4) nearest equivalent
BS EN ISO 17633-A	(T 18 16 5 NL R M 3) nearest equivalent
Approval	TÜV

ASME IX Qualification

QW432 F-No -, **QW442** A-No -

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	N
min	--	2.0	0.2	--	--	17.0	14.0	2.5	0.08
max	0.04	3.0	1.0	0.025	0.03	19.0	16.0	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.

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	560	605
0.2% Proof stress		MPa	300	410
Elongation on 4d		%	30	37
Elongation on 5d		%	25	34
Impact energy	- 196°C *	J	--	50
Lateral expansion	- 196°C *	mm	0.38 (15mils)	0.6
Hardness		HV	--	185

* Useful impact properties are maintained down to 4°K (-269°C) and exceeds proposed ASME Code recommendation.

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 80%.

The wire is suitable for use on 100%CO_2 with some loss of cosmetic appearance and increased spatter.

Current: DC+ve parameters as below (for 100%CO_2 increase voltage by ~3V):

ø mm	amp-volt range	typical	stickout
1.2	130A-25V to 250A-32V	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

Fume composition (wt %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
12	18	2	4	4	< 1	6	1.2

Stainless Steels

DATA SHEET B-34

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318 STAINLESS STEEL

Alloy type

Nb stabilised, Mo-bearing stainless steel.

Materials to be welded

	wrought	cast
ASTM/ASME	316Ti, 316Cb	CF10MC
DIN & BS EN	1.4571/1.4573, 1.4580/1.4583	1.4579/1.4581
BS	320S31/33	318C17
UNS	S31635, S31640	

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.

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.

Products available

Process	Product	Specification
MMA	**Supermet 318**	AWS E318-17
TIG/MIG/SAW	**318S96**	AWS ER318
SAW flux	**SSB**	BS EN SA AF2
	SSCr	BS EN SA FB2
	LA491	BS EN SA FB255

SUPERMET 318

Nb stabilised Mo-bearing stainless steel MMA electrode

Product description

Rutile-aluminosilicate flux on high purity 304L core wire giving very low (<0..025%) 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

AWS A5.4	E318-17
BS EN 1600	E 19 12 3 Nb R 32
BS 2926	19.12.3Nb.AR
DIN 8556	E 19 12 3 Nb R 23

ASME IX Qualification

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

Composition (weld metal wt %)

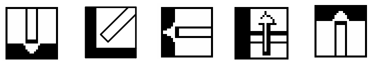
	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	FN
min	--	0.5	--	--	--	17.0	11.0	2.5	10 x C	--	6
max	0.04	2.0	0.90	0.025	0.030	20.0	13.0	3.0	1.0	0.50	13
typ	0.025	0.8	0.7	0.01	0.02	19	11.5	2.7	0.6	0.1	9

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	560	630
0.2% Proof stress		MPa	350	500
Elongation on 4d		%	25	36
Elongation on 5d		%	25	35
Reduction of area		%	--	55
Impact energy	+ 20C	J	--	65

Operating parameters

DC +ve or AC (OCV: 55V 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 mm	300	350	350	450
kg/carton	11.4	14.1	13.2	18.0
pieces/carton	564	387	237	165

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	Mo	Cu	F	OES (mg/m^3)
8	7	1	5	0.5	<0.2	16	1

318S96

Solid 318 stainless steel wire for TIG, MIG and SAW

Product description

Solid wire for TIG, MIG and SAW.

Specifications

AWS A5.9	ER318
BS 2901: Pt2	318S96
DIN 8556	SG X5CrNiMoNb 19 12 (1.4576)
BS EN ISO 14343-A	19 12 3 Nb
BS EN ISO 14343-B	SS318

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	FN
min	--	1.0	0.30	--	--	18.5	11.0	2.5	10xC	--	3
max	0.07	2.0	0.65	0.02	0.030	20.0	13.0	3.0	1.0	0.3	12
typ	0.035	1.8	0.45	0.01	0.02	19.5	11.5	2.5	0.6	0.2	10

All-weld mechanical properties

Typical values as welded			TIG
Tensile strength		MPa	655
0.2% Proof stress		MPa	440
Elongation on 4d		%	42
Elongation on 5d		%	35
Impact energy	+ 20°C	J	90
Hardness cap/mid		HV	200/215

Typical operating parameters

	TIG	MIG	SAW
Shielding	Argon *	Ar+2%O_2 **	SSB ***
Current	DC-	DC+	DC+
Diameter	2.4mm	1.2mm	2.4mm
Parameters	100A, 12V	260A, 26V	350A, 28V

* Also required as a back purge for root runs.
** Also proprietary Ar and Ar-He mixtures with <3%CO_2.
*** **SSCr** (Cr compensating flux), **LA491** and **L2N** also suitable.

Packaging data

ø mm	TIG	MIG	SAW
1.2	--	15kg spool	--
1.6	2.5kg tube	--	--
2.4	2.5kg tube	--	25kg coil

Fume data

MIG fume composition (wt %) (TIG and SAW fume negligible):

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m^3)
30	12	15	11	1.5	<0.5	3.3

Stainless Steels

317L STAINLESS STEEL

DATA SHEET **B-35**

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Email: info@metrode.com
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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 400ºC, or for cryogenic applications.

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.

Products available

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

ULTRAMET 317L

All-positional MMA electrode for 317L stainless 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 A5.4	E317L-16
BS EN 1600	E 19 13 4 N L R 32
BS 2926	(19.13.4.L.R) nearest equivalent

ASME IX Qualification

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

Composition (weld metal wt %)

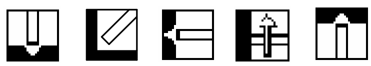
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	FN
min	--	1.0	--	--	--	18.0	12.0	3.5	--	0.08	3
max	0.04	2.5	0.90	0.025	0.030	20.0	14.0	4.0	0.50	0.20	10
typ	0.02	1.2	0.6	0.01	0.02	19	13	3.8	0.1	0.12	5

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	550	620
0.2% Proof stress		MPa	350	470
Elongation on 4d		%	30	38
Elongation on 5d		%	25	36
Reduction of area		%	--	45
Impact energy	+ 20°C	J	--	55
	- 50°C	J	--	30

Operating parameters

DC +ve or AC (OCV: 50V 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 mm	300	350	350	350
kg/carton	12.0	13.5	13.5	13.5
pieces/carton	669	381	225	165

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	F	OES (mg/m^3)
8	6	1	6	<0.2	0.6	16	0.8

ER317L

Solid wire for TIG and MIG welding 317L stainless steel

Product description

Solid wire for TIG and MIG welding of 317L stainless steel.

Specifications

AWS A5.9	ER 317, ER 317L
BS 2901: Pt2	317S92
BS EN ISO 14343-A	19 13 4 L
BS EN ISO 14343-B	SS317, SS317L

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	1.0	0.30	--	--	18.5	13.0	3.0	--	2
max	0.03	2.5	0.65	0.02	0.030	20.0	15.0	4.0	0.3	10
typ	0.015	1.5	0.4	0.01	0.02	19	14	3.5	0.15	5

All-weld mechanical properties

Typical values as welded			TIG
Tensile strength		MPa	630
0.2% Proof stress		MPa	450
Elongation on 4d		%	35
Impact energy	+ 20°C	J	75

Typical operating parameters

	TIG	MIG
Shielding	Argon *	Ar+2%O_2 **
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	220A, 26V

* Also required as a purge for root runs.
** Proprietary Ar and Ar-He gas mixtures with <3%CO_2 also suitable.

Packaging data

ø mm	TIG	MIG
1.2	--	15kg spool
1.6	2.5kg tube	--
2.4	2.5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
28	12	15	12	2	<0.5	3.3

SUPERCORE 317LP

All-positional rutile flux cored wire for 317L

Product description	Flux cored wire made with an austenitic stainless steel sheath and rutile flux system. **Supercore 317LP** 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	**AWS A5.22** E317LT1-4 **BS EN ISO 17633-A** (nearest T 19 13 4 N L P M 2) **BS EN ISO 17633-B** TS317L-FM1
ASME IX Qualification	**QW432** F-No 6, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	FN
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 properties

As welded			min	typical
Tensile strength		MPa	550	570
0.2% Proof stress		MPa	350	440
Elongation on 4d		%	20	27
Elongation on 5d		%	20	25
Reduction of area		%	--	30
Impact energy	+ 20°C	J	--	55
	-50°C	J	--	45
Hardness		HV	--	220

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.
Current: DC+ve ranges as below for Ar-20%CO_2:

ø mm	amp-volt range	typical	stickout
1.2	120 – 250A, 20 – 32V	180A, 26V	15 – 20mm

Packaging data

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.

Fume data

Fume composition (wt %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
17	10	1.5	3	5	< 1	5	1

Stainless Steels

DATA SHEET **B-37**

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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	

BS	UNS
304S11	S 30403
304S15/16/31	S 30400
304S61	S 30453
304C12	
304C15	

Applications

Used to weld 18/8 stainless steels with service temperatures down to –196°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.

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

Process	Product	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

General Data for all 308L 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°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	Mo	Cu	F *	OES (mg/m^3)
8	5	5	0.8	-	< 0.2	16	1

* F=28% for basic coated Ultramet B308LCF but this does not affect the OES.

ULTRAMET 308LCF

Rutile MMA electrode for cryogenic 304L applications

Product description

MMA electrode – special rutile flux coated 308L electrode on high purity 304L core wire. Versatile downhand and positional capability, **Ultramet 308LCF** has a controlled composition and ferrite content designed for cryogenic service requiring >0.38mm lateral expansion at minus 130-196°C. Also suitable for unusual occasions when 304L is specified for service up to 550°C and corrosion conditions preclude the use of 308H.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E308L-16
BS EN 1600	E 19 9 L R 3 2
BS 2926	19.9.LR
DIN 8556	19 9 L R 2 3

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	18.0	9.0	--	--	2
max	0.04	2.0	0.90	0.025	0.030	21.0	11.0	0.50	0.5	5
typ	<0.025	1	0.6	0.01	0.02	18.5	10	0.1	<0.1	3

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	520	600
0.2% Proof stress		MPa	320	445
Elongation on 4d		%	35	50
Elongation on 5d		%	30	46
Reduction of area		%	--	43
Impact energy	-100°C	J	--	45
	-196°C	J	--	35
Lateral expansion *	-196°C	mm	0.38	0.50

* Batch tested for Charpy lateral expansion >0.38mm at –196°C.

Operating parameters

DC +ve or AC (OCV: 50V 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 mm	300	350	350	450
kg/carton	11.4	13.5	13.5	16.2
pieces/carton	618	396	261	159

METRODE WELDING CONSUMABLES

ULTRAMET B308LCF

Basic coated MMA pipe-welding electrode for 304L

Product description

MMA electrode – designed and manufactured to give high moisture resistance using a basic flux system and high purity 304L core wire. **Ultramet B308LCF** is particularly suited to the most demanding vertical and overhead welding applications including fixed pipework in the ASME 5G/6G position. Under site conditions it is tolerant to adverse wind and drafts.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E308L-15
BS EN 1600	E 19 9 L B 4 2
BS 2926	19.9.LB
DIN 8556	E 19 9 L B 20+

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	18.0	9.0	--	--	2
max	0.04	2.0	0.90	0.025	0.030	21.0	11.0	0.50	0.5	5
typ	0.03	1.2	0.3	0.01	0.015	18.5	10	0.05	<0.1	3

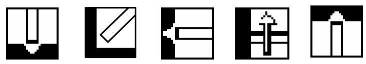
All-weld mechanical properties

As welded			min	typical
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
Lateral expansion *	-196°C	mm	0.38	0.55

* Batch tested for Charpy lateral expansion >0.38mm at –196°C.

Operating parameters

DC +ve only.



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

Packaging data

ø mm	2.5	3.2	4.0
length mm	300	350	350
kg/carton	12.0	13.5	13.5
pieces/carton	681	396	261

ER308LCF

308L solid wire for cryogenic 304L applications

Product description

Batch selected solid wire for TIG and sub-arc welding.

Specifications

AWS A5.9	ER308L
BS EN ISO 14343-A	19 9 L
BS EN ISO 14343-B	SS308L
BS 2901: Pt2	308S92
DIN 8556	SG X2CrNi 19 9 (1.4316)

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	1.0	0.30	--	--	19.5	9.0	--	--	3
max	0.025	2.0	0.65	0.020	0.030	21.0	11.0	0.3	0.3	8
typ	0.01	1.7	0.4	0.01	0.015	20	10	0.1	0.15	7

All-weld mechanical properties

As welded			min	typical TIG	typical SAW + LA491
Tensile strength		MPa	510	605	570
0.2% Proof stress		MPa	320	465	450
Elongation on 4d		%	30	35	41
Elongation on 5d		%	30	33	37
Impact energy	-130°C	J	--	110	50
	-196°C	J	--	80	30
Lateral expansion *	-196°C	mm	0.38	1.0	0.5

* ER308LCF SAW wire batch tested, withLA491 flux, for Charpy lateral expansion >0.38mm at –196°C.

Typical operating parameters

	TIG	SAW
Shielding	Argon	LA491
Current	DC-	DC+
Diameter	2.4mm	2.4mm
Parameters	100A, 12V	350A, 28V

Packaging data

ø mm	TIG	SAW
1.6	2.5kg tube	--
2.4	2.5kg tube	25kg coil
3.2	2.5kg tube	25kg coil

Fume data

MIG fume composition (wt %) (TIG and SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
32	12	16	8	< 0.5	< 0.5	3.1

SUPERCORE 308LCF

Rutile all positional flux cored wire for cryogenic 304L applications

Product description

Supercore 308LCF has a controlled composition and ferrite content designed for cryogenic service requiring >0.38mm lateral expansion at minus 130-196°C.

Supercore 308LCF is designed for all-positional welding including fixed pipework. Metal recovery is about 90% with respect to the wire.

Specifications

AWS A5.22	E308LT1-4
BS EN ISO 17633-A	T 19 9 L P M 2
BS EN ISO 17633-B	TS308L-FM1

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	0.2	--	--	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 properties

As welded			min	typical
Tensile strength		MPa	520	540
0.2% Proof stress		MPa	320	400
Elongation on 4d		%	35	50
Elongation on 5d		%	30	46
Reduction of area		%	--	50
Impact energy	+ 20°C	J	--	74
	-130°C	J	--	40
	-196°C	J	--	36
Lateral expansion *	-196°C	mm	0.38	0.70

* Batch tested for Charpy lateral expansion >0.38mm at –196°C.

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%. The wire is also suitable for use with 100% CO_2 when welding at downhand position.

Current: DC+ve ranges as below for Ar-20%CO_2 (with 100%CO_2 requires approx 2-3V higher):

ø mm	amp-volt range	typical	stickout
1.2	120 – 280A, 21 – 35V	180A, 28V (downhand) 160A, 26V (positional)	15 – 20mm

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 %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
17	10	1.5	3	5	< 1	5	1

Stainless Steels

DATA SHEET **B-38**

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CRYOGENIC 316LCF CONSUMABLES

Alloy type

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

Materials to be welded

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

BS	UNS
316S11/13	S 31603
316S16/31/33	S 31600
316S61	S 31653
316C12	
316C16/71	

Applications

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

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

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

Microstructure

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

Welding guidelines

No preheat, maximum interpass temperature 250°C; 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.

Products available

Process	Product	Specification
MMA	**Ultramet 316LCF**	AWS E316L-16
	Ultramet B316LCF	AWS E316L-15
TIG	**ER316LCF**	AWS ER316L
SAW	**ER316LCF**	AWS ER316L
	LA491	BS EN SA FB255
FCW	**Supercore 316LCF**	AWS E316LT1-4

General Data for all 316L 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°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	Mo	Cu	F *	OES (mg/m^3)
8	7	5	1	0.5	< 0.2	16	1

* F=28% for basic coated Ultramet B316LCF but this does not affect the OES.

ULTRAMET 316LCF

Rutile MMA electrode for cryogenic 316L applications

Product description

MMA electrode – special rutile flux coated 316L electrode on high purity 304L core wire. Versatile downhand and positional capability, **Ultramet 316LCF** has a controlled composition and ferrite content designed for cryogenic service requiring >0.38mm lateral expansion at minus 130-196°C. Also suitable for unusual occasions when 316L is specified for service up to 550°C and corrosion conditions preclude the use of 316H.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E316L-16
BS EN 1600	(Nearest E 19 12 3 L R 3 2)
BS 2926	19.12.3.LR
DIN 8556	(Nearest 19 12 3 L R 2 3)

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo*	Cu	FN
min	--	0.5	--	--	--	17.0	11.0	2.0	--	2
max	0.04	2.0	0.90	0.025	0.030	20.0	13.0	3.0	0.5	5
typ	<0.03	1	0.6	0.01	0.02	18	12	2.2	<0.1	3

* Does not conform to DIN & BS EN which requires Mo 2.5 – 3.0%.

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	520	595
0.2% Proof stress		MPa	320	440
Elongation on 4d		%	30	43
Elongation on 5d		%	25	39
Reduction of area		%	--	48
Impact energy	+ 20°C	J	--	70
	-100°C	J	--	50
	-196°C	J	--	30
Lateral expansion *	-196°C	mm	0.38	0.45
Hardness		HV	--	230

* Batch tested for Charpy lateral expansion >0.38mm at –196°C.

Operating parameters

DC +ve or AC (OCV: 50V min)

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	350
kg/carton	11.4	13.5	13.5	13.5
pieces/carton	618	396	261	165

ULTRAMET B316LCF

Basic coated MMA pipe-welding electrode for 316L

Product description

MMA electrode – designed and manufactured to give high moisture resistance using a basic flux system and high purity 304L core wire. **Ultramet B316L** is particularly suited to the most demanding vertical and overhead welding applications including fixed pipework in the ASME 5G/6G position. Under site conditions it is tolerant to adverse wind and drafts.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E316L-15
BS EN 1600	(Nearest E 19 12 3 L B 4 2)
BS 2926	19.12.3.LB
DIN 8556	(Nearest E 19 12 3 L B 20+)

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo *	Cu	FN
min	--	0.5	--	--	--	17.0	11.0	2.0	--	2
max	0.04	2.0	0.90	0.025	0.030	20.0	13.0	3.0	0.5	5
typ	<0.03	1.2	0.3	0.01	0.02	19	12	2.2	<0.1	3

* Does not conform to DIN & BS EN which requires Mo 2.5 – 3.0%.

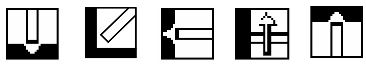
All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	520	600
0.2% Proof stress		MPa	320	470
Elongation on 4d		%	30	37
Elongation on 5d		%	25	33
Reduction of area		%	--	50
Impact energy	-50°C	J	--	80
	-196°C	J	--	50
Lateral expansion *	-196°C	mm	0.38	0.60

* Batch tested for Charpy lateral expansion >0.38mm at –196°C.

Operating parameters

DC +ve only.



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

Packaging data

ø mm	2.5	3.2	4.0
length mm	300	350	350
kg/carton	12.0	13.5	14.1
pieces/carton	681	396	270

ER316LCF

Solid 316L wire for cryogenic applications

Product description

Solid wires for TIG and sub-arc welding.

Specifications

AWS A5.9	ER316L	
BS EN ISO 14343-A	19 12 3 L	W=TIG, S=SAW
BS EN ISO 14343-B	SS316L	
BS 2901: Pt2	316S92	
DIN 8556	SG X2CrNiMo 19 12 (1.4430)	

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	1.0	0.30	--	--	18.0	11.0	2.5	--	3
max	0.025	2.0	0.65	0.020	0.030	20.0	14.0	3.0	0.3	8
typ	0.01	1.4	0.5	0.01	0.015	18.5	12.8	2.6	0.15	6

All-weld mechanical properties

As welded			min	typical TIG	typical SAW + LA491
Tensile strength		MPa	510	605	570
0.2% Proof stress		MPa	320	465	450
Elongation on 4d		%	30	35	41
Elongation on 5d		%	25	33	37
Impact energy	-130°C	J	--	> 100	> 45
	-196°C	J	--	> 60	30
Lateral expansion *	-196°C	mm	0.38	1.0	0.5

* ER316LCF SAW wire batch tested, withLA491 flux for Charpy lateral expansion >0.38mm at –196°C.

Typical operating parameters

	TIG	SAW
Shielding	Argon	LA491
Current	DC-	DC+
Diameter	2.4mm	2.4mm
Voltage	100A, 12V	350A, 28V

Packaging data

ø mm	TIG	SAW
1.6	2.5kg tube	--
2.4	2.5kg tube	25kg coil

Fume data

MIG fume composition (wt %) (TIG and SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
30	12	15	11	1.5	< 0.5	3.3

SUPERCORE 316LCF

Rutile all positional flux cored wire for cryogenic 316L applications

Product description

Supercore 316LCF has a controlled composition and ferrite content designed for cryogenic service requiring >0.38mm lateral expansion at minus 130-196°C.

Supercore 316LCF is designed for all-positional welding including fixed pipework. Metal recovery is about 90% with respect to the wire.

Specifications

AWS A5.22	E316LT1-4
BS EN ISO 17633-A	(nearest T 19 12 3 L P M 2)
BS EN ISO 17633-B	TS316L-FM1

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo *	Cu	FN
min	--	0.5	0.2	--	--	17.0	11.0	2.0	--	2
max	0.04	2.0	1.0	0.025	0.030	20.0	13.0	3.0	0.5	5
typ	0.03	1.4	0.6	0.01	0.02	18.0	12.4	2.2	0.1	3

* Does not conform to BS EN ISO 17633-A which requires Mo 2.5 – 3.0%.

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	510	550
0.2% Proof stress		MPa	320	410
Elongation on 4d		%	30	40
Elongation on 5d		%	25	38
Reduction of area		%	--	45
Impact energy	+ 20°C	J	--	75
	-130°C	J	--	45
	-196°C	J	--	34
Lateral expansion *	-130°C	mm	--	0.70
	-196°C	mm	0.38	0.55

* Batch tested for Charpy lateral expansion >0.38mm at –196°C.

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%. The wire is also suitable for use with 100% CO_2 when welding at downhand position.

Current: DC+ve ranges as below for Ar-20%CO_2 (with 100%CO_2 requires approx 2-3V higher):

ø mm	amp-volt range	typical	stickout
1.2	120 – 280A, 21 – 35V	180A, 28V (downhand) 160A, 26V (positional)	15 – 20mm

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 %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
14	12	2.5	4	4	< 1	5	1.2

Stainless Steels

DATA SHEET **B-40**

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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	DIN	BS
N08904	1.4505	1449: 904S13
	1.4506	1504: 364C11 (cast)
	1.4536	
	1.4539	
	1.4585	
	1.4500 (cast)	

Proprietary alloys

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

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 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 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°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	Ni	Cr	Mo	Cu	F *	OES (mg/m^3)
8	8	2	7	1.5	0.5	18	0.7

* F=28% for basic coated Ultramet B904L but this does not affect OES.

ULTRAMET 904L

Rutile MMA electrode 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.

Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E385-16
BS EN 1600	E 20 25 5 Cu NL R 52
BS 2926	(Nearest 20.25.5.LCuNb.R)
DIN 8556	E 20 25 5 L Cu R26

ASME IX Qualification

QW432 F-No 5

Composition (weld metal wt %)

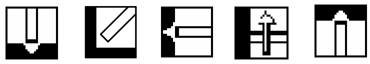
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Nb	N
min	--	1.0	--	--	--	19.5	24.0	4.2	1.2	--	--
max	0.03	2.5	0.90	0.02	0.030	21.5	26.0	5.2	2.0	0.5	0.25
typ	0.015	1.2	0.55	0.015	0.02	20.5	25	4.8	1.8	0.02	0.09

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	560	620
0.2% Proof stress		MPa	320	420
Elongation on 4d		%	30	38
Elongation on 5d		%	25	35
Reduction of area		%	--	50
Impact energy	- 196°C	J	--	50
Hardness cap/mid		HV	--	185/200

Operating 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	12.0	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, silicon, manganese and molybdenum contents to give resistance to microfissuring.

Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.

Specifications

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+

ASME IX Qualification

QW432 F-No 5

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Nb	N
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 properties

As welded			min	typical
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

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 and MIG.

Specifications

AWS A5.9	ER385
BS EN ISO 14343-A	20 25 5 Cu L
BS EN ISO 14343-B	SS385
BS 2901: Pt2	904S92
DIN 8556	(Nearest SG-X2CrNiMoCu 20 25 / 1.4519)

ASME IX Qualification

QW432 F-No 6

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	--	1.0	0.25	--	--	19.5	24.0	4.2	1.2
max	0.025	2.5	0.65	0.015	0.025	21.5	26.0	5.2	2.0
typ	0.01	1.7	0.3	0.001	0.015	20	25	4.5	1.5

All-weld mechanical properties

Typical values as welded			TIG
Tensile strength		MPa	650
0.2% Proof stress		MPa	490
Elongation on 4d		%	35
Elongation on 5d		%	32
Impact energy	+ 20°C	J	210
Hardness cap/mid		HV	175/195

Typical operating parameters

	TIG	MIG
Shielding	Argon *	Ar+2%O_2 **
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	230A, 30V

* Also required as a purge for root runs.
** Ar-He-CO_2 proprietary mixtures also suitable.

Packaging data

ø mm	TIG	MIG
1.2	--	15kg spool
1.6	2.5kg tube	--
2.4	2.5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m^3)
28	13	16	20	3	2.5	2.5

Stainless Steels

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 consumablesdeposit 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 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 suitablefor 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.

Products available

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

E825L-15

MMA electrode for austenitic alloy 825

Product description

MMA electrode for welding 825, alloy 28 and alloy 20 type materials. Specially balanced basic-fluoride-rutile flux on high purity 825 core wire. The electrodes are designed for fixed pipework welds including the demanding ASME 5G/6G positions. Careful control of carbon, manganese, silicon and nitrogen to maximise corrosion resistance in the as-welded condition and to ensure high resistance to solidification cracking and microfissuring in multipass welds. The composition is controlled to give a Pitting Resistance Equivalent (PRE) of about 40, where 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 8556 EL-NiCr28Mo (2.4653)

ASME IX Qualification

QW432 F-No 5 (This is nearest because the electrode does not strictly conform to AWS)

Composition (weld metal wt %)

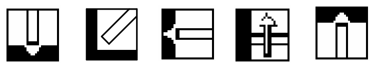
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Nb	Fe
min	--	1.0	--	--	--	27.0	35.0	3.2	1.5	--	--
max	0.03	3.0	0.5	0.015	0.030	31.0	40.0	4.5	3.0	1.0	30
typ	0.02	2	0.3	0.01	0.01	28	38	3.5	2	0.3	27

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	550	640
0.2% Proof stress		MPa	240	410
Elongation on 4d		%	30	43
Elongation on 5d		%	25	40
Reduction of area		%	--	43
Impact energy	+ 20°C	J	--	120
Impact energy	- 196°C	J	--	65
Hardness		HV	--	220

Operating parameters

DC +ve



ø mm	2.5	3.2	4.0	5.0
min A	60	70	90	120
max A	80	110	150	190

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	275	325	325	325
kg/carton	10.8	13.8	14.1	14.1
pieces/carton	612	387	261	168

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°C/1-2h to restore to as-packed condition. Maximum 300° 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	Mo	Cu	F	OES (mg/m^3)
4	5	3	7	1	1	20	0.7

82-50

Solid TIG and MIG wire for welding high alloy austenitic 825 material

Product description

Solid wire for TIG and MIG welding of 825 and alloy 20 type materials. The 82-50 wire only has a nominal 21%Cr and so is not suitable for alloy 28. Note MIG wire is to order only.

Specifications

AWS A5.14	ERNiFeCr-1
BS 2901: Pt5	NA41
BS EN ISO 18274	SNi8065
DIN 1736	(SG-NiCr27Mo / 2.4655) nearest

Also known generically as filler metal 65 (FM65)

ASME IX Qualification

QW432 F-No 45

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Al	Ti	Fe
min	--	--	--	--	--	19.5	38.0	2.5	1.5	--	0.60	22.0
max	0.05	1.0	0.50	0.015	0.020	23.5	46.0	3.5	3.0	0.20	1.2	bal
typ	0.02	0.5	0.3	0.005	0.015	22	40	3	2	0.1	0.8	30

All-weld mechanical properties

Typical values as welded		TIG (Ar)	TIG (Ar+2%H_2)
Tensile strength	MPa	475	580
0.2% Proof stress	MPa	350	350
Elongation on 4d	%	18	39
Elongation on 5d	%	16	35
Reduction of area	%	35	35
Hardness cap/mid	HV	165/180	190/205

Typical operating parameters

	TIG	MIG
Shielding	Argon *	Argon
Current	DC-	DC+ **
Diameter	2.4	1.2mm
Parameters	100A, 12V	220A, 30V

* Also required as a purge for root runs. Ar+1-5%H_2 can prove beneficial see mechanical properties.

** Pulsed current may provide better arc transfer characteristics.

Packaging data

ø mm	TIG	MIG (to order)
1.2	--	15kg spool
1.6	2.5kg tube	--
2.4	2.5kg tube	--
3.2	2.5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
23	2	19	29	2	3	1.7

METRODE WELDING CONSUMABLES

Stainless Steels

CONSUMABLES FOR 310L

DATA SHEET **B-45**

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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 -196ºC.

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.

Products available

Process	Product	Specification
MMA	**25.20.L.R**	None

25.20.L.R

MMA electrode for 310L stainless steel

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.

Recovery is about 140% with respect to core wire, 65% with respect to whole electrode.

Specifications

There are no national specifications for this electrode.

Approvals: Approved for welding equivalent parent material Uranus 65 by independent tests.

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu
min	--	4.0	--	--	--	24.0	19.0	--	--	--
max	0.040	7.0	0.4	0.020	0.025	26.0	22.0	0.2	0.3	0.3
typ	0.03	5	0.3	0.008	0.01	25	21	0.1	<0.1	0.08

All-weld mechanical properties

As welded			typical
Tensile strength		MPa	520
0.2% Proof stress		MPa	350
Elongation on 4d		%	37
Elongation on 5d		%	30
Reduction of area		%	55
Impact energy	- 196°C	J	90
Hardness		HV	170

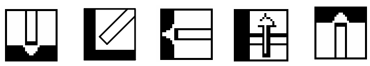
All-weld corrosion properties

The weld metal has been subjected to the Huey test (ASTM A262 practice C: 5 x 48hr periods in boiling 65% nitric acid). The corrosion rates were as follows:

Condition	Corrosion rate	Selective attack
As-welded	0.40 µm/48hr (= 0.07mm or 3 mils/year)	< 0.01mm
PWHT 815°C/2hrs	0.73 µm/48hr (= 0.13mm or 5 mils/year)	< 0.13mm

Operating parameters

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



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	13.5	15.0
pieces/carton	318	258

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°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	Ni	Cr	Cu	F	OES (mg/m^3)
9	10	2	7.5	<0.2	18	0.6

Stainless Steels

DATA SHEET B-46

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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**.

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.

Products available

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

METRODE WELDING CONSUMABLES

ULTRAMET B310MoLN

MMA electrode for welding alloy 310MoLN

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.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

BS EN 1600	E 25 22 2 N L B
BS 2926	25.21.2 L Mn B

ASME IX Qualification

QW432 F-No 5, **QW442** A-No 9.

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	N	Cu
min	--	3.0	--	--	--	24.0	20.0	2.0	0.10	--
Max	0.04	5.0	1.0	0.025	0.030	27.0	23.0	3.0	0.20	0.50
typ	0.03	4	0.4	0.005	0.02	25	22	2.2	0.15	0.05

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	510	640
0.2% Proof stress		MPa	320	430
Elongation on 4d		%	--	39
Elongation on 5d		%	25	38
Reduction of area		%	--	50
Impact energy	-50°C	J	--	75
Hardness cap/mid		HV	--	185/205

Operating parameters

DC +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
length mm	300	340	340
kg/carton	11.4	13.8	13.8
pieces/carton	501	408	270

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 300° 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	F	OES (mg/m^3)
9	10	2	7.5	<0.2	18	0.6

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METRODE WELDING CONSUMABLES

DATA SHEET **B-47**

20.18.6.CU.R

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

ASTM	A351 CK3MCuN (cast). A182 F44. S31254
BS EN	1.4547
Proprietary	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 authorities require >1230°C. This is followed by water quenching to prevent further intermetallic formation on cooling.

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	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 + 3.3Mo + 16N

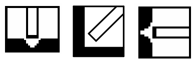
All-weld mechanical properties

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

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°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	Mo	Cu	F	OES (mg/m^3)
8	8	7	2	1.5	1	18	0.7

Stainless Steels

DATA SHEET	B-50

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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.

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.

Products available

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	**309S92**	AWS ER309L
MIG	**Supermig 309LSi**	AWS ER309LSi
SAW	**309S92**	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

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	Cr	Ni	Mo	Cu	F*	OES (mg/m^3)
9	6	7	1	0.1	< 0.2	17	0.7

* F=28% for basic coated Ultramet B309L but this does not affect the OES.

SUPERMET 309L

General purpose rutile 309L MMA electrode

Product description

MMA electrode – rutile aluminosilicate flux on high purity 304L core wire giving very low typical carbon level. 'Low hydrogen' manufacturing technology ensures high resistance to weld metal porosity. 'Supermet Technology' gives acid rutile operability combined with controlled silicon content for maximum cracking/corrosion resistance. Designed for ease of use, exceptional weld bead appearance and high weld metal integrity, primarily in the downhand and HV positions; smaller sizes offer all-positional operability.

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

Specifications

AWS A5.4	E309L-17
BS EN 1600	E 23 12 LR 32
BS 2926	23.12. L.AR
DIN 8556	E 23 12 LR 23

ASME IX Qualification

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

Composition (weld metal wt %)

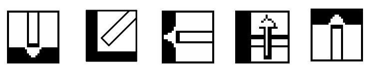
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	22.0	12.0	--	--	8
max	0.04	2.5	0.90	0.025	0.030	25.0	14.0	0.5	0.5	20
typ	0.02	0.8	0.6	0.01	0.02	24	13	0.05	0.1	15

All-weld mechanical properties

As-welded			min	typical
Tensile strength		MPa	560	620
0.2% Proof stress		MPa	320	500
Elongation on 4d		%	30	40
Elongation on 5d		%	30	36
Reduction of area		%	--	50
Impact energy	+ 20°C	J	--	55
Hardness		HV	--	220

Operating parameters

DC +ve or AC (OCV: 50V 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 mm	300	350	450	450
kg/carton	11.4	13.5	18.3	18.0
pieces/carton	579	354	258	156

ULTRAMET 309L

All-positional rutile MMA electrode for 309L

Product description

MMA electrode – rutile flux coated 309L electrode on high purity 304L core wire. Ultramet has all the benefits of an advanced rutile flux design – this includes optimum versatility for downhand welding with high cosmetic finish and weld metal integrity; and all-positional welding with the 2.5/3.2mm electrodes including fixed pipework. The 2.5mm electrodes are also designed for open butt root welding.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E309L-16
BS EN 1600	E 23 12 L R 32
BS 2926	23.12.LR
DIN 8556	E 23 12 L R 23
Approvals	Germanischer Lloyd

ASME IX Qualification

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

Composition (weld metal wt %)

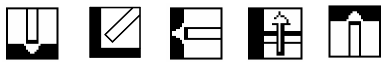
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	22.0	12.0	--	--	8
max	0.04	2.5	0.90	0.025	0.030	25.0	14.0	0.50	0.5	20
typ	0.03	0.8	0.6	0.01	0.02	23.5	13	0.1	0.1	15

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	560	595
0.2% Proof stress		MPa	320	495
Elongation on 4d		%	30	41
Elongation on 5d		%	30	38
Reduction of area		%	--	59
Impact energy	- 20°C	J	--	45
Hardness		HV	--	230

Operating parameters

DC +ve or AC (OCV: 50V 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 mm	300	350	350	450
kg/carton	12.6	13.5	13.5	18.0
pieces/carton	687	393	252	165

ULTRAMET B309L

Basic coated 309L MMA electrode for pipe-welding

Product description

MMA electrode – designed and manufactured to give high moisture resistance using a basic flux system and high purity 304L core wire. **Ultramet B309L** is particularly suited to the most demanding vertical and overhead welding applications including fixed pipework in the ASME 5G/6G position. Under site conditions it is tolerant to adverse wind and drafts.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E309L-15
BS EN 1600	E 23 12 L B 42
BS 2926	23.12.LB
DIN 8556	E 23 12 L B 20+

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	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

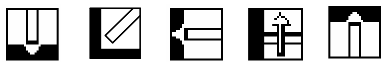
ULTRAMET B309L (continued)

All-weld mechanical properties

As welded			min	typical
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	350/450	450
kg/carton	12.0	13.8	14.1/17.4	17.1
pieces/carton	678	402	267/267	159

* 350mm is the standard length for 4.0mm diameter; 450mm is available to order.
** 5.0mm diameter made to order.

ULTRAMET 309LP

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 309LP is a fully all-positional electrode capable of the most demanding fixed pipework applications including ASME 5G/6G. The Ultramet 309LP 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 A5.4	E309L-16
BS EN 1600	E 23 12 L R 1 1

ASME IX Qualification

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

Composition (weld metal wt %)

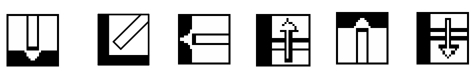
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	22.0	12.0	--	--	8
max	0.04	2.5	0.90	0.025	0.030	25.0	14.0	0.50	0.5	20
typ	0.03	0.8	0.6	0.01	0.02	23.5	13	0.1	0.1	15

All-weld mechanical properties

As welded		min	typical
Tensile strength	MPa	560	635
0.2% Proof stress	MPa	320	525
Elongation on 4d	%	30	41
Elongation on 5d	%	30	38
Reduction of area	%	--	45
Hardness	HV	--	230

Operating parameters

DC +ve or AC (OCV: 50V min)



ø mm	2.5	3.2
min A	60	75
max A	90	120

309S92, SUPERMIG 309LSi

309L solid wire

Product description

Solid wires for TIG, MIG and sub-arc welding.

Specifications

	309S92 (TIG & sub-arc)	Supermig 309LSi (MIG)
AWS A5.9	ER309L	ER309L Si
BS EN ISO 14343-A	23 12 L	G 23 12 L Si
BS EN ISO 14343-B	SS309L	SS309L Si
BS 2901: Pt2	309S92	309S93
DIN 8556	SG X2CrNi 24 12 (1.4332)	SG X2CrNi 24 12 (1.4332)

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si *	S	P	Cr	Ni	Mo	Cu	FN
min	--	1.0	0.30	--	--	23.0	12.0	--	--	8
max	0.03	2.5	0.65	0.020	0.030	25.0	14.0	0.3	0.3	15
typ	0.015	1.7	0.5	0.005	0.015	23.5	13	0.1	0.15	12

* **Supermig 309LSi**: Si range is 0.65 – 1.0%, typically 0.8%.

All-weld mechanical properties

As welded			typical TIG	typical MIG
Tensile strength		MPa	590	560
0.2% Proof stress		MPa	450	430
Elongation on 4d		%	43	42
Elongation on 5d		%	41	39
Reduction of area		%	55	56
Impact energy	+ 20°C	J	>200	100
	- 20°C	J	--	80
	- 75°C	J	>150	--
Hardness cap/mid		HV	205/225	175/215

Typical operating parameters

	TIG	MIG	SAW
Shielding	Argon *	Ar+2%O_2**	SSB***
Current	DC-	DC+	DC+
Diameter	2.4mm	1.2mm	2.4mm
Voltage	100A, 12V	260A, 26V	350A, 28V

* Also required as a purge for root runs.

** Also proprietary Ar and Ar-He gas mixtures with < 3%CO_2.

*** **LA491** also suitable.

Packaging data

ø mm	TIG 309S92	MIG Supermig 309LSi	SAW 309S92
0.8	--	15kg spool	--
1.0	--	15kg spool	--
1.2	--	15kg spool	--
1.6	2.5kg tube	--	25kg coil
2.4	2.5kg tube	--	25kg coil
3.2	2.5kg tube	--	25kg coil

Fume data

MIG fume composition (wt %) (TIG and SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
32	12	20	11	< 0.5	< 0.5	2.5

SUPERCORE 309L, 309LP

Rutile flux cored wires

Product description	Flux cored wires – the wires are made with an austenitic stainless steel sheath and rutile flux system. **Supercore 309L** combines easy operability, high deposit quality and exceptional weld bead appearance for downhand and HV welding. **Supercore 309LP** is designed for all-positional welding including fixed pipework. Metal recovery is about 90% with respect to the wire.

Specifications & Approvals

	Supercore 309L	Supercore 309LP
AWS A5.22	E309LT0-4	E309LT1-4
BS EN ISO 17633-A	T 23 12 L R M 3	T 23 12 L P M 2
BS EN ISO 17633-B	TS309L-FM0	TS309L-FM1
Approvals	TÜV, Germanischer Lloyd	TÜV, Germanischer Lloyd

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	22.0	12.0	--	--	12
max	0.04	2.0	1.0	0.025	0.030	25.0	14.0	0.3	0.3	22
typ	0.03	1.3	0.6	0.02	0.02	24	12.5	0.1	0.1	15

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	520	560
0.2% Proof stress		MPa	320	445
Elongation on 4d		%	30	40
Elongation on 5d		%	25	36
Reduction of area		%	--	52
Impact energy	+ 20°C	J	--	65 *
	- 20°C	J	--	55 *
Hardness		HV	--	205

* These values are for Supercore 309LP. Values for Supercore 309L are 45J at +20°C, 40J at -20°C.

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.

Supercore 309L is also suitable for use with 100% CO_2.

Current: DC+ve ranges as below for Ar-20%CO_2 (Supercore 309L with 100%CO_2 requires approx 3V higher):

ø mm	amp-volt range	typical	stickout
1.2	120 – 280A, 21 – 35V	180A, 28V	15 – 20mm
1.2P	120 – 250A, 20 – 32V	180A, 26V	15 – 20mm

Packaging data

Spools vacuum-sealed in barrier foil with cardboard carton: Supercore 309L – 12.5kg, Supercore 309LP – 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^3	Cr^6	Cu	F	OES (mg/m^3)
14	11	2	5	4	< 1	6	1.2

METRODE WELDING CONSUMABLES

Stainless Steels

309Mo STAINLESS STEELS

DATA SHEET **B-51**

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Internet: http//www.metrode.com

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.

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°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	F *	OES (mg/m^3)
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	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 A5.4** E309LMo-17 **BS EN 1600** E 23 12 2 L R 32 **BS 2926** 23.12.2.AR **DIN 8556** E 23 12 2 R 23
ASME IX Qualification	**QW432** F-No 5, **QW442** A-No 8

Composition (weld metal wt %)

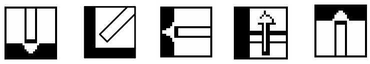
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	22.0	12.0	2.0	--	10
max	0.04	2.5	0.9	0.025	0.030	25.0	14.0	3.0	0.5	30
typ	0.02	0.8	0.6	0.01	0.02	23.5	12.5	2.5	0.05	25

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	560	680
0.2% Proof stress		MPa	350	510
Elongation on 4d		%	30	37
Elongation on 5d		%	30	35
Reduction of area		%	--	40
Impact energy	+ 20°C	J	--	50
Hardness		HV	--	220

Operating parameters

DC +ve or AC (OCV: 50V 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 mm	300	350	450	450
kg/carton	12.0	13.2	18.9	18.0
pieces/carton	609	336	261	162

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. Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.
Specifications	**AWS A5.4** E309LMo-15 **BS EN 1600** E 23 12 2 L B 42 **BS 2926** 23.12.2.B **DIN 8556** E 23 12 2 B 20+
ASME IX Qualification	**QW432** F-No 5, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	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 properties

As welded		min	typical
Tensile strength	MPa	560	680
0.2% Proof stress	MPa	350	510
Elongation on 4d	%	30	37
Elongation on 5d	%	30	35
Reduction of area	%	--	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
pieces/carton	420	396

Note: Product available to order only.

VERTAMET 309Mo

Rutile vertical-down electrode for dissimilar welds

Product description

Rutile-aluminosilicate flux on high purity 309L core wire giving very low typical carbon levels. 'Low hydrogen' manufacturing technology ensures high resistance to weld metal porosity. The electrode is designed for all-positional use where the emphasis is on fast welding speeds achieved by the vertical-down welding technique (BS EN 287-1 PG position). For fillet and lap joints in thinner sheet material, an added advantage is reduced distortion resulting from the lower heat input of vertical-down welding. Although designed primarily for vertical-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 A5.4	E309LMo-17
BS EN 1600	E 23 12 2 L R 11
BS 2926	23.12.2.AR
DIN 8556	E 23 12 2 R 13

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	22.0	12.0	2.0	--	10
max	0.04	2.5	0.90	0.025	0.030	25.0	14.0	3.0	0.5	30
typ	0.02	0.8	0.8	0.01	0.02	23	12	2.4	0.1	15

All-weld mechanical properties

As welded		min	typical
Tensile strength	MPa	560	580
0.2% Proof stress	MPa	350	380
Elongation on 4d	%	30	42
Elongation on 5d	%	30	38
Reduction of area	%	--	50

Operating parameters

DC +ve or AC (OCV: 45V min)

ø mm	2.5	3.2
min A	60	75
max A	90	120
Typical vertical-up	~65	~80
Typical vertical-down	~85	~110

Packaging data

ø mm	2.5	3.2
length mm	300	300
kg/carton	12.9	12.9
pieces/carton	837	450

ER309Mo

Solid 309Mo wire for TIG, MIG and SAW

Product description	Solid wire for TIG, MIG and SAW.
Specifications	**AWS A5.9** (nearest ER309LMo) **BS EN ISO 14343-A** 23 12 2 L **BS EN ISO 14343-B** (nearest SS309LMo) **BS 2901: Pt2** (nearest 309S95) **DIN 8556** SG X8 XrNiMo 23 13 (1.4459)
ASME IX Qualification	**QW432** F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	1.0	0.30	--	--	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 properties

Typical values as welded			TIG
Tensile strength		MPa	610
0.2% Proof stress		MPa	440
Elongation on 4d		%	35
Elongation on 5d		%	31
Reduction of area		%	54
Impact energy	+ 20°C	J	> 90
Hardness cap/mid		HV	205/220

Typical operating parameters

	TIG	MIG	SAW
Shielding	Argon	Ar+2%O_2 *	SSB **
Current	DC-	DC+	DC+
Diameter	2.4mm	1.2mm	2.4mm
Parameters	100A, 12V	260A, 26V	350A, 28V

* Proprietary Ar and Ar-He gas mixtures with <3%CO_2 also suitable.
** **SSCr** (Cr compensating flux) and **LA491** also suitable.

Packaging data

ø mm	TIG	MIG	SAW
1.2	--	15kg spool	--
1.6	2.5kg tube	--	--
2.0	2.5kg tube	--	--
2.4	2.5kg tube	--	25kg coil
3.2	2.5kg tube	--	25kg coil

Fume data

MIG fume composition (wt %) (TIG and SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
32	12	20	11	1.5	<0.5	2.5

SUPERCORE 309Mo

Downhand rutile flux cored wire for dissimilar welding

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

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

QW432 F-No 6, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	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 properties

As welded			min	typical
Tensile strength		MPa	550	700
0.2% Proof stress		MPa	350	550
Elongation on 4d		%	25	32
Elongation on 5d		%	25	30
Reduction of area		%	--	40
Impact energy	+20°C	J	--	50
Hardness		HV	--	245

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%. The wire is suitable for use on 100%CO_2.

Current: DC+ve parameters as below (for 100%CO_2 increase voltage by ~3V):

ø mm	amp-volt range	typical	stickout
1.2	120A-22V to 280A-34V	180A-26V	15-20mm

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

Fume composition (wt %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
16	11	3	4	6	<1	6	0.8

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DATA SHEET **B-53**

ULTRAMET 309Nb

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 A5.4	E309Nb-16 (previously E309Cb-16)
BS EN 1600	E 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°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).

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 %)

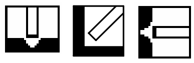
	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu
min	--	0.5	--	--	--	22.0	12.0	--	0.70	--
max	0.04	2.5	0.9	0.025	0.030	25.0	14.0	0.50	1.00	0.50
typ	0.03	1.5	0.5	0.01	0.02	23	12.5	0.05	0.8	0.1

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

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°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:

Fe	Mn	Ni	Cr	Mo	Cu	F	OES (mg/m^3)
9	6	1	7	<0.5	<0.2	17	0.7

Stainless Steels

22%Cr DUPLEX STAINLESS STEELS

DATA SHEET **B-60**

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Alloy type

22%Cr standard duplex ferritic-austenitic stainless steels.

Materials to be welded

ASTM	**BS EN & DIN**
A182 Gr F51	1.4462
A890 Gr 4A (cast)	X2CrNiMoN22-5-3
BS	**UNS**
318S13	S31803, S32205
	J92205 (cast)
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 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.

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.

Products available

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

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 380° 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	Mo	Cu	F *	OES (mg/m^3)
7	6	6	1	0.2	<0.2	16	0.8

* F = 28% for basic coated 2205XKS but this does not affect OES.

SUPERMET 2205

Rutile electrode for 22%Cr duplex

Product description

MMA electrode with enhanced Cr, Mo and N levels, giving higher weld pitting resistance than the nearest AWS specification A5.4 E2209-16. See **Ultramet 2205** for rutile type conforming to AWS.

Supermet 2205 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.

Supermet 2205 is designed for welding wrought, forged or cast "standard" duplex stainless steels for service in the **as-welded** condition. Good properties are also obtained when **solution treated**, 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 120% with respect to core wire, 65% with respect to whole electrode.

Specifications

NONE Nearest is AWS A5.4 E2209-16.

ASME IX Qualification

QW432 F-No -, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE$_N$
min	--	0.5	0.3	--	--	24.0	8.5	3.0	--	0.14	36
max	0.03	2.0	1.0	0.02	0.03	26.0	10.0	4.0	0.5	0.25	43
typ	0.02	1	0.7	0.01	0.02	25	9.5	3.4	0.1	0.17	38

PRE$_N$ = Cr + 3.3Mo + 16N

All-weld mechanical properties

As welded			min	typical	Pipe butt weld	1120°C/ 3h + WQ
Tensile strength		MPa	690	850	867	800
0.2% Proof stress		MPa	480	650	752	480
Elongation on 4d		%	20	30	25	32
Reduction of area		%	--	40	35	--
Impact energy	+20°C	J	--	60-73	--	--
	- 20°C	J	--	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	> 35

Operating parameters

DC +ve or AC (OCV 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 2205

Rutile all-positional electrode for 22%Cr duplex

Product description

MMA electrode made on high quality stainless steel core wire with a rutile flux system designed to give minimum carbon content coupled with optimum operating characteristics. The electrode has a rutile flux system optimised for all welding positions except vertical down and provides excellent operability.

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

Specifications

AWS A5.4	E2209-16
BS EN 1600	E 22 9 3 N L R 3 2

ASME IX Qualification

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

Composition (weld metal wt %)

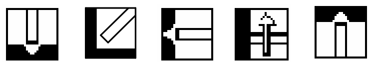
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
min	--	0.5	0.3	--	--	22.0	8.5	2.8	--	0.14	34
max	0.03	2.0	0.90	0.02	0.03	23.5	10.0	3.5	0.5	0.2	38
typ	0.02	1	0.7	0.01	0.02	23.2	9	3.2	0.1	0.17	36

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	690	850
0.2% Proof stress		MPa	480	675
Elongation on 4d		%	20	27
Elongation on 5d		%	20	25
Reduction of area		%	--	40
Hardness		HV10 (HRC)	--	< 305 (< 24)
Impact energy	+ 20°C	J (mm)	--	> 54 (> 0.8)
	- 20°C	J (mm)	--	43-48 (> 0.5)
	- 50°C	J (mm)	--	32-41 (>0.38)

Operating parameters

DC +ve or AC (OCV: 50V min).



ø mm	2.5	3.2	4.0	5.0
min A	60	75	100	130
max A	90	120	155	190

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	300	350	350	450
kg/carton	12.0	13.5	13.5	18.3
pieces/carton	654	372	243	177

2205XKS

Basic pipe-welding electrode for 22%Cr duplex

Product description

MMA electrode made on duplex stainless core wire with a special basic flux to give optimum all-positional operability.

Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.

The electrode has a basic flux system and is recommended where the highest sub-zero toughness is required, and for the most demanding positional welding applications such as fixed pipework qualified in the ASME 6G position.

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, **QW442** A-No 8

2205XKS (continued)

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
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

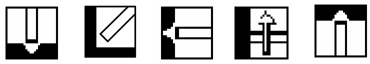
$PRE_N = Cr + 3.3Mo + 16N$

All-weld mechanical properties

As welded			min	typical	1120 – 1135°C +WQ
Tensile strength		MPa	690	750-870	790
0.2% Proof stress		MPa	450	630-700	480
Elongation on 4d		%	20	28	41
Elongation on 5d		%	20	26	37
Reduction of area		%	--	45	64
Impact energy	+ 20°C	J	--	> 85	--
	- 50°C	J	47	> 60	> 75
	- 75°C	J	--	> 30	--
Hardness		HV	--	260-290	240

Operating parameters

DC +ve only.



ø mm	2.5	3.2	4.0	5.0
min A	50	70	100	130
max A	75	95	155	190

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	300	350	350	350
kg/carton	12.0	13.5	13.5	13.5
pieces/carton	720	402	273	171

ER329N / 2205 MIG

Solid welding wire for 22%Cr duplex

Product description

Solid duplex stainless wire for welding 2205 type duplex stainless steels.

Specifications

AWS A5.9	ER2209
BS EN ISO 14343-A	22 9 3 N L
BS EN ISO 14343-B	SS2209
BS 2901: Pt2	22.8.3S92

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N
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*

Duplex weld metal microstructure with austenite + 30-50% ferrite.
Pitting resistance equivalent $PRE_N = Cr + 3.3Mo + 16N$ is > 35.

* ER329N MIG and 2205 MIG spooled wire is selected for suitability for both MIG and auto-TIG, with typically 0.15%N to control porosity.

All-weld mechanical properties

Typical values as welded			min	typical TIG	typical MIG	typical SAW + SSB
Tensile strength		MPa	690	820	800-835	790
0.2% Proof stress		MPa	450	640	560-620	630
Elongation on 4d		%	20	36	28-35	30
Elongation on 5d		%	20	33	30	27
Hardness		HV	--	270 (< 310)	270 (< 310)	275 (< 320)
		HRC	--	23 (< 28)	23 (< 28)	23 (< 28)
Impact energy	- 30°C	J	--	180 (> 140)	> 70	75 (>55)
	- 50°C	J	--	180 (> 120)	> 60	55 (>35)
	- 75°C	J	--	125 (>70)	--	--

ER329N / 2205 MIG (continued)

Typical operating parameters

	TIG	MIG	SAW
Shielding	Argon	Ar / He / CO_2	SSB flux *
Current	DC -	pulsed	DC +
Diameter	1.6 / 2.4mm	1.2mm	1.6mm
Parameters	100A, 12V	180A, 28V	350A, 30V

* LA491 flux also suitable.

Packaging data

ø mm	TIG	MIG	SAW
0.8	--	15kg spool	--
1.0	--	15kg spool	--
1.2	2.5kg tube	15kg spool	--
1.6	2.5kg tube	--	25kg coil
2.0	2.5kg tube	--	to order
2.4	2.5kg tube	--	25kg coil
3.2	2.5kg tube	--	--

Fume data

MIG fume composition (wt %) (TIG and SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
28	10	20	8	1.5	< 0.5	2.5

SUPERCORE 2205, 2205P

Flat and positional FCAW for 22%Cr duplex

Product description

High performance rutile flux cored wires produced in the most versatile size of 1.2mm. **Supercore 2205** is suited to welding in the flat and horizontal-vertical positions (material > 6mm). **Supercore 2205P** 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 <0.03% when using the recommended 80%Ar-20%CO_2 shielding gas.

Metal recovery about 90% with respect to the wire.

Specifications

	Supercore 2205	**Supercore 2205P**
AWS A5.22	E2209T0-4	E2209T1-4
BS EN ISO 17633-A	T 22 9 3 N L R M 3	T 22 9 3 N L P M 2
BS EN ISO 17633-A	TS2209-FM0	TS2209-FM1

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE*
min	--	0.5	--	--	--	21.5	8.5	2.8	--	0.08	34
max	0.04	2.0	1.00	0.02	0.030	24.0	10.0	4.0	0.3	0.20	38
typ	0.03	1.2	0.7	<0.01	0.02	23	9.2	3.1	0.1	0.12	35

* PRE (pitting resistance equivalent) = Cr + 3.3Mo + 16N

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	690	800
0.2% Proof stress		MPa	480	630
Elongation on 4d		%	20	32
Elongation on 5d		%	20	29
Reduction of area		%	--	45
Impact energy	- 20°C	J	--	65 *
	- 50°C	J	--	55 *
	- 75°C	J	--	30 *
Hardness		HV	--	270

* These values are for **Supercore 2205P**. Impact energy values for **Supercore 2205** are typically 40J at –20°C, 30J at –50°C.

SUPERCORE 2205, 2205P (continued)

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 80%. Gas mixtures without oxygen additions can be helpful for optimum weld metal toughness. **Supercore 2205** is also suitable for use with 100% CO_2.
Current: DC+ve ranges as below for Ar-20%CO_2 (Supercore 2205 with 100% CO_2 requires approx 3V higher):

ø mm	amp-volt range	typical	stickout
1.2	150A-25V to 280A-34V	200A-30V	15-20mm
1.2 P	130A-20V to 250A-34V	140A-23V	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 %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
10	12	2	4	5.5	<0.5	9	0.9

SSB FLUX

Sub-arc flux

Product description

Agglomerated basic non-alloying flux for submerged arc welding.

Specifications

DIN 32522	BFB6 63353 DC8M
BS EN 760	SA AF2 DC

ASME IX Qualification

QW432 F-No -, **QW442** A-No -

Composition (typical)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N
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 properties with ER329N wire

As welded			
Tensile strength		MPa	790
0.2% Proof stress		MPa	630
Elongation on 4d		%	30
Hardness		HV	275 (< 320)
		HRC	23 (< 28)
Impact energy	- 30°C	J	75 (>55)
	- 50°C	J	55 (>35)

Operating parameters

Current: DC +ve ranges as below:

ø mm	amp-volt range	typical	stickout
1.6	200-350A, 27-31V	300A, 28V	20-25mm
2.4	250-450A, 28-32V	350A, 29V	20-25mm

Packaging data

Metrode **SSB 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 250-400°C/1-3h.

Stainless Steels

DATA SHEET **B-61**

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL
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Email: info@metrode.com
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25%Cr SUPERDUPLEX - ZERON® 100

Alloy type

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

Materials to be welded

Matching

wrought:	**cast:**
UNS S32760	UNS J93380, DIN 1.4508
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® 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 additions. Offshore applications exploit the high 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® 100 wires are also used for joining supermartensitic stainless steels.

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® 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.

Products available

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

General Data for all Zeron® 100 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°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/m^3)
7	6	1	7	0.5	0.2	<0.1	28	0.7

ZERON® 100XKS

Basic pipe-welding electrode for superduplex

Product description

Basic coated all-positional MMA electrode for welding Zeron® 100 and other 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 6G position.

Fully alloyed matching Zeron® 100 core wire including W and Cu. Moisture resistant flux technology.

Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E2595-15
BS EN 1600	E 25 9 4 N L B 4 2
Weir Materials	MDS 12809/08
Approvals	ABS, DNV

ASME IX Qualification

QW432 F-No -, **QW442** A-No -

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Cu	N	PRE_N	PRE_W
min	--	--	--	--	--	24.0	9.0	3.5	0.5	0.5	0.2	40	40
max	0.040	1.0	1.0	0.01	0.03	26.0	10.0	4.0	1.0	1.0	0.3	--	--
typ	0.03	0.9	0.5	0.005	0.02	25	9.3	3.6	0.7	0.7	0.23	41	42

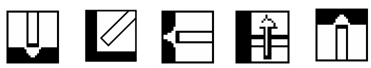
Pitting resistance equivalent $PRE_N = Cr + 3.3Mo + 16N$
Pitting resistance equivalent $PRE_W = Cr + 3.3Mo + 1.65W + 16N$

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	750	800-950
0.2% Proof stress		MPa	550	650-750
Elongation on 5d		%	20	22-25
Reduction of area		%	--	40-45
Impact energy	- 20°C	J	--	> 55
	- 50°C	J	--	> 40
Hardness		HV	--	270-320

Operating parameters

DC +ve



ø mm	2.5	3.2	4.0	5.0
min A	50	70	100	130
max A	75	95	155	210

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	300	350	350	350
kg/carton	12.0	14.1	13.5	13.5
pieces/carton	696	360	270	172

ZERON® 100X

Solid welding wire for superduplex

Product description

Solid wire for TIG, MIG and SAW.

For applications where Zeron® 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.

Specifications

AWS A5.9	ER2594
BS EN ISO 14343-A	25 9 4 N L (prefix W=TIG, G=MIG, S=SAW)
Weir Materials	MDS 12809/07
Approvals	ABS, DNV (TIG and SAW in conjunction with SSB flux)

ASME IX Qualification

QW432 F-No -, **QW442** A-No -

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Cu	N	PRE_N	PRE_W
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 properties

Typical values as welded			min	TIG	MIG	SAW	TIG +160°C
Tensile strength		MPa	750	870	860	885	769
0.2% Proof stress		MPa	550	695	645	700	523
Elongation on 4d		%	--	36	25	26	39
Elongation on 5d		%	20	32	23	24	34
Reduction of area		%	--	68	28	48	72
Impact energy	-50°C	J	--	130	60	40	--
	-75°C	J	--	>100	--	--	--
Hardness cap/mid		HV	--	290	290	290	--

Typical operating parameters

	TIG	MIG	SAW
Shielding	Argon	Ar/He/CO_2	SSB flux
Current	DC-	pulsed	DC+
Diameter	1.6/2.4mm	1.2mm	1.6mm
Voltage	100A, 12V	180A, 28V	350A, 30V

Packaging data

ø mm	TIG	MIG	SAW
0.8	--	To order	--
1.0	--	To order	--
1.2	--	To order	--
1.6	2.5kg tube	--	25kg coil
2.4	2.5kg tube	--	25kg coil
3.2	2.5kg tube	--	--

Fume data

MIG fume composition (wt %) (TIG and SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
28	10	22	8	2	1.3	2.3

SSB FLUX

Sub-arc flux

Product description	Agglomerated basic non-alloying flux for submerged arc welding.
Specifications	**DIN 32522** BFB6 63353 DC8M **BS EN 760** SA AF2 DC
ASME IX Qualification	**QW432** F-No -, **QW442** A-No -

Composition (typical)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	W	N
Zeron® 100X wire	0.015	0.7	0.4	0.002	0.023	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 properties with Zeron® 100X wire

Typical values as welded			min	SAW
Tensile strength		MPa	750	890
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 ranges as below:

ø mm	amp-volt range	typical	stickout
1.6	200-350A, 27-31V	300A, 28V	20-25mm
2.4	250-450A, 28-32V	350A, 29V	20-25mm

Packaging data

Metrode **SSB 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 250-400°C/1-3h.

LA491 FLUX

Sub-arc flux

Product description	Agglomerated fluoride-basic non-alloying flux for submerged arc welding.
Specifications	**DIN 32522** B FB 6 55455 AC 8 **BS EN 760** SA FB 255 AC
ASME IX Qualification	**QW432** F-No -, **QW442** A-No -

Composition (typical)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	W	N
Zeron® 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 properties with Zeron® 100X wire

Typical values as welded			min	SAW
Tensile strength		MPa	750	890
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 ranges as below:

ø mm	amp-volt range	typical	stickout
1.6	200-350A, 27-31V	300A, 28V	20-25mm
2.4	250-450A, 28-32V	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.

SUPERCORE Z100XP

Rutile flux cored wire for superduplex stainless steel

Product description

Flux cored wire made with an alloyed stainless steel sheath and rutile flux system. **Supercore Z100XP** combines easy operability, high deposit quality for both positional pipework and downhand welding. Metal recovery is about 90% with respect to the wire.

Specifications

There are no national specifications for this wire.

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	W	N	PRE_N	PRE_W
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

Pitting resistance equivalent $PRE_N = Cr + 3.3Mo + 16N$
Pitting resistance equivalent $PRE_W = Cr + 3.3Mo + 1.65W + 16N$

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	750	880
0.2% Proof stress		MPa	550	690
Elongation on 4d		%	--	27
Elongation on 5d		%	20	25
Reduction of area		%	--	33
Impact energy	-20°C	J	--	40
	-50°C	J	--	32
Hardness		HV	--	280
		HRC	--	26

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.
Current: DC+ve ranges as below for Ar-20%CO_2:

ø mm	amp-volt range	typical	stickout
1.2	120 – 250A, 20 – 32V	180A, 26V	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 %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
14	10	1.5	5	5	< 1	5	1.0

METRODE WELDING CONSUMABLES

Stainless Steels

25%Cr SUPERDUPLEX - 2507

DATA SHEET B-62

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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® 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.

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 2507 superduplex is available in the Metrode Technical Profile on duplex and superduplex.

Related alloy groups

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

Products available

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	**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/m^3)
7	6	1	7	0.5	0.2	<0.1	16	0.7

* F = 28% for basic coated 2507XKS electrode but this does not affect the OES.

2507XKS

Basic pipe-welding electrode for 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.

Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E2594-15
BS EN 1600	E 25 9 4 N L B 4 2

ASME IX Qualification

QW432 F-No -, **QW442** A-No -

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
min	--	0.5	--	--	--	24.0	8.5	3.5	--	0.20	40
max	0.04	2.0	1.0	0.02	0.03	26.0	10.5	4.5	0.5	0.30	46
typ	0.03	1	0.5	0.01	0.02	25	9.5	3.8	0.1	0.22	41

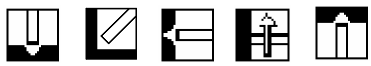
All-weld mechanical properties

As welded			min	typical	>1120°C/>3h + WQ transverse *
Tensile strength		MPa	800	900	>760
0.2% Proof stress		MPa	550	700	--
Elongation on 4d		%	22	28	--
Elongation on 5d		%	18	25	--
Reduction of area		%	--	45	--
Impact energy	+20°C	J	--	85	--
	-50°C		--	60	>80
	-75°C		--	35	--
Hardness		HV	--	280-330	<300

* Representative properties for solution treated welds in castings of ASTM A890 grade 5A. Ferrite >30%.

Operating parameters

DC +ve



ø mm	2.5	3.2	4.0	5.0
min A	50	70	100	130
max A	75	95	155	190

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	300	350	350	350
kg/carton	12.0	13.5	13.5	13.5
pieces/carton	669	420	267	165

METRODE WELDING CONSUMABLES

ULTRAMET 2507

Rutile all-positional electrode for superduplex

Product description

Rutile coated MMA electrode for welding superduplex alloys for service in the as-welded condition. This electrode is overmatching with respect to nickel content to achieve the correct austenite-ferrite microstructural phase balance.

Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E2594-16
BS EN 1600	E 25 9 4 N L R 3 2

ASME IX Qualification

QW432 F-No -, **QW442** A-No -

Composition (weld metal wt %)

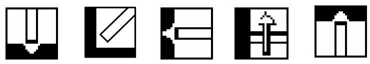
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
min	--	0.5	--	--	--	24.0	8.5	3.5	--	0.20	40
max	0.04	1.5	1.0	0.02	0.03	26.0	10.5	4.5	0.5	0.30	46
typ	0.03	1	0.8	0.01	0.02	25	9.5	4	0.1	0.23	42

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	750	890
0.2% Proof stress		MPa	550	750
Elongation on 4d		%	22	26
Elongation on 5d		%	20	24
Reduction of area		%	--	35
Impact energy	-20°C	J	--	28
	-50°C		--	>21
Hardness		HV	--	275-315
		HRC	--	28

Operating parameters

DC +ve or AC (OCV: 55V 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	11.4	13.5	13.8
pieces/carton	609	393	249

SUPERCORE 2507, 2507P

Rutile flux cored wires for superduplex stainless steel

Product description

Flux cored wire made with an alloyed stainless steel sheath and rutile flux system. The **Supercore 2507** combines easy operability, high deposit quality and exceptional bead appearance for downhand and HV welding. **Supercore 2507P** combines easy operability, high deposit quality for both positional pipework and downhand welding. Metal recovery is about 90% with respect to the wire.

Specifications

There are no national specifications for these wires.

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
min	--	--	--	--	--	24.0	8.5	3.5	--	0.2	40
max	0.04	2.0	1.0	0.02	0.03	26.0	10.5	4.5	0.5	0.3	--
typ	0.03	1.0	0.5	0.010	0.02	24.5	9.3	3.8	0.05	0.23	41

Pitting resistance equivalent $PRE_N = Cr + 3.3Mo + 16N$

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	750	870
0.2% Proof stress		MPa	550	660
Elongation on 4d		%	--	30
Elongation on 5d		%	20	29
Reduction of area		%	--	38
Impact energy *	+20°C	J	--	60
	-20°C	J	--	45
	-50°C	J	--	35
Hardness		HV	--	300

* Values given are for **Supercore 2507P**. Impact values for **Supercore 2507** are typically: 45J at +20°C. 35J at -20°C and 30J at -50°C.

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.
Current: DC+ve ranges as below for Ar-20%CO_2:

ø mm	amp-volt range	typical	stickout
1.2	140 – 280A, 22 – 35V	180A, 28V	15 – 20mm
1.2P	120 – 250A, 20 – 32V	180A, 26V	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 %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
14	10	1.5	5	5	< 1	5	1.0

Stainless Steels

25%Cr SUPERDUPLEX WITH 2%Cu

DATA SHEET **B-63**

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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 non-sulphuric 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**.

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 preheat-interpass 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® 100X with 0.7%Cu (DS B-61). Copper-free 2507 electrodes are also available (DS B-62).

Products available

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

METRODE
WELDING CONSUMABLES

SUPERMET 2506Cu

Rutile coated MMA electrode for copper bearing superduplex

Product description	MMA electrode made on a low carbon stainless steel core wire with a rutile flux containing additional elements for alloying and deoxidation. Nitrogen and nickel are controlled to give a balanced duplex structure to minimise the risk of cracking, particularly in highly restrained welds. Recovery is about 140% with respect to core wire, 65% with respect to whole electrode.
Specifications	**AWS A5.4** E2553-16 **BS EN 1600** E 25 9 3 Cu N L R 52 **BS 2926** (Nearest 25.6.2.Cu.R)
ASME IX Qualification	**QW432** F-No 5, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE *
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 (Pitting Resistance Equivalent) = %Cr + 3.3%Mo + 16%N

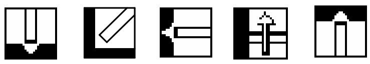
All-weld mechanical properties

Typical as-welded and PWHT			1120°C/2h + WQ min *	1120°C/2h + WQ typical	As-welded min	As-welded typical
Tensile strength		MPa	690	775	760	925
0.2% Proof stress		MPa	485	575	550	780
Elongation on 4d		%	16	32	15	17
Elongation on 5d		%	--	--	15	16
Reduction of area		%	--	40	--	25
Impact energy	+ 20°C	J	--	70	--	35
	- 30°C	J	--	60	--	22
Hardness		HV	--	260	--	340
		HRC	--	--	--	30

* These properties are appropriate for ASTM CD4MCu castings solution treated for optimum corrosion resistance; rapid cooling is important for best impact properties.

Operating parameters

DC +ve 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 mm	300	350	350	450
kg/carton	12.0	15.0	15.0	16.5
pieces/carton	513	321	216	111

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 300° 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/m^3)
9	5	1	7.5	1	0.6	<0.1	16	0.6

SUPERCORE 2507Cu

Rutile flux cored wire for Cu containing superduplex stainless steel

Product description

Flux cored wire made with an alloyed stainless steel sheath and rutile flux system. The **Supercore 2507Cu** combines easy operability, high deposit quality and exceptional bead appearance for downhand and HV welding.

Metal recovery is about 90% with respect to wire.

Specifications

There are no national specifications for this wire, the nearest relevant specification is AWS A5.22 E2553T0-4.

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	**PRE_N**
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 resistance equivalent PRE_N = Cr + 3.3Mo + 16N

All-weld mechanical properties

Typical as welded and PWHT			1120°C/2h + WQ	As-welded	
			typical	min	typical
Tensile strength		MPa	760	750	780
0.2% Proof stress		MPa	450	550	590
Elongation on 4d		%	40	--	35
Elongation on 5d		%	39	20	33
Reduction of area		%	--	--	32
Impact energy	+20°C	J	65	--	40
	-50°C	J	45	--	>27
Hardness		HV	250	--	300

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.
Current: DC+ve ranges as below for Ar-20%CO_2:

ø mm	amp-volt range	typical	stickout
1.2	140 – 280A, 22 – 35V	180A, 28V	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 %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
14	10	1.5	5	5	1	5	1.0

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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 Sheet	Alloy	Process	Product	Specifications	
				AWS	BS EN
300H stainless steel consumables for elevated temperature service					
C-10	308H	MMA	**Ultramet 308H**	E308H-16	E 19 9 H R
			Ultramet B308H	E308H-15	E 19 9 H B
		TIG/MIG/SAW	**308S96**	ER308H	19 9 H
		FCW	**Supercore 308H**	E308HT0-4	--
			Supercore 308HP	E308HT1-4	--
C-11	347H	MMA	**Ultramet 347H**	E347-16	E 19 9 Nb R
			Ultramet B347H	E347-15	E 19 9 Nb B
		TIG/SAW	**ER347H**	ER347	19 9 Nb
		FCW	**Supercore 347HP**	E347T1-4	T 19 9 Nb P M 2
C-12	16.8.2	MMA	**Supermet 16.8.2**	E16.8.2-17	--
			E16.8.2-15	E16.8.2-15	--
		TIG	**ER16.8.2**	ER16.8.2	W 16 8 2
		SAW	**ER16.8.2**	ER16.8.2	S 16 8 2
		FCW	**Supercore 16.8.2**	--	--
			Supercore 16.8.2P	--	--
C-13	316H	MMA	**17.8.2.RCF**	--	BS: 17.8.2.R
			Ultramet 316H	E316H-16	E 19 12 2 R 32
		TIG/MIG/SAW	**316S96**	ER316H	19 12 3 H

Data Sheet	Alloy	Process	Product	Specifications	
				AWS	**BS EN**
High temperature 309 alloys					
C-20	253MA	MMA	**Supermet 253MA**	--	--
C-21	309	MMA	**Thermet 309CF**	E309H-16	(E 22 12 R)
		TIG/MIG	**309S94**	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					
C-30	310	MMA	**25.20 Super R**	(E310-16)	E 25 20 R
			Ultramet B310Mn	(E310-15)	E 25 20 B
		TIG/MIG/SAW	**310S94**	ER310	25 20
C-31	310H	MMA	**Thermet 310H**	E310H-15	E 25 20 H B
Consumables for alloys 330 and 800					
C-40	800	MMA	**Thermet 800Nb**	--	--
		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**	--	--
Consumables for HP40 and other high carbon cast alloys					
C-50	HP40Nb	MMA	**Thermet HP40Nb**	--	BS: 25.35.H.Nb.B
		TIG/MIG	**25.35.4C.Nb**	--	--
C-60	35.45	MMA	**Thermet 35.45.Nb**	--	--
		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

DATA SHEET C-10

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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.

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).

Products available

Process	Product	Specification
MMA	**Ultramet 308H**	AWS E308H-16
	Ultramet B308H	AWS E308H-15
TIG/MIG	**308S96**	AWS ER308H
SAW	**308S96**	AWS ER308H
	SSB	BS EN SA AF2 DC
FCW	**Supercore 308H**	AWS E308HT0-4
	Supercore 308HP	AWS E308HT1-4

ULTRAMET 308H

Rutile electrode for 304H stainless steel

Product description

MMA electrode with rutile flux on matching core wire.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Ultramet 308H 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 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

AWS A5.4	E308H-16
BS EN 1600	E 19 9 H R 3 2
BS 2926	19.9.R
DIN 8556	E 19 9 R 23

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	0.04	0.5	--	--	--	18.0	9.0	--	--	2
max	0.08	1.5	0.9	0.025	0.030	21.0	11.0	0.25	0.5	8
typ	0.05	1	0.6	0.01	0.02	18.5	9.5	0.1	0.05	3

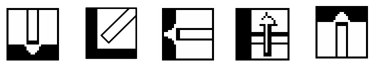
Mo + Nb + Ti = 0.25% max
Note: Cr content of 2.5mm is typically 19.5%.

All-weld mechanical properties

As welded			min	typical	High Temperature 650°C	732°C	816°C
Tensile strength		MPa	560	610	297	231	181
0.2% Proof stress		MPa	350	445	234	187	156
Elongation on 4d		%	35	45	--	--	--
Elongation on 5d		%	30	43	28	51	53
Reduction of area		%	--	35	55	63	64
Impact energy	+ 20°C	J	--	80	--	--	--
Hardness		HV	--	190-210	--	--	--

Operating parameters

DC +ve or AC (OCV: 50V 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 mm	300	350	350	450
kg/carton	12.0	13.5	13.5	17.1
pieces/carton	726	414	261	171

Storage

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for much 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	F	OES (mg/m^3)
8	5	0.8	5	< 0.2	16	1

ULTRAMET B308H

Basic pipe welding electrode for 304H stainless steel

Product description

MMA electrode with basic carbonate-fluoride flux on matching core wire.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Ultramet B308H is particularly suited to positional welding, including fixed pipework qualified in the ASME 6G position, in materials thickness from 3mm up to the heaviest sections.

Specifications

AWS A5.4	E308H-15
BS EN 1600	E 19 9 H B 4 2
BS 2926	19.9.B
DIN 8556	E 19 9 B 20+

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	0.04	0.5	--	--	--	18.0	9.0	--	--	2
max	0.08	2.0	0.9	0.025	0.030	21.0	11.0	0.25	0.5	8
typ	0.05	1	0.4	0.01	0.02	18.5	9.5	0.1	0.05	3

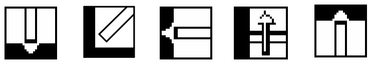
Mo + Nb + Ti = 0.25% max

All-weld mechanical properties

As welded			min	typical	High Temperature 650°C	732°C	816°C
Tensile strength		MPa	560	650	298	225	154
0.2% Proof stress		MPa	350	460	223	168	111
Elongation on 4d		%	35	41	--	--	--
Elongation on 5d		%	30	38	24	48	47
Reduction of area		%	--	48	60	63	54
Impact energy	+ 20°C	J	--	100	--	--	--
Hardness		HV	--	210	--	--	--

Operating parameters

DC +ve.



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	13.5	13.5	16.5
pieces/carton	726	414	261	159

Storage

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for much 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	F	OES (mg/m^3)
8	5	0.8	5	< 0.2	28	1

308S96

Solid wire for 304H stainless steel

Product description	Solid wire for TIG, MIG and SAW.
Specifications	**AWS A5.9** ER308H (ER19-10H on request) **BS EN ISO 14343-A** 19 9 H **BS EN ISO 14343-B** SS308H **BS 2901: Pt2** 308S96 **DIN 8556** SG X5CrNi 19 9 (1.4302)
ASME IX Qualification	**QW432** F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.04	1.0	0.30	--	--	19.5	9.0	--	--
max	0.08	2.0	0.65	0.020	0.030	20.5	10.0	0.25	0.25
typ	0.05	1.8	0.4	0.002	0.015	19.9	9.5	0.1	0.1

Typical ferrite level of undiluted weld metal is in the range 3-8FN.

ER19-10H (on request) has Cr ≤ 20.0, Mo ≤ 0.25, Nb ≤ 0.05, Ti ≤ 0.05.

All-weld mechanical properties

Typical values as welded			TIG
Tensile strength		MPa	630
0.2% Proof stress		MPa	450
Elongation on 4d		%	43
Impact energy	+ 20°C	J	> 100
Hardness cap/mid		HV	195/215

Typical operating parameters

	TIG	MIG	SAW
Shielding	Argon	$Ar/2\%O_2$ or Ar/1-3%CO_2	SSB or SSCr flux
Diameter	2.4mm	1.2mm	1.6mm
Current	100A, DC-	260A, DC+	350A, DC+
Voltage	12V	28V	30V

Packaging data

ø mm	TIG	MIG	SAW
0.8	--	To order	--
1.0	--	To order	--
1.2	To order	15 kg spool	--
1.6	2.5kg tube	--	25kg coil
2.0	To order	--	--
2.4	2.5kg tube	--	25kg coil
3.2	2.5kg tube	--	To order

Fume data

MIG fume composition (wt %) (TIG fume negligible):

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
32	12	16	8	<0.5	<0.5	3.1

SUPERCORE 308H / 308HP

Downhand and positional FCW for 304H stainless steel

Product description

Flux cored wires made with an austenitic stainless steel sheath and rutile flux system.

Supercore 308H 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. **Supercore 308HP** designed for all-positional welding from 1G/2G up to 5G/6G pipework.

Metal recovery is about 90% with respect to wire.

Specifications

	Supercore 308H	Supercore 308HP (1.2mm only)
AWS A5.22	E308HT0-4	E308HT1-4
BS EN ISO 17633-B	TS308H-FM0	TS308H-FM1

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	0.04	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			min	typical	High Temperature 650°C	732°C	816°C
Tensile strength		MPa	550	620	287	222	163
0.2% Proof stress		MPa	--	420	213	177	140
Elongation on 4d		%	35	40	--	--	--
Elongation on 5d		%	30	36	30	46	40
Reduction of area		%	--	50	58	69	74
Impact energy	+ 20°C	J	--	100	--	--	--
Aged at 730°C/1000h		J	--	90	--	--	--

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 80%.

Current: DC+ve ranges as below:

ø mm	amp-volt range	typical	stickout
1.2	140A-23V to 250A-32V	180A-29V	12 – 20mm
1.2 (positional)	140A-23V to 250A-32V	165A-24V	12 – 20mm
1.6	200A-28V to 330A-34V	230A-30V	15 – 25mm

Packaging data

Spools vacuum-sealed in barrier foil with cardboard carton: 15kg
The as-packed shelf life is virtually indefinite.
Resistance to moisture absorption is high, but to 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 composition (wt %):

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
17	11	2	4	5	<1	5	1

High Temperature Alloys

DATA SHEET C-11

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347H STAINLESS STEEL

Alloy type

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

Materials to be welded

ASTM-ASME	BS EN & DIN
321H	1.4941
347H	1.4961

BS	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.

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.

Products available

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	**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	F *	OES (mg/m^3)
8	5	0.8	5	<0.2	16	1

* F=28% for basic coated Ultramet B347 but this does not affect the OES.

ULTRAMET 347H

All-positional rutile MMA electrode 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.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E347-16
BS EN 1600	E 19 9 Nb R32
BS 2926	19.9.Nb.R
DIN 8556	E 19 9 Nb R 23

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb *	Cu	FN
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	0.7	0.7	0.01	0.02	19	9.5	0.05	0.5	0.07	4

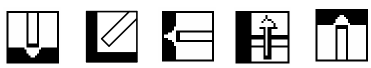
* BS requires 10xC minimum.

All-weld mechanical properties

As welded		Room Temperature		High Temperature		
		min	typical	650˚C	732˚C	815˚C
Tensile strength	MPa	560	650	354	308	233
0.2% Proof stress	MPa	350	500	283	269	206
Elongation on 4d	%	30	40	--	--	--
Elongation on 5d	%	25	37	19	20	7
Reduction of area	%	--	52	47	38	23

Operating parameters

DC +ve or AC (OCV: 50V 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 mm	300	350	350	450
kg/carton	12.0	12.0	12.9	16.5
pieces/carton	693	354	243	168

ULTRAMET B347H

Basic pipe-welding electrode for 321H/347H which is made to order

Product description

MMA electrode with basic carbonate-fluoride flux on high purity 304L core wire. Designed to give good moisture resistance and hence freedom from weld porosity. The electrode is particularly suited to positional welding of fixed pipework qualified in the ASME 5G/6G position and is tolerant to adverse wind and draughts under site conditions. 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 A5.4	E347-15
BS EN 1600	E 19 9 Nb B 42
BS 2926	19.9.Nb.B
DIN 8556	E 19 9 Nb B 20+

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb *	Cu	FN
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

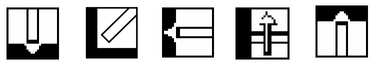
* BS requires 10xC minimum.

All-weld mechanical properties

As welded		Room Temperature		High Temperature		
		min	typical	650˚C	732˚C	815˚C
Tensile strength	MPa	560	650	354	311	248
0.2% Proof stress	MPa	350	500	263	265	223
Elongation on 4d	%	30	40	--	--	--
Elongation on 5d	%	25	37	18	14	5
Reduction of area	%	--	52	43	30	19

Operating parameters

DC +ve



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	11.4	13.5	13.5	16.8
pieces/carton	627	396	258	159

ER347H

Solid welding wire for 321H/347H

Product description	Solid wire for TIG and SAW.
Specifications	**AWS A5.9** ER347 **BS EN ISO 14343-A** 19 9 Nb **BS EN ISO 14343-B** SS347 **BS 2901: Pt2** 347S96
ASME IX Qualification	**QW432** F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	FN
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 properties

As welded			Typical	High Temperature		
			TIG	650˚C	732˚C	815˚C
Tensile strength		MPa	660	398	312	235
0.2% Proof stress		MPa	450	318	244	184
Elongation on 4d		%	42	23	22	22
Elongation on 5d		%	40	21	20	21
Reduction of area		%	67	55	53	52
Impact Energy	+20˚C	J	125	--	--	--
Hardness cap/mid		HV	190/230	--	--	--

Typical operating parameters

	TIG	SAW
Shielding	Argon *	SSB
Current	DC-	DC+
Diameter	2.4mm	2.4mm
Parameters	100A, 12V	350A, 28V

* Also required as a purge for root runs.

Packaging data

ø mm	TIG	SAW
2.4	2.5kg tube	25kg coil

Fume data

Fume composition (wt %) (TIG and SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
32	12	16	8	<0.5	<0.5	3.1

METRODE WELDING CONSUMABLES

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.

Specifications

AWS A5.22	E347T1-4
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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	FN
min	0.04	0.5	--	--	--	18.0	9.0	--	8xC	--	4
max	0.08	2.0	1.0	0.025	0.030	21.0	11.0	0.5	1.0	0.3	9
typ	0.05	1.4	0.6	0.01	0.02	19.5	10.2	0.1	0.5	0.1	5

All-weld mechanical properties

As welded			Room Temperature min	Room Temperature typical	High Temperature 732°C
Tensile strength		MPa	550	630	310
0.2% Proof stress		MPa	350	470	265
Elongation on 4d		%	30	43	24
Elongation on 5d		%	25	40	22
Reduction of area		%	--	46	43
Impact energy	+ 20°C	J	--	70	--

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/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
1.2	120-280A, 22-34V	180A, 29V (down-hand)	15-20mm
		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 %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
17	11	2	4	5	<1	5	1

High Temperature Alloys

16.8.2 FOR HIGH TEMPERATURE 3XXH STAINLESS STEELS

DATA SHEET **C-12**

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

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	321S51
347H / S34709	1.4961	347S51
316H / S31609	-	316S51, 316S53

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 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°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).

Products available

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

SUPERMET 16.8.2

Rutile electrode for 3XXH stainless steel

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 resistance to weld porosity.

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

Specifications

AWS A5.4	E16-8-2-17
BS EN 1600	(E 16 8 2 R)
BS 2926	(17.8.2.AR)

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo*	Cu	FN
min	0.04	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
typ	0.05	1	0.45	0.01	0.02	15.5	8.5	1.2	0.1	3

* Mo controlled around 1.0 – 1.3% unless requested otherwise.
BS EN E16 8 2 R has Mo 1.50 – 2.50%.

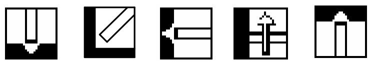
All-weld mechanical properties

As welded			min	typical	High Temperature 650°C	732°C	816°C
Tensile strength		MPa	550	> 620	310	232	161
0.2% Proof stress		MPa	--	> 410	225	179	126
Elongation on 4d		%	35	42	--	--	--
Elongation on 5d		%	25	42	28	47	43
Reduction of area		%	--	45	52	59	55
Impact energy (and LE*)	+ 20°C	J (mm)	--	> 70 (>1.3)	--	--	--
Impact energy (and LE*)	- 50°C	J (mm)	--	> 50 (>0.9)	--	--	--

* LE = Charpy lateral expansion, mm (0.38mm = 15 mils)

Operating parameters

DC +ve or AC (OCV: 55V 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 mm	300	350	350	450
kg/carton	12.0	13.5	13.5	18.0
pieces/carton	648	381	249	165

Storage

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for much 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	Mo	Cu	F	OES (mg/m^3)
8	5	0.7	5	0.1	0.2	16	1

E16.8.2-15

Basic pipe welding electrode for 3XXH stainless steel

Product description

MMA electrode with fully basic lime-fluoride flux on high purity 304L core wire. **E16.8.2-15** is a basic coated all-positional electrode suited to the most demanding vertical and overhead welding applications, including fixed pipework in the ASME 5G/6G positions.

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

Specifications

AWS A5.4	E16-8-2-15
BS EN 1600	(E16 8 2 B)
BS 2926	(17.8.2.B)

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo*	Cu	FN
min	0.04	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
typ	0.05	1.8	0.3	0.01	0.02	15.5	8.5	1.2	0.06	3

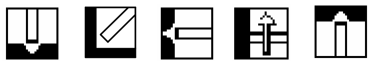
* BS EN E16 8 2 B has Mo 1.50 – 2.50%
Mo controlled around 1.0 – 1.3% unless requested otherwise.

All-weld mechanical properties

As welded			min	typical	High Temperature 650°C	732°C	816°C
Tensile strength		MPa	550	> 620	294	230	165
0.2% Proof stress		MPa	--	> 410	216	187	132
Elongation on 4d		%	35	42	--	--	--
Elongation on 5d		%	--	40	27	36	57
Reduction of area		%	--	45	61	70	75
Impact energy	-100°C	J	--	> 50	--	--	--

Operating parameters

DC + ve. Unsuitable for AC.



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	684	396	255

Storage

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for much 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	Mo	Cu	F	OES (mg/m^3)
8	5	0.7	5	0.1	0.2	16	1

ER16.8.2

Solid wire TIG and SAW for 3XXH stainless steel

Product description

Solid wire for TIG welding and sub-arc welding of 300H stainless steel.

Specifications

AWS A5.9	ER16-8-2
BS EN ISO 14343-A	16 8 2
BS EN ISO 14343-B	SS16-8-2

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo*	Cu
min	0.04	1.0	0.3	--	--	14.5	7.5	1.0	--
max	0.10	2.0	0.6	0.02	0.03	16.5	9.5	2.0	0.3
typ	0.06	1.4	0.4	0.01	0.01	15.5	8.5	1.3	0.1

* Mo 1.0 – 1.3% on request.
Typical ferrite level 1-6FN.

All-weld mechanical properties

		typical		High Temperature (TIG)		
As welded		TIG	SAW	650°C	732°C	816°C
Tensile strength	MPa	620	630	315	241	173
0.2% Proof stress	MPa	450	360	221	178	147
Elongation on 4d	%	35	29	--	--	--
Elongation on 5d	%	--	29	31	36	42
Reduction of area	%	--	30	67	69	65
Impact energy –196°C	J	--	30	--	--	--

Typical operating parameters

	TIG	SAW
Shielding	Argon	SSB flux
Diameter	2.4	2.4
Current	100A	350A, DC+
Voltage	12V	30V

Packaging data

ø mm	TIG	SAW
1.6	2.5kg tube	to order
2.4	2.5kg tube	to order

Fume data

Fume composition (wt %) (TIG & SAW fume negligible):

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
40	10	12	7	0.5	< 0.5	4.2

SUPERCORE 16.8.2 / 16.8.2P

Rutile FCW for 3XXH stainless steel

Product description

These wires are made with an austenitic stainless steel sheath and rutile flux system with alloying controlled to maximise high temperature strength and resistance to service embrittlement. **Supercore 16.8.2** ismade in 1.6mm only and is designed for applications primarily in the downhand and HV positions on plate and material of about 6mm thickness and above. **Supercore 16.8.2P** is made in 1.2mm only and isdesigned for welding in all welding positions from ASME 1G/2G up to 5G/6G pipework, and also provides very good operability in the flat/HV position. Metal recovery is about 90% with respect to wire.

Specifications

AWS A5.22	None applicable
BS EN ISO 17633-B	(nearest TS16-8-2-FM1)

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	0.04	0.5	--	--	--	14.5	7.5	1.0	--	1
max	0.08	2.0	0.70	0.03	0.04	17.0	10.0	2.0	0.5	8
typ	0.05	1.2	0.5	0.01	0.02	16.2	9.2	1.1*	0.1	4

* Mo controlled around 1.0 – 1.3% unless requested otherwise.

All-weld mechanical properties

As welded		min	typical	High Temperature 650°C	732°C	816°C
Tensile strength	MPa	560	620	290	224	160
0.2% Proof stress	MPa	--	410	207	180	134
Elongation on 4d	%	35	42	--	--	--
Elongation on 5d	%	25	42	30	44	39
Reduction of area	%	--	50	66	68	79

All-weld mechanical properties (continued)

As welded			min	typical
Impact energy (and LE*)	+ 20°C	J (mm)	--	100 (1.8)
	-130°C	J (mm)	--	50 (0.8)
	- 196°C	J (mm)	--	45 (0.7)

* LE = Charpy lateral expansion, mm (0.38mm = 15 mils)

Operating parameters

Shielding gas: Ar+20%CO_2 at 20-25l/min. Other proprietary gas mixtures may be used but argon should not exceed 80%.

Current: DC+ve ranges as below:

ø mm	amp-volt range	typical	stickout*
1.2	130A-25V to 250A-32V	180A-29V	12 – 20mm
1.6	200A-28V to 350A-34V	300A-30V	15 – 25mm

* Stick-out too short may cause surface porosity, too long will cause arc instability.

Packaging data

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 composition (wt %):

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
17	11	1.5	4	4	<1	5	1.2

High Temperature Alloys

316H TYPE CONSUMABLES

DATA SHEET **C-13**

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

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**.

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).

Products available

Process	Product	Specification
MMA	**17.8.2.RCF**	BS 17.8.2.R
	Ultramet 316H	AWS E316H-16
TIG/MIG/SAW	**316S96**	AWS ER316H
SAW flux	**SSB**	BS EN SA AF2 DC

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** 150 – 200°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	Ni	Cr	Mo	Cu	F	OES (mg/m^3)
8	5	0.7	5	0.1	< 0.2	16	1

17.8.2.RCF

Rutile electrode for 316 at elevated temperature

Product description

MMA electrode with a rutile (low silica) flux on high purity 304L core wire, giving a tightly controlled level of silicon and residual elements to minimise formation of intermetallic phases (sigma, chi) during service.

Designed primarily for downhand and HV welding although for structural applications it is usable positionally.

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

Specifications

AWS A5.4	(E16.8.2-16) nearest
BS 2926	17.8.2.R

ASME IX Qualification

QW432 F-No -, **QW442** A-No -

Composition (weld metal wt %)

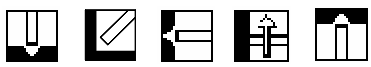
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	0.06	0.5	--	--	--	16.5	8.0	1.5	--	3
max	0.10	2.5	0.50	0.030	0.040	18.5	9.5	2.5	0.50	8
typ	0.08	1.6	0.25	0.008	0.02	17	8.5	2	<0.1	5

All-weld mechanical properties

As welded			Room Temperature		High Temperature		
			min	typical	650˚C	732˚C	815˚C
Tensile strength		MPa	560	> 630	369	274	191
0.2% Proof stress		MPa	--	> 460	287	197	147
Elongation on 4d		%	--	> 30	--	--	--
Elongation on 5d		%	25	> 30	28	44	53
Reduction of area		%	--	> 45	55	61	75
Impact energy	-100°C	J	--	> 50	--	--	--

Operating parameters

DC +ve 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 mm	300	350	350	450
kg/carton	12.6	14.4	14.7	18.6
pieces/carton	684	411	267	165

ULTRAMET 316H

Rutile coated MMA electrode for 316H stainless steel

Product description

Rutile coated electrode made on high purity 304 core wire, previously called **Metrode E316H-16**. The higher alloy content compared to 17.8.2.RCF does increase the risk of intermetallic formation during service at elevated temperatures (500-800°C).

Specifications

AWS A5.4	E316H-16
BS EN 1600	E 19 12 2 R 3 2
BS 2926	19.12.3.R

ASME IX Qualification

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

Composition (weld metal wt %)

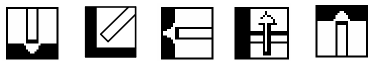
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	0.04	0.5	--	--	--	17.0	11.0	2.0	--	3
max	0.08	2.0	0.90	0.025	0.030	20.0	13.0	3.0	0.5	8
typ	0.05	1	0.6	0.01	0.02	18	12	2.2	0.1	5

All-weld mechanical properties

As welded		Room Temperature		High Temperature		
		min	typical	650˚C	732˚C	815˚C
Tensile strength	MPa	550	570	352	268	197
0.2% Proof stress	MPa	350	450	264	204	152
Elongation on 4d	%	30	35	--	--	--
Elongation on 5d	%	25	33	32	43	54
Reduction of area	%	--	50	58	53	60

Operating parameters

DC +ve or AC (OCV: 50V 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	11.4	13.5	13.5
pieces/carton	633	393	261

316S96

Solid wire for TIG/MIG and SAW of 316H

Product description

Solid wire for TIG, MIG and SAW which can not only be used in conjunction with E316H-16, but also with 17.8.2.RCF and other 300H consumables.

Specifications

AWS A5.9	ER316H
BS EN ISO 14343-A	19 12 3 H
BS EN ISO 14343-B	SS316H
BS 2901: Pt2	316S96
DIN 8556	(Nearest SG X5CrNiMo 19 11 1.4403)

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	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 properties

Typical values as welded		typical
Tensile strength	MPa	650
0.2% Proof stress	MPa	460
Elongation on 4d	%	35

Typical operating parameters

	TIG	MIG	SAW
Shielding	Ar	Ar + 2%O_2/CO_2	SSB flux
Diameter	2.4	1.2	2.4
Current	DC-	DC+	DC+
Parameters	100A, 12V	220A, 26V	350A, 30V

316S96 (continued)

Packaging data

ø mm	TIG	MIG	SAW
1.2	--	15kg reel	--
1.6	2.5kg tube	--	--
2.4	2.5kg tube	--	25kg spool

Fume data

MIG fume composition (wt %) (TIG & SAW fume negligible):

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
30	12	15	11	1.5	< 0.5	3.3

SSB FLUX

Sub-arc flux

Product description

Agglomerated basic flux with a BI~2.2 producing weld deposits with minimal Si pick-up and low Mn and Cr losses. Approximate composition is 40% (Al_20_3 + MnO) –10% (SiO_2 + TiO_2) –50% (CaF_2).

Specifications

DIN 32522	BFB6 63353 DC8M
BS EN 760	SA AF2 DC

ASME IX Qualification

QW432 F-No -, **QW442** A-No -

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
wire (316S96)	0.05	1.8	0.5	0.01	0.02	19	13	2.2	0.15
deposit	0.04	1.6	0.6	0.01	0.02	18	13	2.2	0.15

All-weld mechanical properties

As welded		typical
Tensile strength	MPa	650
0.2% Proof stress	MPa	460
Elongation on 4d	%	35

Operating parameters

Current: DC+ve ranges as below:

ø mm	amp-volt range	typical	stickout
2.4	250-450A, 28-32V	350A, 30V	20-25mm

Packaging data

Metrode **SSB Flux** is supplied in sealed moisture resistant 20kg metal drums. Preferred storage conditions of opened drums: <60%RH, >18°C. If the flux has become damp or has been stored or has been stored for a long period, it should be redried in the range 250-400°C/1-3h.

High Temperature Alloys

DATA SHEET **C-20**

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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.

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.

Products available

Process	Product	Specification
MMA	**Supermet 253MA**	--

SUPERMET 253MA

Rutile electrode for matching alloy 253MA

Product description

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 applicable national standards.

ASME IX Qualification

QW432 F-No --, **QW442** A-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	N	Cu	Ce *	FN
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

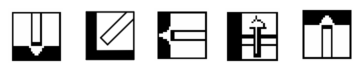
* Cerium is present but actual value not reported on test certificate.

All-weld mechanical properties

As welded		typical
Tensile strength	MPa	705
0.2% Proof stress	MPa	550
Elongation on 4d	%	40
Elongation on 5d	%	38
Reduction of area	%	50

Operating parameters

DC +ve or AC (OCV: 50V min)



ø mm	2.5	3.2	4.0	5.0
min A	50	75	100	130
max A	75	120	155	210

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	300	350	350	450
kg/carton	11.4	13.5	14.4	17.7
pieces/carton	594	366	261	168

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	F	OES (mg/m^3)
9	6	1	7	<0.2	17	0.7

High Temperature Alloys

DATA SHEET C-21

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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) S30908 (309S) S30909 (309H)	A351 Grades CH8, CH10, CH20.
DIN	1.4829 (X12CrNi 22 12)	1.4832 (G-X25CrNiSi20 14)
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.

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

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.

Products available

Process	Product	Specification
MMA	**Thermet 309CF**	AWS E309H-16
TIG/MIG	**309S94**	AWS ER309

THERMET 309CF

309 electrode with controlled carbon and ferrite content

Product description

MMA electrode with a rutile flux coating on high purity 304L core wire.

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

Specifications

AWS A5.4	E309H-16
BS EN 1600	(E 22 12 R 32)
BS 2926	23.12.R
DIN 8556	(E 22 12 R 26)

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	0.06	0.5	0.2	--	--	22.0	12.0	--	--	2
max	0.15	2.0	0.8	0.025	0.030	24.0	14.0	0.5	0.50	8
typ	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
Tensile strength	MPa	560	605
0.2% Proof stress	MPa	350	460
Elongation on 4d	%	30	34
Elongation on 5d	%	25	31
Reduction of area	%	--	30
Hardness	HV	--	210

Operating parameters

DC +ve 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 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:

Fe	Mn	Cr	Ni	Cu	F	OES (mg/m^3)
9	6	7	1	<0.2	17	0.7

309S94

309 solid wire with controlled carbon and ferrite

Product description	Solid wire for TIG and MIG.
Specifications	**AWS A5.9** ER309 **BS EN ISO 14343-A** 22 12 H **BS EN ISO 14343-B** SS309 **BS 2901: Pt2** 309S94 **UNS** S30980
ASME IX Qualification	**QW432** F-No 6, **QW442** A-No 8

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	0.04	1.0	0.30	--	--	23.0	12.0	--	--	3
max	0.12	2.5	0.65	0.02	0.030	24.0	14.0	0.3	0.3	12
typ	0.07	1.7	0.5	0.01	0.02	23.5	13	0.1	0.1	6

All-weld mechanical properties

Typical values as welded		TIG
Tensile strength	MPa	580
0.2% Proof stress	MPa	415
Elongation on 4d	%	42
Elongation on 4d	%	39
Reduction of area	%	56
Hardness cap/mid	HV	175/215

Typical operating parameters

	TIG	MIG
Shielding	Argon *	$Ar+2\%O_2$ **
Current	DC-	DC+
Diameter	2.4mm	1.2mm
Parameters	120A, 14V	260A, 26V

* Also required as a purge for root runs.

** Proprietary Ar, and Ar-He mixtures with $<3\%CO_2$ are also suitable.

Packaging data

ø mm	TIG	MIG
1.0	--	15kg spool
1.2	--	15kg spool
1.6	2.5kg tube	--
2.4	2.5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
32	12	20	11	<0.5	<0.5	2.5

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METRODE WELDING CONSUMABLES

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 %)

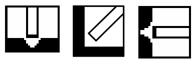
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	FN
min	0.25	0.5	0.2	--	--	24.0	11.0	--	--	--	--
max	0.45	2.5	1.0	0.03	0.04	28.0	14.0	0.5	0.5	--	--
typ	0.3	1.7	0.4	0.01	0.02	26	13	0.05	0.1	0.12	<2

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°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	Mo	Cu	F	OES (mg/m^3)
8	6	1	8	<0.1	<0.2	16	0.6

High Temperature Alloys

DATA SHEET C-30

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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 (Firth Vickers) 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).

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°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).

Products available

Process	Product	Specification
MMA	**25.20 Super R**	(E310-16)
	Ultramet B310Mn	(E310-15)
TIG/MIG	**310S94**	AWS ER310

25.20 SUPER R

Rutile MMA electrode for welding 310 stainless steel

Product description	MMA electrode with low silica rutile flux on high purity 310 core wire. Low silicon and high manganese levels are desirable to ensure freedom from microfissuring. Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.
Specifications	**AWS A5.4** (E310-16) AWS specification has Mn range of 1.0-2.5%. **BS EN 1600** E 25 20 R 32 **BS 2926** 25.20.R **DIN 8556** E 25 20 R 26
ASME IX Qualification	**QW432** F-No 5, **QW442** A-No 9

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
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 properties

As welded			min	typical
Tensile strength		MPa	560	575
0.2% Proof stress		MPa	350	400
Elongation on 4d		%	30	38
Elongation on 5d		%	25	37
Reduction of area		%	--	50
Impact energy	+ 20°C	J	--	100
Impact energy	- 196°C	J	--	60
Hardness		HV	--	200

Operating parameters

DC +ve 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 mm	300	350	350	450
kg/carton	12.0	13.5	14.7	20.1
pieces/carton	675	405	282	198

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°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	Ni	Cr	Cu	F	OES (mg/m^3)
9	10	2	7.5	<0.2	18	0.6

ULTRAMET B310Mn

All-positional basic MMA electrode for welding 310 stainless steel

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.

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

Specifications

AWS A5.4	(E310-15)	AWS specification has Mn range of 1.0-2.5%.
BS EN 1600	E 25 20 B 42	
BS 2926	25.20.B	
DIN 8556	E 25 20 B 20+	

ASME IX Qualification

QW432 F-No 5, **QW442** A-No 9

Composition (weld metal wt %)

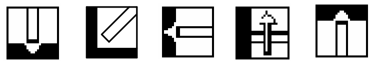
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.08	2.0	--	--	--	25.0	20.0	--	--
max	0.15	5.0	0.70	0.025	0.030	27.0	22.0	0.50	0.50
typ	0.1	3.8	0.4	0.008	0.018	26	21	0.2	0.1

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	560	615
0.2% Proof stress		MPa	350	435
Elongation on 4d		%	30	36
Elongation on 5d		%	25	34
Reduction of area		%	--	50
Impact energy	+ 20°C	J	--	105
Impact energy	- 196°C	J	--	75
Hardness		HV	--	220

Operating parameters

DC +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
length mm	300	350	350
kg/carton	12.0	13.5	13.5
pieces/carton	669	384	255

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	F	OES (mg/m^3)
9	10	2	7.5	<0.2	28	0.6

310S94

Solid wire for TIG, MIG and SAW of 310 stainless steel

Product description

Solid wire for TIG, MIG and SAW.

Specifications

AWS A5.9	ER310
BS EN ISO 14343-A	25 20
BS EN ISO 14343-B	SS310
BS 2901: Pt2	310S94
DIN 8556	SG X12CrNi 25 20
UNS	S31080

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 9

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.08	1.0	0.30	--	--	25.0	20.0	--	--
max	0.15	2.5	0.65	0.02	0.030	27.0	22.0	0.3	0.3
typ	0.11	1.8	0.4	0.005	0.02	26	21	0.1	0.1

All-weld mechanical properties

Typical values as welded			MIG Ar+2%O_2
Tensile strength		MPa	540
0.2% Proof stress		MPa	355
Elongation on 4d		%	27
Impact energy	- 196°C	J	70
Hardness cap/mid		HV	185

Typical operating parameters

	TIG	MIG	SAW ***
Shielding	Argon *	Ar+2%O_2 **	SSB
Current	DC-	DC+	DC+
Diameter	2.4mm	1.2mm	2.4mm
Parameters	100A, 12V	220A, 29V	325A, 30V

* Also required as a purge for root runs.
** Proprietary Ar and Ar-He mixtures with <3%CO_2 also suitable.
*** Heat input should be restricted with SAW to minimise the risk of solidification cracking.

Packaging data

ø mm	TIG	MIG	SAW
0.8	--	15kg spool	--
1.2	--	15kg spool	--
1.6	2.5kg tube	--	25kg coil
2.4	2.5kg tube	--	25kg coil
3.2	2.5kg tube	--	--

Fume data

MIG fume composition (wt %) (TIG & SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
30	13	22	16	<0.5	<0.5	2.3

High Temperature Alloys

DATA SHEET **C-31**

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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**.

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.

Products available

Process	Product	Specification
MMA	**Thermet 310H**	AWS E310H-15

THERMET 310H

Basic all-positional MMA electrode for HK40 type castings

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. Moisture resistant coating giving sound porosity free deposits.

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

Specifications

AWS A5.4	E310H-15
BS EN 1600	E 25 20 H B 42
BS 2926	25.20.H.B

ASME IX Qualification

QW432 F-No 5

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
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

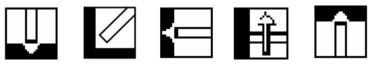
All-weld mechanical properties

As welded		min	typical
Tensile strength	MPa	620	760
0.2% Proof stress	MPa	350	550
Elongation on 4d	%	10	20
Elongation on 5d	%	10	17
Reduction of area	%	--	25
Hardness	HV	--	230

These alloys are designed for operation at elevated temperatures and modest ambient temperature elongations in the range 10-20% are normal.

Operating parameters

DC +ve



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	11.4	13.5	14.4	18.0
pieces/carton	546	384	258	165

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° 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	Mo	Cu	F	OES (mg/m^3)
12	6	2	8	<0.2	<0.2	16	0.6

High Temperature Alloys

CONSUMABLES TO MATCH CAST & WROUGHT ALLOY 800

DATA SHEET **C-40**

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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 NA15H	N08800 N08810 N08811

Proprietary alloys include:

cast:
Paralloy CR32W
Manaurite 900 (Manoir)
Thermalloy T52 (Lloyds)
Vicro 8 (Firth Vickers)
MORE 21 (Duraloy)
Centralloy 4859 (Centracero)

wrought:
Incoloy 800, 800H, 800HT (Special Metals)
Sanicro 31 (Sandvik)
Nicrofer 3220 (VDM)
RA330 (Rolled Alloys)

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:

$$P \leq 9 \text{ where } P = (7C + 5Si + 8Nb - 3Mn).$$

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.

Products available

Process	Product	Specification
MMA	**Thermet 800Nb**	None
TIG/MIG	**21.33.MnNb**	None

METRODE WELDING CONSUMABLES

THERMET 800Nb

MMA electrode to match alloy 800

Product description

MMA electrode – Basic moisture resistant coated electrode made on high alloy, high purity core wire.

Recovery is about 120% 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 -, **QW442** A-No -

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu
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

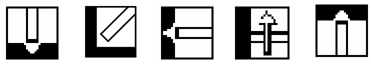
All-weld mechanical properties

As welded			min *	typical
Tensile strength		MPa	520	615
0.2% Proof stress		MPa	210	410
Elongation on 4d		%	--	> 33
Elongation on 5d		%	25	> 32
Reduction of area		%	--	46
Impact energy	+ 20°C	J	--	> 55
Hardness		HV	--	170-220

* Minimum tensile properties based on wrought alloy 800H.

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	450
kg/carton	12.0	13.5	13.5	18.0
pieces/carton	642	354	243	165

Storage

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for much 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°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°C.

Fume data

Fume composition, wt % typical:

Fe	Mn	Cr	Ni	Mo	Cu	F	OES (mg/m^3)
4	6	6	2	< 0.2	< 0.2	18	0.8

21.33.MnNb

Solid TIG welding wire for 800H and similar heat resisting alloys

Product description	Solid wire – This is a high Mn, 21%Cr-33%Ni-1%Nb, micro-alloyed wire for TIG welding of 800 type alloys.
Specifications	There are no national specifications for this wire.
ASME IX Qualification	**QW432** F-No -, **QW442** A-No -

Composition (wire wt %)

	C *	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	Al	Ti
min	0.10	3.5	--	--	--	19.0	30.0	--	0.8	--	--	--
max	0.20	5.0	0.70	0.015	0.025	23.0	35.0	0.50	1.5	0.5	0.35	0.30
typ	0.15	4.3	0.5	0.008	0.012	21	33	0.3	1	0.1	0.1	0.15

* Weld deposit carbon is typically a little lower than wire analysis.

All-weld mechanical properties

Typical values as welded			min	TIG
Tensile strength		MPa	520	670
0.2% Proof stress		MPa	210	500
Elongation on 4d		%	--	18
Elongation on 5d		%	--	18
Impact energy	+ 20°C	J	--	60

* Minimum tensile properties based on wrought alloy 800H.

Typical operating parameters

	TIG
Shielding	Ar
Current	DC –
Diameter	2.4mm
Parameters	100A, 12V

Packaging data

ø mm	TIG
1.6	To order
2.0	To order
2.4	2.5kg tube
3.2	2.5kg tube

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Cu	OES (mg/m^3)
40	15	18	20	< 1	2.5

METRODE
WELDING CONSUMABLES

High Temperature Alloys

HIGH CARBON 18/37 HEAT RESISTING AUSTENITIC ALLOY

DATA SHEET **C-41**

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Internet: http//www.metrode.com

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 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.

Products available

Process	Product	Specification
MMA	**Thermet R17.38H**	BS 15.35.H.R

THERMET R17.38H

MMA electrode to match high carbon 18/37 heat resisting alloys

Product description

MMA electrode with a basic-rutile flux covering on a high alloy core wire. Moisture resistant coating giving sound, porosity-free deposits. Sizes above 3.2mm are not recommended for positional welding.

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

Specifications

AWS A5.4	(E330H-16)	Thermet R17.38H has higher C, Cr & Ni than AWS specification.
BS 2926	15.35.H.R	

ASME IX Qualification

QW432 F-No 5

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo
min	0.35	1.0	0.3	--	--	17.0	35.0	--
max	0.60	2.0	1.0	0.030	0.040	20.0	40.0	0.5
typ	0.45	1.5	0.5	0.01	0.015	18.5	38	0.4

All-weld mechanical properties

As welded		min	typical
Tensile strength	MPa	620	780
0.2% Proof stress	MPa	--	520
Elongation on 4d	%	10	16
Elongation on 5d	%	5	14
Reduction of area	%	--	15
Hardness	HV	--	250

These alloys are designed for operation at elevated temperatures and modest ambient temperature elongations in the range 10-20% are normal.

Operating 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	12.6	15.6	15.6
pieces/carton	639	396	264

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	Ni	Cr	Mo	Cu	F	OES (mg/m^3)
4	7	4	5	<0.1	<0.2	16	1

High Temperature Alloys

THERMET 25.35.Nb

DATA SHEET **C-45**

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Email: info@metrode.com
Internet: http//www.metrode.com

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** 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).

Products available

Process	Product	Specification
MMA	**Thermet 25.35.Nb**	--

THERMET 25.35.Nb

Basic all-positional MMA electrode for ‘HP10Cb’ type castings

Product description

MMA electrode with basic flux coating made on nearly matching core wire. The electrode is optimised for DC+ welding in all positions including fixed pipework in ASME 5G/6G positions. Moisture resistant coating giving sound porosity-free deposits.

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

Specifications

There are no relevant national standards.

ASME IX Qualification

QW432 --.

Composition (weld metal wt %)

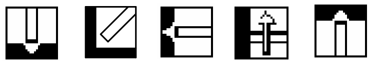
	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	Pb	Sn
min	0.08	2.5	0.2	--	--	24.0	34.0	--	0.50	--	--	--
max	0.14	4.0	1.0	0.02	0.03	28.0	39.0	0.5	1.50	0.15	0.01	0.01
typ	0.12	3.5	0.5	0.01	0.01	26	36	0.2	0.8	0.05	<0.001	0.005

All-weld mechanical properties

As welded		min	typical
Tensile strength	MPa	520	660
0.2% Proof stress	MPa	300	460
Elongation on 4d	%	20	34
Elongation on 5d	%	20	32
Reduction of area	%	--	42

Operating parameters

DC +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
length mm	265	320	320
kg/carton	10.5	12.0	12.0
pieces/carton	555	330	204

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°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°C.

Fume data

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Mo	Cu	F	OES (mg/m^3)
4	6	2	7	<0.1	<0.2	18	0.7

High Temperature Alloys

DATA SHEET C-50

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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 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.

Products available

Process	Product	Specification
MMA	**Thermet HP40Nb**	BS 25.35.H.Nb.B
TIG	**25.35.4CNb**	--

THERMET HP40Nb

Basic electrode matching HP40Nb alloys

Product description

Basic moisture resistant MMA electrode made on high purity alloy core wire, giving high resistance to microfissuring and porosity in large multi-run deposits.

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

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	--	0.75	0.02
max	0.50	2.0	1.3	0.030	0.040	27.0	36.0	0.5	1.50	0.20
typ	0.43	1.7	0.9	0.010	0.010	25	35	0.1	1.1	0.08

All-weld mechanical properties

As welded		min *	typical
Tensile strength	MPa	600 (450)	740
0.2% Proof stress	MPa	-- (250)	560
Elongation on 4d	%	-- (5)	15
Elongation on 5d	%	--	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.

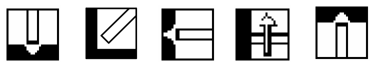
Room temperature elongation has little significance for weld metal designed for high temperature service and creep resistance. Values down to 4.5% (on 4d) are allowed in ASTM HP40 castings and the ductility of multipass welds may approach this value due to carbide precipitation in successive runs.

Stress rupture/creep data:

Temperature		Stress		Life	Elongation
°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



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	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/m^3)
4	6	7	7	< 0.5	< 0.1	< 0.1	18	0.7

25.35.4CNb

Solid TIG wire for matching HP40Nb alloys

Product description

Solid wire for TIG and auto-TIG.

Specifications

There are no national specifications for this wire

ASME IX Qualification

QW432 F-No -

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Ti	Zr	Cu	Sn	Pb
min	0.40	1.0	0.5	--	--	23.0	32.0	--	0.75	0.05	0.01	--	--	--
max	0.50	2.5	1.6	0.02	0.02	27.0	36.0	0.50	1.50	0.25	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 properties

Typical values as welded		min *	TIG
Tensile strength	MPa	450	809
0.2% Proof stress	MPa	250	593
Elongation on 4d	%	5	9
Elongation on 5d	%	--	11
Reduction of area	%	--	15
Hardness cap/mid	HV	--	211/263

* Parent material minimum values (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.

Typical operating parameters

	TIG
Shielding	Argon
Current	DC-
Diameter	2.4mm
Parameters	100A,12V

Packaging data

ø mm	TIG	Spooled wire normally used for automatic TIG
1.2	--	12.5kg reel
1.6	2.5kg tube	--
2.0	2.5kg tube	--
2.4	2.5kg tube	--
3.2	2.5kg tube	--

Fume data

Fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Mo	Cu	OES (mg/m^3)
35	13	26	< 0.5	< 0.5	2

High Temperature Alloys

DATA SHEET **C-60**

METRODE PRODUCTS LTD
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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.

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

Thermet 35.45.Nb is a basic coated electrode with some alloy additions in the coating and is made on a high purity NiCr core wire. Recovery is approximately 140% with respect to core wire, 65% with respect to whole electrode.

Specifications

No relevant national specifications.

ASME IX Qualification

QW432 F-No - , **QW442** A-No -

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Nb	Mo	Ti	Fe
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 properties

As welded		min *	typical
Tensile strength	MPa	450	740
0.2% Proof stress	MPa	245	550
Elongation on 4d	%	3	6
Hardness	HV	-	270

* Minimum values are for static castings.

THERMET 35.45.Nb (continued)

MMA electrode

Operating parameters

DC +ve

ø mm	2.5	3.2	4.0
min A	70	85	110
max A	95	120	160

Packaging data

ø mm	2.5	3.2	4.0
length mm	260	350	350
kg/carton	9.9	13.5	13.5
pieces/carton	450	306	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°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°C.

Fume data

Fume composition, wt % typical:

Fe	Mn	Cr^{6}	Ni	Cu	F	OES (mg/m^3)
3	6	10	9	<0.2	18	0.5

35.45.Nb

Solid welding wire for TIG welding

Product description

Straight lengths and spooled wire for manual and automatic TIG/GTAW welding.

Specifications

There are no national specifications for this wire.

ASME IX Qualification

QW432 F-No -- , **QW442** A-No --

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Nb	Mo	Ti	Zr	Fe
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 properties

Typical values as welded		TIG
Tensile strength	MPa	690
0.2% Proof stress	MPa	550
Elongation on 4d	%	3
Hardness	HV	280

Typical operating parameters

	TIG
Shielding	Argon
Current	DC-
Diameter	2.4mm
Parameters	120A, 12V

Packaging data

ø mm	TIG	Spooled
1.2	-	12.5kg spool
2.4	2.5kg tube	-
3.2	2.5kg tube	-

Fume data

Fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^{3}	Ni	Mo	Cu	OES (mg/m^3)
15	5	28	28	<0.5	<0.5	1.8

High Temperature Alloys

HIGH CARBON 25Cr-35Ni-WCo

DATA SHEET **C-70**

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Internet: http//www.metrode.com

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**.

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).

Products available

Process	Product	Specification
MMA	**Thermet HP50WCo**	--

THERMET HP50WCo

MMA electrode for matching high carbon austenitic cast alloys

Product description

All-positional basic MMA electrode designed to match similar cast alloys. Basic flux system with alloy additions on high purity NiCrFe core wire.

Recovery is about 150% 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 -, **QW442** A-No -.

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Co	W	Mo	Cu	Fe
min	0.40	0.5	0.2	--	--	24.0	34.0	13.0	4.0	--	--	--
max	0.60	1.5	1.2	0.020	0.030	28.0	40.0	18.0	6.0	0.5	0.5	bal
typ	0.50	0.6	0.5	0.008	0.010	25	35	14	4.6	0.05	0.05	19

All-weld mechanical properties

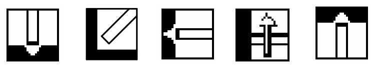
As welded		min *	typical **
Tensile strength	MPa	450	840
0.2% Proof stress	MPa	240	610
Elongation on 4d	%	3	8.5
Elongation on 5d	%	--	8
Reduction of area	%	--	6
Hardness	HV	--	265

* Minimum values are for static castings. Average strength of centrispun tube is typically 550MPa with <10% elongation.

** The high strength of the weld metal is derived from the chill-cast microstructure coupled with carbide precipitation and strain-hardening by successive weld beads. Room temperature elongation has little significance for weld metal designed for elevated temperature service.

Operating parameters

DC +ve



ø mm	2.5	3.2	4.0
min A	70	85	110
max A	95	120	160

Packaging data

ø mm	2.5	3.2	4.0
length mm	265	320	320
kg/carton	10.5	12.0	13.2
pieces/carton	396	267	159

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°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°C.

Fume data

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Co	F	OES (mg/m^3)
3	6	8	7	<0.2	2	22	0.7

METRODE
WELDING CONSUMABLES

High Temperature Alloys

ALLOY 22H HEAT RESISTANT AUSTENITIC STAINLESS STEEL

DATA SHEET **C-80**

METRODE PRODUCTS LTD
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Email: info@metrode.com
Internet: http//www.metrode.com

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

Proprietary cast alloys:
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.

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**	--

THERMET 22H

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 --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	W	Fe
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 properties

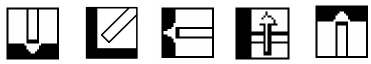
As welded		min *	typical **
Tensile strength	MPa	440	780
0.2% Proof stress	MPa	--	590
Elongation on 4d	%	--	7
Elongation on 5d	%	4	6
Reduction of area	%	--	6
Hardness	HV	--	270

* Minimum values for DIN 2.4879 castings.

** The high strength of the weld metal is derived from the chill-cast microstructure coupled with carbide precipitation and strain-hardening by successive weld beads. Room temperature elongation has little significance for weld metal designed for elevated temperature service.

Operating parameters

DC +ve



ø mm	2.5	3.2	4.0	5.0
min A	70	85	110	140
max A	95	120	160	200

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	260	310	310	310
kg/carton	10.5	12.0	12.3	12.0
pieces/carton	492	300	198	120

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°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°C.

Fume data

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	F	OES (mg/m^3)
3	6	9	7	<0.2	22	0.7

High Temperature Alloys

SPECIAL ELECTRODE FOR IN-657

DATA SHEET **C-90**

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Internet: http//www.metrode.com

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

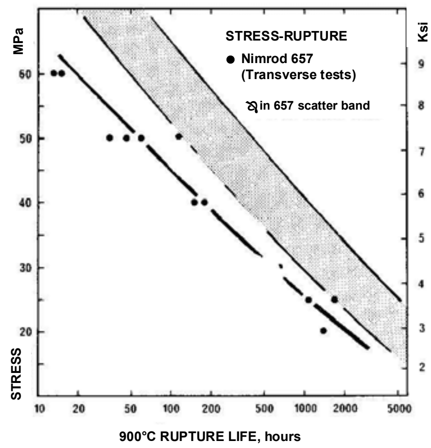
Very careful control of chromium and niobium is maintained to minimise the risk of weld metal cracking. The microstructure of IN-657 castings and Nimrod 657 weld metal consists of two phases: a chromium-rich alpha phase (bcc) and a nickel-rich gamma phase (fcc). The precise structure obtained is complicated 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.

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).

Products available

Process	Product	Specification
MMA	**Nimrod 657**	AWS ENiCr-4

METRODE
WELDING CONSUMABLES

Nimrod 657

MMA electrode for alloy 657/671

Description

MMA electrode made on a special nickel-chromium core wire, with a basic lime-fluorspar flux covering.

Recovery is approx 160% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.11 ENiCr-4

ASME IX Qualification

QW422 P-No -, **QW432** F-No -

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Nb	Fe	N	Cu
min	--	--	--	--	--	48	bal	1.0	--	--	--
max	0.10	1.5	1.0	0.02	0.02	52	--	2.5	1.0	0.16	0.25
typ	0.07	1.0	0.5	0.01	0.01	50	47	1.8	0.5	0.07	0.05

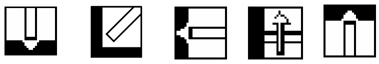
All-weld mechanical properties

As-welded		min Nimrod 657	typical Nimrod 657	IN-657 (as cast)
Tensile strength	MPa	760	830-985	600-700
0.2% Proof stress	MPa	--	570-725	330-400
Elongation on 4d	%	--	2-4	10-40
Hardness	HV	--	340	210-260

Note: Weld metal tensile properties are much higher than those of as-cast IN-657, mainly because pre-ageing takes place during multipass welding. IN-657 responds similarly at high temperature and differences between the two are effectively eliminated during service.

Operating parameters

DC +ve AC(OCV:70V)



ø mm	2.5	3.2	4.0
min A	70	85	110
max A	95	120	160

Packaging data

ø mm	2.5	3.2	4.0
length mm	260	305	305
kg/carton	10.5	12.0	12.0
pieces/carton	450	300	195

Storage

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for much 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 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 maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

Fume data

Fume composition (wt %)

Fe	Mn	Ni	Cr	Mo	Cu	F	OES (mg/m^3)
1	2	2.5	8	0.1	0.1	23	0.6

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METRODE WELDING CONSUMABLES

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®) 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.

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Data Sheet	Alloy	Process	Product	Specifications	
				AWS	BS EN
D-10	182	MMA	**Nimrod 182KS**	ENiCrFe-3	E Ni6182
			Nimrod 182	ENiCrFe-3	E Ni6182
			Nimax 182	ENiCrFe-3	E Ni6182
		TIG/MIG/SAW	**20.70.Nb**	ERNiCr-3	SNi6082
D-11	AB	MMA	**Nimrod AKS**	ENiCrFe-2	E Ni6092
			Nimrod AB	ENiCrFe-2/4	E Ni6093
			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
D-20	625	MMA	**Nimrod 625**	ENiCrMo-3	E Ni6625
			Nimrod 625KS	ENiCrMo-3	E Ni6625
		TIG/MIG/SAW	**62-50**	ERNiCrMo-3	SNi6625
D-30	C276	MMA	**Nimrod C276**	ENiCrMo-4	E Ni6276
			Nimrod C276KS	ENiCrMo-4	E Ni6276
		TIG/MIG/SAW	**HAS C276**	ERNiCrMo-4	SNi6276
D-31	59	MMA	**Nimrod 59KS**	ENiCrMo-13	E Ni6059
		TIG/MIG	**HAS 59**	ERNiCrMo-13	SNi6059
D-32	C22	MMA	**Nimrod C22KS**	ENiCrMo-10	E Ni6022
		TIG/MIG	**HAS C22**	ERNiCrMo-10	SNi6022
E-45	C	MMA	**Nimrod C**	(ENiCrMo-5)	DIN: E23-UM-200CKT
			Nimax C	(ENiCrMo-5)	DIN: E23-UM-200CKT
D-40	617	MMA	**Nimrod 617KS**	ENiCrCoMo-1	E Ni6617
		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
		TIG/MIG	**Nickel 2Ti**	ERNi-1	SNi2061
D-60	Monel	MMA	**Nimrod 190**	ENiCu-7	E Ni4060
		TIG/MIG	**65NiCu**	ERNiCu-7	SNi4060
D-70	Cupronickel	MMA	**Cupromet N30**	ECuNi	--
		TIG	**70CuNi**	ERCuNi	BS: C18
		TIG	**90CuNi**	--	BS C16
D-80	B2	MMA	**Nimax B2L**	ENiMo-7	E Ni1066
		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

DATA SHEET D-10

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Alloy type

Inconel™ type consumables with manganese and niobium additions.

Materials to be welded

Nickel alloys such as Inconel™ 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™ 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°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.

Stress relief may be carried out if required.

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

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 380° 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	Mo	Cu	F	OES (mg/m^3)
2	13	5	10	0.2	0.1	15	1

NIMROD 182KS

All-positional Inconel™ type MMA electrode

Product description

MMA electrode – This electrode is made on a nearly matching core wire with a basic flux system designed to produce optimum operability and radiographically sound weld metal. **Nimrod 182KS** is optimised for DC+ welding in all positions including pipework qualified in the ASME 6G position.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.11	ENiCrFe-3
BS EN 14172	ENi6182
DIN 1736 (Werkstoff No)	EL-NiCr15FeMn (2.4807)

ASME IX Qualification

QW432 F-No 43

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Nb	Fe	Cu	Ti	Co *	Ta *
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	7	0.5	0.01	0.01	16	~ 65	1.5	< 8	0.1	0.1	< 0.05	0.05

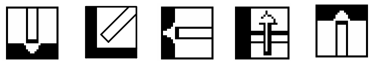
* Co and Ta maximums only when specified at time of order.

All-weld mechanical properties

As-welded			min	typical
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 only



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

Inconel™ type MMA electrode for downhand welding and surfacing

Product description

MMA electrode – This electrode is made on a nearly matching core wire with a basic slag system designed to produce optimum operability and weld metal soundness for downhand/HV welding. Optimised for DC+ operability primarily for surfacing and cladding applications.

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

Specifications

AWS A5.11	ENiCrFe-3	(3.2mm will not necessarily satisfy 3G usability criteria)
BS EN 14172	ENi6182	
DIN 1736 (Werkstoff No)	EL-NiCr15FeMn (2.4807)	

ASME IX Qualification

QW432 F-No 43

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Nb	Fe	Cu	Ti	Co *	Ta *
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 and Ta maximums only when specified at time of order.

NIMROD 182 (continued)

All-weld mechanical properties

As-welded			min	typical
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

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

High recovery electrode for cladding & surfacing

Product description

MMA electrode – high efficiency metal powder type with basic flux covering on high conductivity pure nickel core wire. **Nimax 182** is a high efficiency version of Nimrod 182KS, with versatile features for fabrication, repair and maintenance.

Recovery is about 140% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.11	ENiCrFe-3
BS EN 14172	ENi6182
DIN 1736 (Werkstoff No)	EL-NiCr15FeMn (2.4807)

ASME IX Qualification

QW432 F-No 43

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Nb	Fe	Cu	Ti
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 properties

As-welded			min	typical
Tensile strength		MPa	550	660
0.2% Proof stress		MPa	360	390
Elongation on 4d		%	30	40
Elongation on 5d		%	27	38
Reduction of area		%	--	40
Impact energy	-196°C	J	--	> 80
Hardness		HV	--	190

Operating parameters

DC +ve only

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/carton	9.9	12.0	13.5	13.5	17.1
pieces/carton	807	468	291	192	129

20.70.Nb

Solid welding wire for TIG, MIG and SAW

Product description

Solid wire – wires for TIG, MIG and sub-arc welding of nickel base alloys and dissimilar joints between nickel alloys, ferritic and austenitic stainless steels.

Specifications

AWS A5.14	ERNiCr-3
BS EN ISO 18274	SNi6082
BS2901:PT5	NA35
DIN 1736 (Werkstoff No)	SG-NiCr20Nb (2.4806)
UNS	N06082

Also known generically as filler metal 82 (FM82)

ASME IX Qualification

QW432 F-No 43

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Nb	Cu	Ti	Fe
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 properties

Typical values as welded			typical
Tensile strength		MPa	640
0.2% Proof stress		MPa	360
Elongation on 4d		%	40
Impact energy	-196°C	J	> 100

Typical operating parameters

	TIG	MIG	SAW
Shielding	Ar	Ar	NiCr flux
Current	DC-	Pulsed	DC+
Diameter	2.4mm	1.2mm	1.6mm
Parameters	100A, 12V	180A, 26V	300A, 26V

Packaging data

ø mm	TIG	MIG	SAW
1.2	--	15kg	--
1.6	2.5kg	--	25kg
2.0	2.5kg	--	25kg
2.4	2.5kg	--	25kg
3.2	2.5kg	--	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
1	6	15	56	< 0.1	< 0.5	0.9

NiCr FLUX

Sub-arc flux

Product description

Sub-arc flux – Agglomerated, fluoride basic flux of high basicity (Boniczewski B1~3). The high basicity ensures low loss of critical alloying elements in the transfer from wire to weld deposit; the low silica content ensures a low silicon content of the weld metal and reduces the risk of hot cracking. **NiCr flux** can be used DC+, DC- and AC, although DC+ operation is preferred. Flux:wire ratio is 1-2:1 depending on operating conditions; recycled flux should be limited to about 10% to avoid build-up of fines.

Specifications

DIN 32522	BFB7 6534 AC5
BS EN 760	SA FB2

Composition (typical)

	C	Mn	Si	S	P	Cr	Ni	Nb	Fe	Ti
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 properties with 20.70.Nb wire

As welded		typical
Tensile strength	MPa	640
0.2% Proof stress	MPa	360
Elongation	%	40

Operating parameters

Current: DC +ve ranges as below:

ø mm	amp-volt range	typical	stickout
1.6	200-350A, 27-31V	300A, 28V	20-25mm
2.4	250-450A, 28-32V	350A, 29V	20-25mm

Packaging data

Metrode **NiCr Flux** is supplied in sealed moisture resistant 25kg 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 250-400°C/1-3h.

Nickel Base Alloys

NICKEL BASE AB CONSUMABLES

DATA SHEET **D-11**

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Fax: +44(0)1932 566199 Export
Email: info@metrode.com
Internet: http//www.metrode.com

Alloy type

Inconel™ 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.

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

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 – 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°C.
Fume data	Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Mo	Cu	F	OES (mg/m^3)
2	13	10	5	0.2	0.1	15	1

NIMROD AKS

All-positional Inconel™ type MMA electrode

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.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.11	ENiCrFe-2
BS EN 14172	E Ni6092
DIN 1736	EL-NiCr15MoNb (2.4625)

ASME IX Qualification

QW432 F-No 43

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Nb	Fe	Mo	Cu	Co *	Ta *
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	0.12	0.30
typ	0.05	2.8	0.5	0.01	0.01	16	69	2	8	1.5	0.05	0.05	0.05

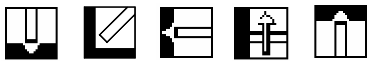
* Co and Ta maximums only when specified at time of order.

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	550	700
0.2% Proof stress		MPa	360	420
Elongation on 4d		%	30	42
Elongation on 5d		%	27	39
Reduction of area		%	--	50
Impact energy	- 196°C	J	--	110
Hardness cap/mid		HV	--	200/215

Operating parameters

DC +ve



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	12.0	14.4	13.5
pieces/carton	762	441	300	186

NIMROD AB

Inconel™ type MMA electrode for downhand welding and surfacing

Product description

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 usability criterion in AWS A5.11.

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

Specifications

AWS A5.11	ENiCrFe-2/4
BS EN 14172	E Ni6092
DIN 1736	EL-NiCr15MoNb (2.4625)

ASME IX Qualification

QW432 F-No 43

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Nb	Fe	Mo	Cu
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

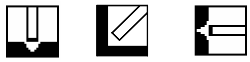
NIMROD AB (continued)

All-weld mechanical properties

As welded			min	typical
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 (OCV: 70V min)



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
length mm	280	330	330
kg/carton	12.0	14.4	13.8
pieces/carton	387	249	162

NIMAX A

High recovery electrode for cladding and surfacing

Product description

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.

Specifications

AWS A5.11	ENiCrFe-2
BS EN 14172	E Ni6092
DIN 1736	EL-NiCr15MoNb (2.4625)

ASME IX Qualification

QW432 F-No 43

Composition (weld metal wt %)

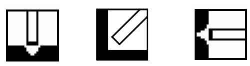
	C	Mn	Si	S	P	Cr	Ni	Nb	Fe	Mo	Cu
min	--	1.0	--	--	--	13.0	62	1.5	--	1.0	--
max	0.10	3.5	0.75	0.015	0.02	17.0	bal	3.0	12.0	2.5	0.50
typ	0.05	2	0.5	0.01	0.01	16	69	2	8	1.5	0.05

All-weld mechanical properties

As welded			min	typical
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	--	80
Hardness		HV	--	205

Operating parameters

DC +ve



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	12.0	13.5	13.5
pieces/carton	492	291	186

20.70Nb

Solid wire for TIG, MIG and SAW

Product description	Solid wire for TIG, MIG and SAW.
Specifications	**AWS A5.14** ERNiCr-3 **BS EN ISO 18274** SNi6082 **BS 2901: Pt5** NA35 **DIN 1736** SG-NiCr20Nb (2.4806) **UNS** N06082 Also known generically as filler metal 82 (FM82)
ASME IX Qualification	**QW432** F-No 43

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Nb	Cu	Ti	Fe
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 properties

Typical values as welded			TIG
Tensile strength		MPa	640
0.2% Proof stress		MPa	360
Elongation on 4d		%	40
Impact energy	- 196°C	J	>100

Typical operating parameters

	TIG	MIG	SAW
Shielding	Argon *	Argon **	NiCr flux
Current	DC-	DC+ ***	DC+
Diameter	2.4mm	1.2mm	2.4mm
Parameters	100A, 12V	220A, 30V	300A, 31V

* Also required as a purge for root runs.
** Proprietary Ar/He mixtures also suitable.
*** Pulsed current may provide benefits with respect to operability and arc transfer characteristics.

Packaging data

ø mm	TIG	MIG	SAW
1.2	--	15kg spool	--
1.6	2.5kg tube	--	25kg coil
2.0	2.5kg tube	--	25kg coil
2.4	2.5kg tube	--	25kg coil
3.2	2.5kg tube	--	--

Fume data

MIG fume composition (wt %) (TIG & SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
1	6	15	56	<0.1	<0.5	0.9

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METRODE WELDING CONSUMABLES

NIMROD 132KS

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:

UNS N06600	Inconel 600 (Special Metals)
BS NA14	Nicrofer 7216 (Krupp VDM)
DIN 2.4816 (NiCr15Fe)	Nicrofer 7216H (Krupp VDM)
AFNOR NC15Fe	Pyromet 600 (Carpenter)
ASTM A494 CY40 (cast)	RA600 (rolled Alloys)

Other alloys:

Alloy 330	Nimonic 75 (Special Metals)
Alloy 601 (to about 900°C)	

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) are very similar; and the 20.70.Nb solid wire would be used in conjunction with Nimrod 132KS.

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	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

Parameters

DC +ve

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:

Fe	Mn	Ni	Cr	Cu	F	OES (mg/m^3)
2	12	11	5	0.1	15	1

Nickel Base Alloys

DATA SHEET **D-20**

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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:	Dissimilar:
9%Ni steels	Combinations of above

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 **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 super-austenitic 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.

Products available

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

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° 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	Mo	Cu	F	OES (mg/m^3)
1	4	9	6	1	0.1	20	0.8

NIMROD 625

Downhand MMA electrode for surfacing

Product description

MMA electrode designed to combine easy operation with the deposition of high quality weld metal and a finished bead of good appearance. The electrode has a basic-rutile flux system and is made on a nickel core wire. **Nimrod 625** operates on AC or DC+ and is designed primarily for the downhand/flat or H-V positions. Optimised for surfacing and overlays, for joining Nimrod 625KS is preferred.

Recovery is about 170% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.11	ENiCrMo-3
BS EN 14172	E Ni6625
DIN 1736	EL-NiCr 20 Mo 9 Nb (2.4621)

ASME IX Qualification

QW432 F-No 43

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Nb	Fe	Mo	Cu
min	--	0.5	--	--	--	20.0	55	3.15	--	8.0	--
max	0.10	1.0	0.75	0.015	0.020	23.0	--	4.15	2.5	10.0	0.50
typ	0.04	0.8	0.7	0.005	0.008	21.5	64	3.4	< 1.5	9	0.05

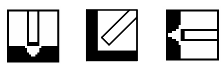
All-weld mechanical properties

As welded			min *	typical
Tensile strength		MPa	760	800
0.2% Proof stress		MPa	420	480
Elongation on 4d		%	30	34
Elongation on 5d		%	27	32
Reduction of area		%	--	30
Impact energy	- 196°C	J	--	> 28
Hardness (as welded)		HV	--	250
Hardness (work-hardened)		HV	--	450

* Cannot meet TS > 827MPa required by cold rolled ASTM N06625 Grade 1, but meets PS > 414MPa and properties of hot rolled grades. Cast CW-6MC solution annealed 1175°C + WQ requires TS > 485MPa.

Operating parameters

DC +ve AC (OCV: 70V)



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	13.2	16.8
pieces/carton	243	153	93

NIMROD 625KS

Basic coated MMA pipe-welding electrode for 625

Product description

MMA electrode with a basic flux system made on a 625 core wire. The electrode is designed to combine easy operation with the deposition of high quality, radiographically sound weld metal and a finished bead of good appearance. **Nimrod 625KS** is optimised for DC+ welding in all positions including pipework qualified in the ASME 6G position.

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

Specifications

AWS A5.11	E NiCrMo-3
BS EN 14172	ENi 6625
DIN 1736	EL-NiCr 20 Mo 9 Nb (2.4621)

ASME IX Qualification

QW432 F-No 43

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Nb	Fe	Mo	Cu
min	--	0.5	--	--	--	20.0	55	3.15	--	8.0	--
max	0.10	1.0	0.75	0.015	0.020	23.0	--	4.15	2.5	10.0	0.50
typ	0.03	0.8	0.4	0.005	0.008	21.5	64	3.5	< 1.5	9	0.05

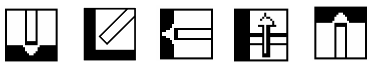
All-weld mechanical properties

As welded			min *	typical	+ 160°C
Tensile strength		MPa	760	800	725
0.2% Proof stress		MPa	420	500	440
Elongation on 4d		%	30	40	33
Elongation on 5d		%	27	38	31
Reduction of area		%	--	40	32
Impact energy	- 196°C	J	--	60	--
Hardness (as welded)		HV	--	250	--
Hardness (work-hardened)		HV	--	450	--

* Cannot meet TS > 827MPa required by cold rolled ASTM N06625 Grade 1, but meets PS > 414MPa and properties of hot rolled grades. Cast CW-6MC solution annealed 1175°C + WQ requires TS > 485MPa.

Operating parameters

DC +ve



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	260	300	350	350
kg/carton	11.1	13.5	15.0	15.0
pieces/carton	660	375	300	189

62-50

Solid wire for TIG, MIG and SAW

Product description

Solid wire for TIG, MIG and SAW.

Specifications

AWS A5.14	ERNiCrMo-3
BS EN ISO 18274	SNi6625
BS 2901: Pt5	Grade NA43
DIN 1736	SG-NiCr 21 Mo 9 Nb (2.4831)
Approvals	TÜV (MIG)

ASME IX Qualification

QW432 F-No 43

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	Al	Ti	Fe
min	--	--	--	--	--	20.0	60.0	8.0	3.15	--	--	--	--
max	0.05	0.50	0.50	0.015	0.015	23.0	bal	10.0	4.15	0.50	0.40	0.40	1.0
typ	0.015	0.02	0.1	0.005	0.005	22	65	9	3.5	0.05	0.2	0.2	0.8

All-weld mechanical properties

Typical values as welded			TIG	SAW + NiCr	TIG +165°C
Tensile strength		MPa	780	715	710
0.2% Proof stress		MPa	520	430	440
Elongation on 4d		%	42	50	42
Elongation on 5d		%	40	47	40
Impact energy	- 100°C	J	100	--	--
Impact energy	- 196°C	J	80	100	--
Hardness cap/mid		HV	205/225	235/255	--

Cannot meet TS > 827MPa required by cold rolled ASTM N06625 Grade 1, but meets PS > 414MPa and properties of hot rolled grades. Cast CW-6MC solution annealed 1175°C + WQ requires TS > 485MPa.

Typical operating parameters

	TIG *	MIG	SAW
Shielding	Ar	Ar or ArHe	NiCr flux
Current	DC-	Pulsed	DC+
Diameter	2.4mm	1.2mm	1.6mm
Parameters	100A, 12V	130A, 29V (mean)	260A, 26V

* Also required as a purge for root runs.

Packaging data

ø mm	TIG	MIG	SAW
0.8	--	15kg spool	--
1.0	--	To order	--
1.2	--	15kg spool	--
1.6	2.5kg tube	--	25kg coil
2.0	2.5kg tube	--	--
2.4	2.5kg tube	--	25kg coil
3.2	2.5kg tube	--	--

Fume data

MIG fume composition (wt %) (TIG & SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
1	1	17	50	9	< 0.5	1

Nickel Base Alloys

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 (NiMo16Cr15W)	2.4883 (G-NiMo16Cr)

Proprietary alloys:
Hastelloy™ 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 stress-corrosion 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.

Products available

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	**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** 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 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	Mo	Cu	F	OES (mg/m^3)
1	4	10	5	5	0.2	16	1

NIMROD C276

Rutile C276 electrode primarily used for surfacing

Product description

MMA electrode manufactured on special nickel-chromium core wire, with an alloyed basic-rutile flux coating to ensure low carbon and silicon transfer and a high refining capacity to remove undesirable impurities. Primarily used for surfacing and cladding; for joining applications the Nimrod C276KS is preferred.

Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.11	ENiCrMo-4
BS EN 14172	E Ni6276
DIN 1736	EL-NiMo15Cr15W (2.4887)

ASME IX Qualification

QW432 F-No 43

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Fe	V	Cu	Co
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

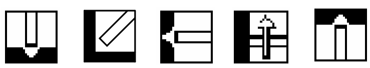
All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	690	770
0.2% Proof stress		MPa	400	550
Elongation on 4d		%	25	26
Elongation on 5d		%	22	25
Hardness *	Cap/mid	HV	--	230/255

* Work hardens to about 450HV.

Operating parameters

DC +ve 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 mm	260	310	310	310
kg/carton	12.0	13.5	14.1	13.2
pieces/carton	600	378	234	141

NIMROD C276KS

All-positional pipe welding electrode for alloy C276

Product description

MMA electrode with special basic flux coating on matching nickel-chromium-molybdenum core wire to provide clean and homogenous weld metal. Nimrod C276KS has exceptional operability, optimised for DC+ welding in all positions including fixed pipework qualified in the ASME 6G (inclined overhead) position.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.11	ENiCrMo-4
BS EN 14172	E Ni6276
DIN 1736	EL-NiMo15Cr15W (2.4887)

ASME IX Qualification

QW432 F-No 43

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Fe	V	Cu	Co
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

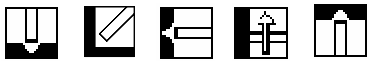
All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	700	780
0.2% Proof stress		MPa	400	520
Elongation on 4d		%	25	30
Elongation on 5d		%	25	28
Impact energy	-50°C	J	--	65
	-196°C	J	--	55
Hardness *		HV	--	240

* Work hardens to about 450HV.

Operating parameters

DC +ve



ø mm	2.5	3.2	4.0
min A	60	75	100
max A	80	110	155

Packaging data

ø mm	2.5	3.2	4.0
length mm	250	300	350
kg/carton	11.4	13.5	15.0
pieces/carton	789	435	294

HAS C276

Solid wire for TIG and MIG welding of alloy C276

Product description

Solid wire for TIG, MIG and SAW.

Specifications

AWS A5.14	ERNiCrMo-4
BS EN ISO 18274	SNi6276
BS 2901: Pt5	NA48
DIN 1736	SG-NiMo16Cr16W (2.4886)
UNS	N10276

ASME IX Qualification

QW432 F-No 43

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Fe	V	Cu
min	--	--	--	--	--	14.5	bal	15.0	3.0	4.0	--	--
max	0.02	1.0	0.08	0.015	0.020	16.5	--	17.0	4.5	7.0	0.3	0.50
typ	0.005	0.5	0.05	0.005	0.01	16	58	16	3.5	6	0.2	0.05

All-weld mechanical properties

Typical values as welded		min	TIG
Tensile strength	MPa	700	740
0.2% Proof stress	MPa	400	500
Elongation on 4d	%	--	46
Elongation on 4d	%	30	43
Reduction of area	%	--	50

Typical operating parameters

	TIG	MIG
Shielding	Ar *	Argon or Ar-He
Current	DC-	Pulsed
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	160A, 28V (mean)

* Also required as purge for root runs.

Packaging data

ø mm	TIG	MIG
0.9	--	15kg spool
1.0	--	15kg spool
1.2	--	15kg spool (to order)
1.6	2.5kg tube	--
2.0	To order	--
2.4	2.5kg tube	--
3.2	2.5kg tube	--

Fume data

MIG fume composition (wt %) (TIG and SAW fume negligible):

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m^3)
14	3	10	28	11	1	1.8

Nickel Base Alloys

DATA SHEET D-31

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Internet: http//www.metrode.com

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)
Proprietary	Nicrofer 5923hMo (Krupp VDM). Inconel™ Alloy 686 (Special Metals) +W. Hastelloy™ Alloy C-2000™ (Haynes 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™ Alloy C-22™ (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 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 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.

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.

Products available

Process	Product	Specification
MMA	**Nimrod 59KS**	AWS ENiCrMo-13
TIG/MIG	**HAS 59**	AWS ERNiCrMo-13

NIMROD 59KS

Basic all-positional pipe-welding electrode for alloy 59

Product description

MMA electrode with special basic flux covering on high purity NiCrMo core wire to give clean homogenous weld metal. Very low levels of C and Si minimise the occurrence of deleterious precipitates in the as-welded condition. The special flux coating provides exceptional operability, optimised for DC+ welding in all positions including fixed pipework in the ASME 5G/6G positions. The electrode is equally suitable for general fabrication welds.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.11	ENiCrMo-13
BS EN 14172	E Ni6059
DIN 1736	EL-NiCr22Mo16 (2.4609)

ASME IX Qualification

QW432 F-No 43

Composition (weld metal wt %)

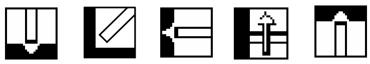
	C	Mn	Si	S	P	Cr	Ni	Mo	Fe	Cu
min	--	--	--	--	--	22.0	57.0	15.0	--	--
max	0.02	1.0	0.2	0.010	0.015	24.0	bal	16.5	1.5	0.50
typ	0.01	0.5	0.15	0.006	0.01	23	60	15.5	1	0.01

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	690	750
0.2% Proof stress		MPa	350	520
Elongation on 4d		%	30	32
Elongation on 5d		%	25	30
Reduction of area		%	--	30
Impact energy	- 50°C	J	--	50

Operating parameters

DC +ve



ø mm	2.5	3.2	4.0
min A	60	75	100
max A	80	120	155

Packaging data

ø mm	2.5	3.2	4.0
length mm	250	300	350
kg/carton	10.5	13.5	15.0
pieces/carton	714	480	297

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 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 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	Mo	Cu	F	OES (mg/m^3)
1	4	10	5	6	0.2	16	1

HAS 59

Solid wire for TIG and MIG welding of alloy 59

Product description

Solid wire for TIG and MIG.

Specifications

AWS A5.14	ERNiCrMo-13
BS EN ISO 18274	SNi6059
DIN 1736	SG-NiCr23Mo16 (2.4607)

ASME IX Qualification

QW432 F-No 43

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Fe	Co	Al
min	--	--	--	--	--	22.0	56.0	15.0	--	--	0.1
max	0.010	0.5	0.10	0.005	0.015	24.0	Bal	16.5	1.5	0.3	0.4
typ	0.003	0.2	0.03	0.003	0.003	23	60	15.6	0.4	0.1	0.3

All-weld mechanical properties

Typical values as welded			TIG
Tensile strength		MPa	730
0.2% Proof stress		MPa	510
Elongation on 4d		%	34
Elongation on 5d		%	32
Impact energy	+ 20°C	J	140
Hardness		HV	240

Typical operating parameters

	TIG	MIG
Shielding	Argon *	Argon or Ar-He
Current	DC-	Pulsed
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	160A, 28V (mean)

* Also required as a purge for root runs.

Packaging data

ø mm	TIG	MIG
1.2	--	15kg spool
1.6	To order	--
2.4	2.5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
1	1	17	50	11	<0.5	1

METRODE WELDING CONSUMABLES

Nickel Base Alloys

DATA SHEET D-32

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Fax: +44(0)1932 566199 Export
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Internet: http//www.metrode.com

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™ 5621hMoW (VDM)
Inconel™ 622 (Special Metals)

Other Alloys:

Alloy C4
ASTM UNS N06455
DIN 2.4610 (NiMo16Cr16Ti)
Hastelloy™ 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.

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.

Products available

Process	Product	Specification
MMA	**Nimrod C22KS**	AWS ENiCrMo-10
TIG/MIG	**HAS C22**	AWS ERNiCrMo-10

METRODE WELDING CONSUMABLES

Nimrod C22KS

All-positional MMA electrode for alloy C22

Description

Basic flux covered electrode with exceptional operability optimised for DC+ welding in all positions including fixed pipework qualified in the ASME 5G/6G positions. It is equally suitable for general fabrication welds.

Special basic flux covering on matching high purity nickel alloy core wire to give clean and homogenous weld metal. Very low levels of carbon and silicon minimise the occurrence of deleterious precipitates in the as-welded condition.

Recovery is approx 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.11	ENiCrMo-10
BS EN 14172	E Ni6022

ASME IX Qualification

QW422 P-No 43, **QW432** F-No 43

Composition (weld metal wt %)

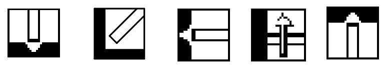
	C	Mn	Si	S	P	Cr	Ni	Mo	W	V	Co	Cu	Fe
min	--	--	--	--	--	20.0	49.0	12.5	2.5	--	--	--	2.0
max	0.02	1.0	0.2	0.015	0.02	22.5	--	14.5	3.5	0.35	2.5	0.50	6.0
typ	0.01	0.5	0.15	0.008	0.008	21	58	14	3	0.05	0.05	0.05	4

All-weld mechanical properties

Typical as-welded			min	typical
Tensile strength		MPa	690	780
0.2% Proof stress		MPa	350	550
Elongation on 4d		%	25	36
Elongation on 5d		%	22	35
Reduction of area		%	--	40
Impact energy	-196°C	J	--	45
Hardness, cap/mid		HV	--	245/275

Operating parameters

DC +ve



ø mm	2.5	3.2	4.0
min A	60	75	100
max A	80	120	155

Packaging data

ø mm	2.5	3.2	4.0
length mm	250	300	350
kg/carton	10.5	13.5	15.6
pieces/carton	711	486	306

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. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase 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 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.

Fume data

Fume composition (wt %)

Fe	Mn	Ni	Cr	Mo	Cu	F	OES (mg/m^3)
1	4	10	5	6	0.2	16	1

HAS C22

Solid wire for nickel base alloy C22

Product description

Solid wire for TIG and MIG.

Specifications

AWS A5.14	ERNiCrMo-10
BS EN ISO 18274	SNi6022

ASME IX Qualification

QW432 F-No 43

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	V	Co	Cu	Fe
min	--	--	--	--	--	20.0	49.0	12.5	2.5	--	--	--	2.0
max	0.01	0.50	0.08	0.010	0.02	22.5	--	14.5	4.5	0.3	2.5	0.50	6.0
typ	0.003	0.2	0.03	0.002	0.01	21	56	13.5	3	0.15	1.5	0.1	4

All-weld mechanical properties

Typical values as welded			TIG
Tensile strength		MPa	770
0.2% Proof stress		MPa	525
Elongation on 4d		%	44
Elongation on 5d		%	42
Impact energy	- 196°C	J	130
Hardness		HV	220

Typical operating parameters

	TIG	MIG
Shielding	Argon *	Argon or Ar-He
Current	DC-	Pulsed
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	160A, 28V (mean)

* Also required as a purge for root runs.

Packaging data

ø mm	TIG	MIG
1.0	--	To order
1.2	--	To order
1.6	2.5kg tube	--
2.4	2.5kg tube	--
3.2	2.5kg tube	--

Fume data

Fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
14	1	17	30	10	<0.5	1.7

Nickel Base Alloys

DATA SHEET D-40

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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**
UNS NO6617	2.4663 (NiCr23Co12Mo)

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.

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 heat-resistant 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.

Products available

Process	Product	Specification
MMA	**Nimrod 617KS**	AWS ENiCrCoMo-1
TIG	**61-70**	AWS ERNiCrCoMo-1

NIMROD 617KS

617 MMA electrode for high temperature applications

Product description

Special basic flux on matching nickel alloy core wire. The chromium range of the weld metal is higher than the parent material to maintain oxidation resistance at a lower aluminium level. The electrode is optimised for DC+ welding in all positions including fixed pipework qualified in the ASME 5G/6G positions.

Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.11	ENiCrCoMo-1
BS EN 14172	E Ni 6617
DIN 1736	(EL-NiCr21Co12Mo, 2.4628)

ASME IX Qualification

QW432 F-No 43

Composition (weld metal wt %)

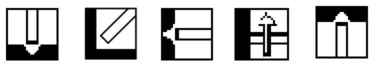
	C	Mn	Si	S	P	Cr	Ni	Co	Mo	Nb	Cu	Fe	Al	Ti
min	0.05	0.3	--	--	--	21.0	45.0	9.0	8.0	--	--	--	--	--
max	0.10	2.5	0.75	0.015	0.020	26.0	bal	15.0	10.0	1.0	0.50	5.0	1.5	0.6
typ	0.07	1.0	0.4	0.003	<0.01	24	52	12	9	<0.5	0.05	1	0.15	0.2

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	700	760
0.2% Proof stress		MPa	400	520
Elongation on 4d		%	25	43
Elongation on 5d		%	25	40
Reduction of area		%	--	40
Impact energy	+ 20°C	J	--	70
Hardness mid/cap		HV	--	230/245

Operating parameters

DC +ve



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	300	350	350
kg/carton	12.0	15.0	15.0
pieces/carton	738	459	273

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 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°C.

Fume data

Fume composition, wt % typical:

Fe	Mn	Ni	Co	Cr^6	Mo	Cu	F	OES (mg/m^3)
1	4	9	2.5	6	1	0.2	20	0.8

61-70

Solid TIG wire matching alloy 617

Product description	Solid wire for TIG.
Specifications	**AWS A5.14** ERNiCrCoMo-1 **BS EN ISO 18274** SNi6617 **BS 2901: Pt5** NA50 **DIN 1736** (SG-NiCr22Co12Mo, 2.4627)
ASME IX Qualification	**QW432** F-No 43

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Co	Mo	Cu	Fe	Al	Ti
min	0.05	--	--	--	--	20.0	44.0	10.0	8.0	--	--	0.80	--
max	0.15	1.0	0.5	0.015	0.020	24.0	bal	15.0	10.0	0.5	3.0	1.50	0.60
typ	0.08	0.1	0.1	0.002	<0.01	22	55	12	9	<0.2	0.5	1	0.3

All-weld mechanical properties

Typical values as welded			min	TIG typical
Tensile strength		MPa	700	750
0.2% Proof stress		MPa	400	500
Elongation on 4d		%	25	43
Elongation on 5d		%	30	41
Impact energy	+ 20°C	J	--	230
Hardness cap/mid		HV	--	200/225

Typical operating parameters

	TIG
Shielding	Argon
Current	DC-
Diameter	2.4mm
Parameters	100A, 12V

Packaging data

ø mm	TIG
1.6	2.5kg tube
2.4	2.5kg tube

Fume data

Fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr[3]	Ni	Mo	Co	OES (mg/m^3)
1	1	17	45	9	11	0.9

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METRODE WELDING CONSUMABLES

DATA SHEET **D-41**

NIMROD 690KS

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**.

Microstructure

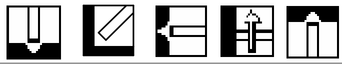
High alloy nickel base austenite.

Welding guidelines

Preheat and PWHT is not generally required.

Parameters

DC+ve



ø mm	4.0
min A	100
max A	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° 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	F	OES (mg/m^3)
2	13	10	8	0.2	0.1	16	0.6

All-weld mechanical properties

			As welded		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^2	--	--	84	--

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Nb	Fe	Mo	Ti	Al	Cu	Co
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

DATA SHEET D-50

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PURE NICKEL

Alloy type

Low carbon pure nickel wed metal with titanium de-oxidation.

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 pipework** and **heat exchangers**, in **chemical plant** for **salt production**, **chlorination** and **evaporation of 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.

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

MMA electrode with special carbonate-fluoride-rutile flux system on matching core wire. Smaller diameters offer excellent all-positional operability. Recovery is about 100% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.11	ENi-1
BS EN 14172	E Ni 2061
DIN 1736	(EL-NiTi3, 2.4156)

ASME IX Qualification

QW432 F-No 41

Composition (weld metal wt %)

	C	Mn	Si	S	P	Ni	Ti	Al	Fe	Cu	Nb
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 properties

As welded			min	typical
Tensile strength		MPa	410	450
0.2% Proof stress		MPa	200	295
Elongation on 4d		%	20	22
Elongation on 5d		%	18	20
Reduction of area		%	--	40
Impact energy	- 30°C	J	--	160
Hardness		HV	--	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

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° 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	Cu	F	OES (mg/m^3)
<1	1	10	0.2	10	5

NICKEL 2Ti

Solid pure nickel TIG and MIG wire

Product description

Solid wire for TIG & MIG.

Specifications

AWS A5.14	ERNi-1
BS 2901: Pt5	NA32
BS EN ISO 18274	SNi2061
DIN 1736	SG-NiTi4 (2.4155)
UNS	N02061

Also known generically as filler metal 61 (FM61)

ASME IX Qualification

QW432 F-No 41

Composition (wire wt %)

	C	Mn	Si	S	P	Ni	Ti	Al	Cu	Fe
min	--	--	--	--	--	93.0	2.0	--	--	--
max	0.15	1.0	0.7	0.015	0.020	bal	3.5	1.5	0.2	1.0
typ	<0.02	0.4	<0.3	0.005	0.005	96	3	0.1	<0.02	0.1

All-weld mechanical properties

Typical values as welded		min	TIG
Tensile strength	MPa	410	585
0.2% Proof stress	MPa	200	335
Elongation on 4d	%	--	35
Elongation on 5d	%	25	31
Reduction of area	%	--	65
Hardness cap/mid	HV	--	155/185

Typical operating parameters

	TIG	MIG	
Shielding	Argon *	Ar or Ar-He	* Ar + 1-5%H_2 also suitable.
Current	DC-	Pulsed	
Diameter	2.4mm	1.2mm	
Voltage	100A, 12V	150A, 29V (mean)	

Packaging data

ø mm	TIG	MIG
1.2	--	15kg spool
1.6	2.5kg tube	--
2.4	2.5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
2	2	<0.1	68	0.1	<0.5	0.7

Nickel Base Alloys

DATA SHEET D-60

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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 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 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.

Products available

Process	Product	Specification
MMA	**Nimrod 190**	AWS ENiCu-7
TIG/MIG	**65NiCu**	AWS ERNiCu-7

NIMROD 190

Nickel-copper MMA electrode for Monel alloy 400

Product description

Special basic carbonate-fluoride-rutile flux system on matching 400 core wire to give low levels of residuals. Deoxidation system designed to ensure sound deposits. The raised levels of manganese and titanium help suppress hot cracking and porosity. Analysis is optimised to give the highest as-welded ductility and strength attainable in weld metal of this type. The smaller electrode sizes are particularly suitable for fixed pipework welds demanding qualification in the ASME 6G position.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

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	Mn	Si *	S	P	Ni	Cu	Ti	Fe	Al
min	--	1.0	--	--	--	62.0	27.0	--	0.5	--
max	0.15	4.0	1.5	0.015	0.02	69.0	34.0	1.0	2.5	0.5
typ	0.08	3.5	1.2	0.005	0.01	63	30	0.9	1	0.03

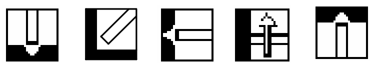
* DIN maximum 1.0% Si

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	480	550
0.2% Proof stress		MPa	200	350
Elongation on 4d		%	30	40
Elongation on 5d		%	27	35
Reduction of area		%	--	60
Impact energy	- 30°C	J	--	110
Hardness		HV	--	160-180

Operating parameters

DC +ve



ø mm	2.5	3.2	4.0	5.0
min A	60	70	90	120
max A	80	110	145	190

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	300	350	350	350
kg/carton	12.6	13.5	15.0	15.0
pieces/carton	612	417	294	189

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° 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	Cu	F	OES (mg/m^3)
1	7	4	16	8	1.2

65NiCu

Solid TIG and MIG to match Monel alloys

Product description

Solid wire for TIG & MIG.

Specifications

AWS A5.14	ERNiCu-7
BS EN ISO 18274	SNi4060
BS 2901: Pt5	NA33
DIN 1736	(SG-NiCu30MnTi, 2.4377)

Also known generically as filler metal 60 (FM60)

ASME IX Qualification

QW432 F-No 42

Composition (wire wt %)

	C	Mn	Si	S	P	Ni	Cu	Ti	Fe	Al
min	--	3.0	--	--	--	62.0	28.0	1.5	--	--
max	0.15	4.0	1.2	0.015	0.020	69.0	32.0	3.0	2.5	1.2
typ	0.03	3.2	0.2	0.005	0.005	64	29	2.2	<1	0.1

All-weld mechanical properties

Typical values as welded			min	TIG
Tensile strength		MPa	460	525
0.2% Proof stress		MPa	200	280
Elongation on 4d		%	--	41
Elongation on 5d		%	25	38
Impact energy	- 30°C	J	--	120

Typical operating parameters

	TIG	MIG	SAW
Shielding	Argon *	Ar or Ar-He	NiCu
Current	DC-	Pulsed	DC+
Diameter	2.4mm	1.2mm	2.4mm
Parameters	100A, 12V	150A, 29V (mean)	300A, 28V

* Also required as a purge for root runs.

Packaging data

ø mm	TIG	MIG	SAW
1.2	--	15kg spool	--
1.6	2.5kg tube	--	--
2.4	2.5kg tube	--	25kg reel

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Cu	OES (mg/m^3)
3	5	<0.1	47	24	1

Nickel Base Alloys

DATA SHEET D-70

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CUPRONICKEL ALLOYS

Alloy type

70/30 and 90/10 copper-nickel alloys.

Materials to be welded

	70/30	90/10
ASTM	C71500 C96400 (cast)	C70600 C96200 (cast)
DIN	2.0882 2.0883	2.0872
BS	CN106 CN107 CN108	CN102
CDA	CA715	CA706
Proprietary	Kunifer 30 (IMI) Cunifer 30 (Krupp VDM)	Kunifer 10 (IMI) Cunifer 10 (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 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.

Products available

Process	Product	Specification
MMA	**Cupromet N30**	AWS ECuNi
TIG/MIG	**70CuNi**	AWS ERCuNi
TIG	**90CuNi**	BS C16

CUPROMET N30

All-positional MMA electrode for cupronickel

Product description

MMA electrode made on matching 70/30 core wire with a special basic flux system giving very low residuals (S, P, Pb, Sn, Zn etc) and hence maximum crack resistance. Suitable for all-positional welding.

Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.6	ECuNi
DIN 1733	EL-CuNi30Mn (2.0838)

ASME IX Qualification

QW432 F-No 34

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cu	Ni	Fe	Ti	Pb	Sn *	Zn *
min	--	1.00	--	--	--	bal	29.0	0.40	--	--	--	--
max	--	2.50	0.50	0.015	0.020	--	33.0	0.75	0.50	0.02	--	--
typ	0.03	1.8	0.2	0.005	0.010	67	30	0.6	0.15	0.002	0.01	0.005

* Total maximum = 0.50%.

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	350	420
0.2% Proof stress		MPa	--	270
Elongation on 4d		%	20	39
Elongation on 5d		%	--	34
Reduction of area		%	--	57
Impact energy	+ 20°C	J	--	115
Hardness		HV	--	120

Operating parameters

DC +ve

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	280	345	345	345
kg/carton	12.6	15.0	15.0	16.5
pieces/carton	684	450	297	198

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 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 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	Cu	F	OES (mg/m^3)
< 1	2	3	16	15	1.2

70CuNi

Solid 70/30 cupronickel wire for TIG and MIG

Product description

Solid wire for TIG and MIG.

Specifications

AWS A5.7	ERCuNi
BS EN 14640	S Cu 7158 / CuNi30
BS 2901: Pt3	C18
DIN 1733	SG-CuNi30Fe (2.0837)

Also known generically as filler metal 67 (FM67)

ASME IX Qualification

QW432 F-No 34

Composition (wire wt %)

	Mn	Si	S	P	Cu	Ni	Fe	Ti	Pb	Al	C
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 properties

Typical values as welded		TIG
Tensile strength	MPa	365
0.2% Proof stress	MPa	200
Elongation on 5d	%	40
Hardness	HV	105

Typical operating parameters

	TIG	MIG
Shielding	Argon or Ar + 1-5%H_2	Argon or Ar-He
Current	DC-	Pulsed
Diameter	2.4mm	1.2mm
Voltage	100A, 12V	160A, 28V (mean)

Packaging data

ø mm	TIG	MIG
1.2	--	15kg spool
1.6	2.5kg tube	--
2.0	2.5kg tube	--
2.4	2.5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr3	Ni	Mo	Cu	OES (mg/m^3)
<1	5	<0.1	22	<0.1	72	0.3

90CuNi

Solid 90/10 cupronickel wire for TIG

Product description

Solid wire for TIG.

Specifications

BS EN 14640	S Cu 7061 / CuNi10
BS 2901: Pt3	(C16)
DIN 1733	SG-CuNi10Fe (2.0873)

ASME IX Qualification

QW432 F-No 34

Composition (wire wt %)

	Mn	Si	S	P	Cu	Ni	Fe *	Ti	Pb	Al	C
min	0.5	--	--	--	bal	10.0	1.0	0.20	--	--	--
max	1.0	0.1	0.01	0.01	--	11.0	2.0	0.50	0.007	0.03	0.05
typ	0.8	0.02	0.001	0.002	86	10.5	1.2	0.3	0.001	0.005	0.01

* BS range Fe = 1.5-1.8%.

All-weld mechanical properties

Typical values as welded		TIG
Tensile strength	MPa	365
0.2% Proof stress	MPa	200
Elongation on 5d	%	40
Hardness	HV	105

Typical operating parameters

	TIG
Shielding	Argon or Ar + 1-5%H_2
Current	DC-
Diameter	2.4mm
Parameters	100A, 12V

Packaging data

ø mm	TIG
1.6	2.5kg tube
2.4	2.5kg tube

Fume data

Fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr3	Ni	Mo	Cu	OES (mg/m^3)
2	5	<0.1	8	<0.1	80	0.3

Nickel Base Alloys

DATA SHEET D-80

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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 as-welded 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.

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_4Mo. 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

NIMAX B2L

High molybdenum nickel base MMA electrode to match alloy B-2

Product description

MMA electrode made on pure nickel core wire with a special basic flux coating to give low levels of impurities. Sizes above 3.2mm are not suitable for positional welding.

Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.11	ENiMo-7
BS EN 14172	E Ni1066
DIN 1736	EL-NiMo29

ASME IX Qualification

QW432 F-No 44

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Cu	Fe	Co	V
min	--	--	--	--	--	0.3	64.5	26	--	--	1.0	--	--
max	0.02	1.75	0.2	0.015	0.02	1.0	bal	30	1.0	0.50	2.0	1.0	0.4
typ	0.018	1.3	0.1	0.005	0.01	0.7	68	28	0.1	0.01	1.5	0.04	0.1

All-weld mechanical properties

As welded		min	typical
Tensile strength	MPa	760	775
0.2% Proof stress	MPa	400	525
Elongation on 4d	%	25	31
Elongation on 5d	%	22	30
Reduction of area	%	--	25
Hardness	HV	--	260

ASTM A494 castings require elongation >6% (N-12MV) or >20% (N-7M) after solution treatment.

Operating parameters

DC +ve

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	12.6	15.0	14.1
pieces/carton	447	300	174

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 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 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	Mo	Cu	F	OES (mg/m^3)
1	2	10	0.2	15	0.2	16	5

HAS B2

Solid TIG wire to match alloy B-2

Product description	Solid wire for TIG.
Specifications	**AWS A5.14** ERNiMo-7 **BS EN ISO 18274** SNi1066 **BS 2901: Pt5** NA44 **DIN 1736** SG-NiMo27 (2.4615)
ASME IX Qualification	**QW432** F-No 44

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Cu	Fe	Co
min	--	--	--	--	--	--	64.0	26.0	--	--	--	--
max	0.02	1.0	0.10	0.015	0.020	1.0	bal	30.0	1.0	0.50	2.0	1.0
typ	0.01	0.7	0.05	0.005	0.005	0.5	70	27	0.5	0.02	1.5	0.05

All-weld mechanical properties

Typical values as welded			TIG
Tensile strength		MPa	815
0.2% Proof stress		MPa	510
Elongation on 4d		%	48
Elongation on 5d		%	47
Reduction of area		%	40
Impact energy	+ 20°C	J	220
Hardness cap/mid		HV	230/245

Typical operating parameters

	TIG
Shielding	Argon
Current	DC-
Diameter	2.4mm
Parameters	100A, 12V

Packaging data

ø mm	TIG
2.4	2.5kg tube

Fume data

Fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
2	2	<0.5	50	25	<0.5	1

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METRODE WELDING CONSUMABLES

DATA SHEET D-87

EPRI P87

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.

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 %)

	C	Mn	Si	S	P	Cr	Ni	Mo	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 strength 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

ø mm	2.5	3.2	4.0
min A	60	70	90
max A	80	110	150

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:

Fe	Mn	Ni	Cr	Cu	F	OES (mg/m^3)
9	5	6	2.5	<0.5	12	2

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METRODE WELDING CONSUMABLES

DATA SHEET **D-90**

NIMROD NCM6

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

AWS A5.11	ENiCrMo-6
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 including:

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°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.

Microstructure

High alloy nickel base austenite with some carbides.

Welding guidelines

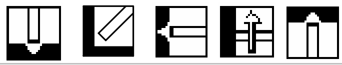
Preheat is not generally required. PWHT is not normally applied up to 50mm thickness.

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 min)
preferred or DC+/- ve



ø mm	2.5	3.2	4.0	5.0
min A	70	90	130	160
max A	115	155	210	260

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	300	350	350	450
kg/carton	12.0	13.2	13.5	18.0
pieces/carton	456	294	183	123

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° 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.

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

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Mo	F	OES (mg/m^3)
2	13	10	5	<0.5	1	15	1

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	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

Repair & Maintenance

DATA SHEET **E-10**

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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.

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.

Products available

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

METRODE WELDING CONSUMABLES

CI SOFT FLOW Ni

Pure nickel MMA electrode for cast iron

Product description

MMA electrode with special basic-graphite flux (no barium compounds) on pure nickel core wire. Good refining action provides maximum resistance to cracking and freedom from porosity. Sound welds can be produced even with oil impregnated and contaminated surfaces. The stable arc characteristics also provide uniform low penetration and minimum dilution. The smallest diameters can be used in all positions including vertical down.

Recovery is about 95% with respect to core wire, 70% with respect to whole electrode.

Specifications

AWS A5.15	ENi-CI
BS EN 1071	E C Ni-CI 1
DIN 8573	(ENi BG 1)

ASME IX Qualification

QW432 F-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cu	Ni	Fe	Al
min	--	--	--	--	--	--	92	--	--
max	2.0	2.5	2.0	0.03	0.03	2.5	bal	5.0	1.0
typ	0.5	2	0.1	0.01	0.01	0.1	96	2	0.1

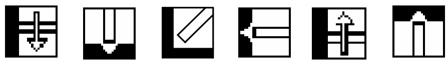
All-weld mechanical properties

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 run sequence.

Operating parameters

DC +ve or AC (OCV: 50V min)



ø mm	2.5	3.2	4.0	5.0 *
min A	60	70	90	120
max A	80	110	150	190

Packaging data

ø mm	2.5	3.2	4.0	5.0 *
length mm	300	350	350	375
kg/carton	15.0	16.5	16.8	18.6
pieces/carton	903	480	309	234

* 5.0mm diameter made to order, minimum order quantity.

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 100 – 150°C/1-2h to restore to as-packed condition. Maximum 150° C, 3 cycles, 10h total.
Storage: Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

Fume data

Fume composition, wt % typical:

Fe	Mn	Ni	Cu	F	Ba	OES (mg/m^3)
0.5	1	10	<0.5	12	<0.5	5

METRODE WELDING CONSUMABLES

CI CAVITY FILL Ni

Pure nickel MMA electrode for 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	ENi-CI
BS EN 1071	E C Ni-CI 1
DIN 8573	(ENi BG 1)

ASME IX Qualification

QW432 F-No --

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cu	Ni	Fe	Al
min	--	--	--	--	--	--	92	--	--
max	2.0	2.5	2.0	0.03	0.03	2.5	bal	5.0	1.0
typ	1	0.7	0.6	0.01	0.01	1.8	95	2	0.1

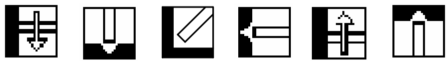
All-weld mechanical properties

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 run sequence.

Operating parameters

DC +ve or AC (OCV: 50V 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	300	350	350
kg/carton	15.0	18.6	18.9
pieces/carton	879	546	360

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 100 – 150°C/1-2h to restore to as-packed condition. Maximum 150° C, 3 cycles, 10h total.
Storage: Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

Fume data

Fume composition, wt % typical:

Fe	Mn	Ni	Cu	F	Ba	OES (mg/m^3)
0.5	1	5	<0.5	8	34	1.4

NICKEL 2Ti

Solid pure nickel wire for cast iron

Product description

Solid wire for TIG and MIG. This is the same wire that is used for alloy 200 pure nickel base materials (data sheet D-50) but it is also useful for welding cast irons as a match for the CI Soft Flow Ni electrode.

Specifications

AWS A5.14	ERNi-1
BS 2901: Pt5	NA32
BS EN proposed	Ni2061
DIN 1736	SG-NiTi4 (2.4155)

Also known generically as filler metal 61 (FM61)

ASME IX Qualification

QW432 F-No 41

Composition (wire wt %)

	C	Mn	Si	S	P	Ni	Ti	Al	Cu	Fe
min	--	--	--	--	--	93.0	2.0	--	--	--
max	0.15	1.0	0.75	0.015	0.03	bal	3.5	1.5	0.25	1.0
typ	<0.02	0.4	<0.3	0.005	0.005	96	3	0.1	<0.02	0.1

All-weld mechanical properties

Typical values as welded		TIG
Tensile strength	MPa	585
0.2% Proof stress	MPa	335
Elongation on 4d	%	35
Elongation on 5d	%	31
Reduction of area	%	65
Hardness cap/mid	HV	155/185

Typical operating parameters

	TIG	MIG
Shielding	Argon	Ar or Ar-He
Current	DC-	Pulsed
Diameter	2.4mm	1.2mm
Parameters	100A, 12V	150A, 29V (mean)

Packaging data

ø mm	TIG	MIG
1.2	--	15kg spool
1.6	2.5kg tube	--
2.4	2.5kg tube	--

Fume data

MIG fume composition (wt %) (TIG fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
2	2	<0.1	68	0.1	<0.5	0.7

Repair & Maintenance

DATA SHEET E-11

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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.

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.

Products available

Process	Product	Specification
MMA	**CI Special Cast NiFe**	AWS ENiFe-CI
	CI-Met NiFe	AWS ENiFe-CI
MIG	**55NiFe**	BS NA47

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 electrodes that have been exposed: **Redry** 100 – 150°C/1-2h to restore to as-packed condition. Maximum 150° C, 3 cycles, 10h total. **Storage**: 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	F	Ba	OES (mg/m^3)
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

MMA electrode with special basic-graphite flux (no barium compounds) on a 55%Ni alloy core wire. Good 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

AWS A5.15	ENiFe-CI
BS EN 1071	E C NiFe-CI 1
DIN 8573	(E NiFe-1 BG)

ASME IX Qualification

QW432 F-No --

Composition (weld metal wt %)

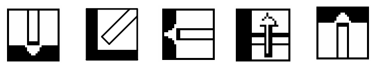
	C	Mn	Si	S	P	Fe	Ni	Al	Cu
min	--	--	--	--	--	bal	45.0	--	--
max	2.0	2.5	2.0	0.03	0.03	bal	60.0	1.0	2.5
typ	0.5	1.5	0.5	0.010	0.005	42	55	<0.1	<0.1

All-weld mechanical properties

As welded		typical
Tensile strength	MPa	400
0.2% Proof stress	MPa	230
Elongation	%	10-12
Hardness	HV	170-200

Operating parameters

DC +ve or AC (OCV: 50V min)



ø mm	2.5	3.2	4.0
min A	60	70	90
max A	80	110	150

Packaging data

ø mm	2.5	3.2	4.0
length mm	305	355	355
kg/carton	13.5	15.0	15.0
pieces/carton	618	450	297

CI-MET NiFe

NiFe MMA electrode on bi-metallic core wire

Product description

MMA electrode with special basic-graphite flux (no barium compounds) on bi-metallic Fe clad Ni core wire. Good refining action provides maximum resistance to cracking and freedom from porosity. The bi-metallic core wire minimises the risks of over-heating normally associated with NiFe MMA electrodes and produces excellent operability.

Recovery is about 95% with respect to core wire, 70% with respect to whole electrode.

Specifications

AWS A5.15	ENiFe-CI
BS EN 1071	E C NiFe-CI 1
DIN 8573	(E NiFe-1 BG)

ASME IX Qualification

QW432 F-No --

CI-MET NiFe (continued)

Composition (weld metal wt %)

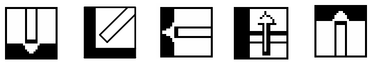
	C	Mn	Si	S	P	Fe	Ni	Al	Cu
min	--	--	--	--	--	bal	45.0	--	--
max	2.0	2.5	2.0	0.03	0.03	bal	60.0	1.0	2.5
typ	0.5	1.5	0.5	0.010	<0.01	42	55	<0.1	<0.1

All-weld mechanical properties

As welded		typical
Tensile strength	MPa	400
0.2% Proof stress	MPa	230
Elongation	%	10-12
Hardness	HV	170-200

Operating parameters

DC +ve or AC (OCV: 50V min)



ø mm	2.5	3.2	4.0
min A	60	75	100
max A	80	120	155

Packaging data

ø mm	2.5	3.2	4.0
length mm	300	350	350
kg/carton	13.5	15.0	15.0
pieces/carton	789	468	300

55NiFe

Solid MIG wire for welding cast irons

Product description

Solid wire for MIG.

Specifications

BS 2901 pt 5	NA47
BS EN 1071	S C NiFe-1
DIN 8573	(MSG NiFe-1)

ASME IX Qualification

QW432 F-No --

Composition (wire wt %)

	C	Mn	Si	S	P	Ni	Fe	Cu	Co
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 properties

Typical values as welded		MIG (Ar-5%CO_2)
Tensile strength	MPa	400
0.2% Proof stress	MPa	230
Elongation	%	24
Hardness	HV	150

Typical operating parameters

	MIG
Shielding	Ar / Ar + 1-2%O_2 / Ar + 2-25%CO_2 / 100%CO_2
Current	DC+
Diameter	1.2mm
Parameters	200A, 28V

Packaging data

ø mm	MIG
1.2	15kg spool
1.6	15kg spool

Fume data

MIG fume composition, wt %:

Fe	Mn	Cr^3	Ni	Cu	OES (mg/m^3)
35	2	<0.1	30	<0.5	1.7

Repair & Maintenance

DATA SHEET E-20

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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:	**13%Mn (Hadfield steel):**
MVEE 816 (MoD)	Abro M (Cresuot)
Armox 816 (Swedish Steel)	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 work-hardenability, 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.

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^{0}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 ~ 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.

Products available

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

Rutile MMA electrode for welding armour plate

Product description

Rutile MMA electrode made on austenitic stainless steel core wire. High moisture resistance, designed and manufactured with low hydrogen technology to give weld metal with low potential hydrogen content.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	E308Mo-16
BS EN 1600	E 20 10 3 R 32
BS 2926	(19.9.3.R)
DIN 8556	E 20 10 3 R 26
Approvals:	MoD MVEE 1050 Class 1A and 1B

ASME IX Qualification

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

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	0.03	0.5	--	--	--	18.5	9.0	2.0	--	10
max	0.08	2.5	1.0	0.025	0.030	21.0	11.0	3.5	0.75	25
typ	0.06	1.1	0.7	0.010	0.025	20	9.5	2.5	0.1	15

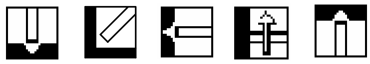
All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	620	670-780
0.2% Proof stress		MPa	400	> 520
Elongation on 4d		%	--	> 24
Elongation on 5d		%	20	> 25
Reduction of area		%	--	> 25
Impact energy	+ 20°C	J	--	> 55
Impact energy	- 50°C	J	--	> 45
Hardness		HV	--	220 *

* Increases to about 400 – 450HV on work hardening

Operating parameters

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



ø mm	2.5	3.2	4.0	5.0
min A	60	70	100	150
max A	90	120	170	230

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	300	350	350	350
kg/carton	11.4	13.5	13.5	16.5
pieces/carton	660	408	261	228

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	F	OES (mg/m^3)
8	5	1	4	< 0.2	16	1.2

METRODE WELDING CONSUMABLES

SUPERCORE 20.9.3

Downhand rutile flux cored wire for welding armour plate

Product description

Rutile flux cored wire made with an austenitic stainless steel sheath and rutile flux system designed primarily for downhand and horizontal welding, giving a mitred fillet profile. The 1.2mm diameter wire is also suitable for all-positional welding.

Metal recovery is approximately 90% with respect to wire.

Specifications

	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

QW432 F-No 6, **QW442** A-No 8

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
min	--	0.5	--	--	--	19.5	9.0	2.0	--	10
max	0.08	2.5	0.9	0.025	0.035	21.0	11.0	3.0	0.3	25
typ	0.06	1.2	0.5	0.01	0.03	20	9.5	2.8	0.05	17

All-weld mechanical properties

As welded			min	typical
Tensile strength		MPa	620	720
0.2% Proof stress		MPa	400	520
Elongation on 4d		%	25	30
Elongation on 5d		%	20	25
Impact energy	+ 20°C	J	--	60
Impact energy	- 50°C	J	--	50
Hardness		J	--	230 *

* Increases to about 400 – 450HV on work-hardening.

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25 l/min. Proprietary gas mixtures may be used but argon should not exceed 85%.

The wire is suitable for use on 100%CO_2 but with some loss of cosmetic appearance and increased spatter.

Current: DC+ve ranges as below, with Ar-20%CO_2 (when using CO_2, voltages need to be increased by 2-3V):

ø mm	amp-volt range	typical	stickout
1.2	130A-25V to 250A-32V	180A-29V	15-20mm
1.6	200A-28V to 330A-34V	230A-30V	15-25mm

Packaging data

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 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^3	Cr^6	F	OES (mg/m^3)
Ar+20%CO_2	14	11	1	8	4	5	1.2
CO_2	17	10	1	9.5	1	5	5

Repair & Maintenance

DATA SHEET E-21
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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.

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.

Products available

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	**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	F	OES (mg/m^3)
Metmax 307R	19	11	1	5	< 0.2	-	18	1
19.9.6Mn	18	15	1	5	< 0.2	-	18	1

METMAX 307R

Rutile high recovery MMA electrode

Product description	Rutile high recovery, metal powder, electrode made on high purity steel core wire. Moisture resistant coating ensures sound porosity free deposits. Recovery is about 150% with respect to core wire, 65% with respect to whole electrode.
Specifications	**AWS A5.4** E307-26 **BS EN 1600** E 18 9 Mn Mo R 52 **DIN 8556** similar to E 18 8 Mn MPR 26
ASME IX Qualification	**QW432** F-No 5

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.04	3.3	--	--	--	18.0	9.0	0.5	--
max	0.14	4.75	0.9	0.025	0.035	21.5	10.7	1.5	0.75
typ	0.1	4.0	0.6	0.010	0.015	19	9.5	0.8	0.1

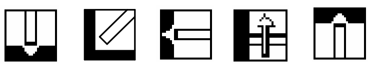
All-weld mechanical properties

As welded			min	typical	PWHT 600°C/2h
Tensile strength		MPa	590	660	--
0.2% Proof stress		MPa	350	475	--
Elongation on 4d		%	30	40	--
Elongation on 5d		%	25	36	--
Reduction of area		%	--	45	--
Impact energy	+ 20°C	J	--	85	--
Impact energy	- 50°C	J	--	70	47
Hardness		HV	--	210 *	--

* Increases to about 400-450HV on work hardening.

Operating parameters

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



ø mm	2.5	3.2	4.0	5.0
min A	70	90	130	160
max A	115	155	210	260

Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	350	380	380	450
kg/carton	12.0	13.5	13.2	15.0
pieces/carton	429	234	153	102

19.9.6Mn

All-positional rutile coated MMA electrode

Product description

Rutile electrode made on nearly matching austenitic steel core wire. Moisture resistant coating ensures sound porosity free deposits.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

Specifications

AWS A5.4	similar to E307-16
BS EN 1600	E 18 8 Mn R 3 2
DIN 8556	E 18 8 Mn R 26

ASME IX Qualification

QW432 F-No -

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo
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

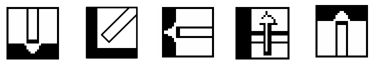
All-weld mechanical properties

As welded			typical
Tensile strength		MPa	680
0.2% Proof stress		MPa	480
Elongation on 4d		%	35
Reduction of area		%	40
Impact energy	+ 20°C	J	80
Hardness		HV	210 *

* Increases to about 400-450HV on work hardening.

Operating 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	12.0	14.1	15.0
pieces/carton	621	372	261

19.9.6Mn

Solid wire for MIG

Product description	Solid wire for MIG.
Specifications	**AWS A5.9** Similar to ER307 (AWS ranges: 3.3-4.75%Mn, 19.5-22.0%Cr and 0.5-1.5%Mo) **BS EN ISO 14343-A** G 18 8 Mn **BS 2901: Pt2** 307S98 **DIN 8556** SG-X 15 CrNiMn 18 8 (1.4370)
ASME IX Qualification	**QW432** F-No --

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	0.04	5.5	0.65	--	--	17.0	7.5	--	--
max	0.14	7.5	1.0	0.025	0.03	20.0	9.5	0.3	0.3
typ	0.08	6	0.8	0.01	0.015	19	8.5	0.2	0.1

All-weld mechanical properties

Typical values as welded			MIG: Ar + 5%CO_2
Tensile strength		MPa	605
0.2% Proof stress		MPa	414
Elongation on 4d		%	42
Elongation on 5d		%	40
Reduction of area		%	52
Impact energy	+ 20°C	J	105
Impact energy	- 50°C	J	65
Hardness cap/mid		HV	185/210

Typical operating parameters

	MIG
Shielding	Ar+5%CO_2 *
Current	DC+
Diameter	1.2mm
Parameters	220A, 26V

* Other proprietary shielding gases also suitable eg. Ar+2%O_2, Ar-He mixtures etc

Packaging data

ø mm	MIG
1.0	15kg spool
1.2	15kg spool

Fume data

MIG fume composition (wt %):

Fe	Mn	Ni	Cr^3	Mo	Cu	OES (mg/m^3)
30	26	3.5	12	< 0.5	< 1	3.8

Repair & Maintenance

DATA SHEET **E-22**

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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.

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

29.9 SUPER R

Acid rutile MMA electrode

Product description

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	(E312-17)
BS EN 1600	E 29 9 R 32
BS 2926	29.9.AR
DIN 8556	E 29 9 R 21

ASME IX Qualification

QW432 F-No 5

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
min	--	--	--	--	--	28.0	8.0	--	--
max	0.15	1.5	1.2	0.025	0.035	31.0	10.5	0.5	0.75
typ	0.1	0.8	1	0.01	0.02	29	9.5	0.1	0.1

All-weld mechanical properties

As welded		min	typical
Tensile strength	MPa	660	830
0.2% Proof stress	MPa	450	650
Elongation on 4d	%	22 *	26
Elongation on 5d	%	15	25
Reduction of area	%	--	30
Hardness	HV	--	280

* Minimum elongation required by AWS not always obtained.

A high tensile strength with moderate ductility is typical for multipass all-weld test specimens but these properties may be altered under conditions of high dilution from base material for which this electrode is intended. Dilution typically raises ductility.

Operating parameters

DC +ve or AC (OCV: 50V min)

ø mm	1.6	2.0	2.5	3.2	4.0	5.0
min A	25	40	60	75	100	130
max A	45	60	90	120	155	210

Packaging data

ø mm	1.6	2.0	2.5	3.2	4.0	5.0
length mm	250	250	300	350	350	350
kg/carton	9.0	9.3	12.0	13.8	14.1	13.5
pieces/carton	1389	948	642	435	276	168

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 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	F	OES (mg/m^3)
8	4	1	8	0.2	17	0.6

312S94

Solid wire for MIG, TIG and SAW

Product description	Solid wire for TIG, MIG and SAW.
Specifications	**AWS A5.9** ER312 **BS EN ISO 14343-A** 29 9 **BS EN ISO 14343-B** SS312 **BS 2901: Pt2** 312S94 **DIN 8556** SG X10CrNi 30 9 (1.4337)
ASME IX Qualification	**QW432** F-No 6

Composition (wire wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
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 properties

Typical values as welded			TIG	MIG	
				Ar + 5%CO_2	Ar + 2%O_2
Tensile strength		MPa	790	813	789
0.2% Proof stress		MPa	640	628	638
Elongation on 4d		%	21	25	10
Elongation on 5d		%	19	24	10
Reduction of area		%	35	31	10
Impact energy	+ 20°C	J	50	--	27
Hardness		HV	275	270	300

Typical operating parameters

	TIG	MIG	SAW
Shielding	Ar *	Ar + 2-5%CO_2 **	SSB ***
Current	DC-	DC+	DC+
Diameter	2.4mm	1.2mm	2.4
Voltage	120A, 14V	220A, 26V	350A, 30V

* Also required as a purge for root runs.

** Ar – CO_2 gases were found to produce better ductility than Ar – 2%O_2 (see properties above).

*** **SSCr** (Cr compensating) and **LA491** also suitable.

Packaging data

ø mm	TIG	MIG	SAW
1.2	--	15kg spool	--
1.6	2.5kg tube	--	25kg coil
2.4	2.5kg tube	--	25kg coil
3.2	To order	--	--

Fume data

MIG fume composition (wt %) (TIG and SAW fume negligible)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
30	12	22	9	<1	<1	2.3

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METRODE WELDING CONSUMABLES

DATA SHEET **E-30**

100Cu

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

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^3	Ni	Mo	Cu	OES (mg/m^3)
<1	2	<0.1	<0.1	<0.1	82	0.2

Composition (wire wt %)

	Cu	Mn	Si	Sn	Pb	Al	Fe	Ni	As	Sb	P	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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METRODE WELDING CONSUMABLES

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	P
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^3	Ni	Mo	Cu	OES (mg/m^3)
<1	5	<0.1	<0.1	<0.1	80	0.3

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METRODE WELDING CONSUMABLES

DATA SHEET **E-33**

92CuSn

Product description

Tin bronze alloy wire for welding similar tin bronze (phosphor bronze) alloys.

Specifications

AWS A5.7	(ERCuSn-C)
BS EN 14640	S Cu 5210
BS 2901 Pt 3	(C11)
DIN 1733	(SG-CuSn6 / 2.1022)

ASME IX Qualification

92CuSn QW432 F-No 33

Materials to be welded

Tin bronze	Up to 10%Sn+0.5%P. BS PB101-103, UNS C50100-C52400.
Gunmetals	BS LG3, LG4, LPB1, (but >5%Pb leaded types difficult).
Bell metal	Cu + 20-25%Sn.
Brass	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 %)

	Cu	Sn	Pb	Al	P	Zn	Fe
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[3]	Ni	Mo	Cu	OES (mg/m^3)
<1	<1	<0.1	<0.1	<0.1	80	0.3

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DATA SHEET **E-36**

90CuAl

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

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 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	Mo	Cu	OES (mg/m^3)
3	1	<0.1	<0.1	<0.1	80	0.3

Beryllium has a very low OEL ($0.002mg/m^3$) so special precautions may be required when welding beryllium coppers.

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METRODE WELDING CONSUMABLES

DATA SHEET **E-37**

80CuNiAl

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:

Fe	Mn	Cr	Ni	Mo	Cu	OES (mg/m^3)
6	4	<0.1	3	<0.1	75	0.3

Nickel Base Alloys

DATA SHEET **E-45**

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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.

Microstructure

Solid solution strengthened high nickel austenite with some carbides and microsegregation typical of as-deposited 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.

Products available

Process	Product	Specification
MMA	**Nimrod C**	BS EN: E Ni2
	Nimax C	BS EN: E Ni2

General Data for all Alloy C 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 200–250°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°C.

Fume data

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Mo	Cu	F	OES (mg/m^3)
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 coating. Primarily used for surfacing and cladding; for joining applications the Nimrod C276KS (data sheet D-30) is preferred.

Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.

Specifications

BS EN 14700	E Ni2
DIN 8555	E23-UM-200-CKT
AWS A5.11	(ENiCrMo-5 has similar composition)

ASME IX Qualification

QW432 F-No 44

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Fe	V	Cu	Co
typ	0.04	0.4	0.6	0.01	0.01	15	56	15.5	3.5	5.5	0.1	0.05	0.05

All-weld mechanical properties

As welded			min *	typical	
Tensile strength		MPa	495	715	
0.2% Proof stress		MPa	275	510	
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 (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	260	310	310
kg/carton	12.0	12.9	13.5
pieces/carton	657	339	234

NIMAX C

High recovery alloy C electrode primarily used for surfacing

Product description

MMA electrode with special metal powder rutile- basic flux coating on high conductivity pure nickel core wire.

Recovery is about 150% with respect to core wire, 65% with respect to whole electrode.

Specifications

BS EN 14700	E Ni2
DIN 8555	E23-UM-200-CKT
AWS A5.11	(ENiCrMo-5 has similar composition)

ASME IX Qualification

QW432 F-No 44

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Fe	V	Cu	Co
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

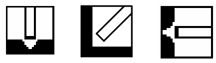
All-weld mechanical properties

As welded		min *	typical	
Tensile strength	MPa	495	680	
0.2% Proof stress	MPa	275	540	
Elongation on 4d	%	4	10-25	
Hardness	HV	--	240	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



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

DATA SHEET **E-50**

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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**, **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.

Products available

Process	Product	Specification
MMA	**Methard 350**	(BS EN EFe1)
FCW	**Hardcore 350**	BS EN TFe1

METHARD 350

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** E1-UM-400-GP **BS EN 14700** (E Fe1 nearest)
ASME IX Qualification	**QW432** F-No --
Composition (weld metal wt %)	see below
All-weld mechanical properties	Typical hardness as-welded assuming at least three layers on mild steel base plate: Vickers HV 380-410 Rockwell HRC 39-42 Brinell HB 360-390 Preheat and dilution will affect hardness in the first two layers but will have little effect in subsequent layers.

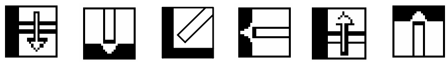
Composition (weld metal wt %):

	C	Mn	Si	Cr	Mo
typical	0.3	0.2	0.2	3	0.1

METHARD 350 (continued)

Operating parameters

DC +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	450	450	450
kg/carton	18.6	18.9	18.0
pieces/carton	471	234	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 100 – 150°C/1-2h to restore to as-packed condition. Maximum 150° C, 3 cycles, 10h total.
Storage: Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

Fume data

Fume composition, wt % typical:

Fe	Mn	Cr	F	OES (mg/m^3)
16	5	1	18	5

HARDCORE 350

Self-shielded flux cored wire for surfacing

Product description

A self-shielded flux cored wire for surfacing applications in the flat and HV positions. The lime-fluorspar flux fill eliminates the need for an external shielding gas.

Metal recovery about 90% with respect to wire.

Specifications

DIN 8555	MF1-GF-350-GP
BS EN 14700	T Fe1

ASME IX Qualification

QW432 F-No --

Composition (weld metal wt %)

	C	Mn	Si	Cr	Mo	Al
typ	0.25	2	0.1	1	0.2	1.7

All-weld mechanical properties

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

No shielding gas is required.
Current: DC+ve ranges as below:

ø mm	amp-volt range	stickout
1.2	150-250A, 20-26V	40-50mm
1.6	200-300A, 24-30V	40-50mm
2.8	300-500A, 27-35V	40-50mm

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^3)
18	8	<0.5	1	<1	8	5

Repair & Maintenance

650 HARDFACING

DATA SHEET E-51

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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.

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

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 electrodes that have been exposed: **Redry** 100 – 150°C/1-2h to restore to as-packed condition. Maximum 150° C, 3 cycles, 10h total. **Storage**: Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.
Fume data	Fume composition, wt % typical:

Fe	Mn	Cr	Mo	V	F	OES (mg/m^3)
20	6	2.5	0.1	0.5	18	2

METHARD 650

MMA hardfacing electrode producing a nominal 650HV hardness deposit

Product description

Rutile metal powder flux on a low carbon core wire.

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

Specifications

DIN 8555	E6-UM-60-GP
BS EN 14700	(E Fe2 nearest)

ASME IX Qualification

QW432 F-No --

Composition (weld metal wt %)

	C	Mn	Si	Cr	Mo	V
typical	0.7	0.6	0.4	8	0.6	0.5

All-weld mechanical properties

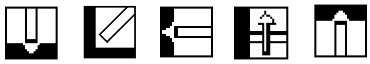
Typical hardness as-welded on mild steel base plate:

		1 layer	3 layers
Vickers	HV	600-700	700-760
Rockwell	HRC	55-60	60-63

Preheat and dilution will affect hardness in the first two layers but will have little effect in subsequent layers.

Operating parameters

DC +ve or AC (OCV: 45V 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	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	E6-UM-60-GP
BS EN 14700	(E Fe2 nearest)

ASME IX Qualification

QW432 F-No --

Composition (weld metal wt %)

	C	Mn	Si	Cr	Mo	V
typical	0.4	0.3	0.8	8	1	0.6

All-weld mechanical properties

Typical hardness as-welded on mild steel base plate:

		1 layer	3 layers	1 layer on high carbon steel
Vickers	HV	560-600	620-680	580-640
Rockwell	HRC	53-55	56-59	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 (OCV: 45V 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	320	380	380	450
kg/carton	12.0	13.8	13.2	15.0
pieces/carton	606	255	162	102

HARDCORE 650

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:

Vickers	HV	600-700
Rockwell	HRC	55-60
Brinell	HB	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 mm	amp-volt range	stickout
1.2	150-250A, 20-26V	40-50mm
1.6	200-300A, 24-30V	40-50mm

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^3)
18	7	<0.5	1.5	<0.5	12	5

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DATA SHEET E-53

METHARD 750TS

Product description

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 as-welded, 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.

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 %)

	C	Mn	Si	S	P	Cr	Mo	W	V
min	0.5	--	--	--	--	3.0	5.0	1.0	0.8
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

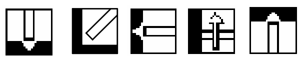
All-weld mechanical properties

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 (OCV: 60V 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	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°C.

Fume data

Fume composition, wt % typical:

Fe	Mn	Cr	Mo	V	F	OES (mg/m^3)
20	6	2	2	0.5	20	2.5

Repair & Maintenance

DATA SHEET **E-55**

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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 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	**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 350° C, 3 cycles, 10h total. **Storage**: Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.
Fume data	Fume composition, wt % typical:

Fe	Mn	Cr	Mo	V	F	OES (mg/m^3)
25	4	12	2	0.5	3	0.4

METHARD 850

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-60-G
BS EN 14700 E Fe14

ASME IX Qualification

QW432 F-No --

Composition (weld metal wt %)

	C	Mn	Si	Cr	Mo+Nb+V+W
typ	3	0.8	1	25	2

All-weld mechanical Properties

Typical hardness on mild steel:

		1 layer	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 (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	13.2	13.2	15.0
pieces/carton	213	153	105

METHARD 950

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

QW432 F-No --

Composition (weld metal wt %)

	C	Mn	Si	Cr	Mo+Nb+V+W
typ	4	1.2	1	34	3

All-weld mechanical properties

Typical hardness on mild steel:

		1 layer	2 layers	3 layers
Vickers	HV	475-575	675-750	700-850
Rockwell	HRC	48-54	56-62	60-66

Actual hardness is dependent upon base material composition, number of layers, cooling rate and welding conditions.

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 all FCW

Operating parameters	No shielding gas is required. **Current:** DC+ve ranges as below: ø mm / amp-volt range / stickout 1.6 / 200-300A, 24-30V / 40-50mm
Packaging data	Spools in cardboard carton: 13kg Where possible, preferred storage conditions are 60% RH max, 18°C min.
Fume data	Fume composition (wt %)

ø mm	amp-volt range	stickout
1.6	200-300A, 24-30V	40-50mm

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
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.

Metal recovery about 90% with respect to wire.

Specifications

DIN 8555	MF10-GW-60-G
BS EN 14700	T Fe15

ASME IX Qualification

QW432 F-No --

Composition (weld metal wt %)

	C	Mn	Si	Cr
Typical	4.8	2.7	1.7	22

All-weld mechanical properties

Typical all-weld metal hardness on mild steel:

55-59 HRC

Actual hardness dependent on base material, number of layers, cooling rate and welding conditions.
Maximum deposit thickness 8mm.

HARDCORE 950

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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METRODE WELDING CONSUMABLES

DATA SHEET **E-58**

METHARD 1050

Product description

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.

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 %)

	C	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

Fume composition, wt % typical:

Fe	Mn	Cr	Mo	V	F	OES (mg/m^3)
25	4	12	2	0.5	3	0.4

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METRODE
WELDING CONSUMABLES

DATA SHEET **E-60**

WORKHARD 13Mn

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 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 %)

	C	Mn	Si	S	P	Cr	Mo
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 ±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°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

Fume composition, wt % typical:

Fe	Mn	Cr	F	OES (mg/m^3)
19	23	0.1	10	2.2

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METRODE WELDING CONSUMABLES

DATA SHEET **E-65**

COBSTEL 6

Product description

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 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 %)

	C	Mn	Si	Cr	Ni	Mo	W	Fe	Co
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:

Temperature °C	Vickers HV	Rockwell 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°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

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Co	W	F	OES (mg/m^3)
1	3	<1	11	18.5	1	9	0.5

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METRODE WELDING CONSUMABLES

DATA SHEET **E-66**

COBSTEL 8

Product description

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.

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 %)

	C	Mn	Si	Cr	Ni	Mo	W	Fe	Co
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)

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°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

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Co	W	F	OES (mg/m^3)
1	4	1	10	19	1	9	0.5

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DATA SHEET **E-68**

MAR 250

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.

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 %)

	C	Mn	Si	S	P	Ni	Co	Mo	**Ti**	**Al**
min	--	--	--	--	--	17.0	7.0	4.0	0.2	--
max	0.03	1.0	0.5	0.02	0.03	20.0	9.0	5.5	0.6	0.2
typ	0.01	0.1	0.1	0.01	0.01	18	8	5	0.4	0.1

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	Mo	OES (mg/m^3)
30	1	<0.1	10	5	3	2

METRODE WELDING CONSUMABLES

Repair & Maintenance

DATA SHEET E-70

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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**.

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	Recommended ambient storage conditions: <60% RH, >18°C.
Typical operating parameters	see below
Fume data	Fume composition, wt % typical (TIG fume negligible):

Typical operating parameters:

	TIG
Shielding	Ar
Current	DC-
Diameter	2.4mm
Voltage	150A, 15V

Fume data:

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
53	7	< 0.1	< 0.1	0.1	1.2	5

ER70S-2

Mild steel TIG wire

Product description

Solid copper coated wire for TIG. This wire has extra deoxidation (Al, Ti & Zr) and is often referred to as 'triple deoxidised'. This is claimed to have advantages for rimming or semi-killed steels and rusty or contaminated plate. Owing to the high levels of deoxidants some precipitation may occur in multipass welds, particularly following PWHT. Also suitable for subsequent vitreous enamelling, where the low carbon and the Ti+Zr suppress blistering of the enamel during stoving.

Specifications

AWS A5.18	ER70S-2
BS EN 1668	(W2Ti)
BS 2901: Pt1	A15
DIN 8559	(WSG1)

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 1

Composition (wire wt %)

	C	Mn	Si	S	P	Cu	Al	Ti	Zr	Ni	Cr	Mo	V
min	--	0.90	0.40	--	--	--	0.05	0.05	0.02	--	--	--	--
max	0.07	1.40	0.70	0.025	0.025	0.4	0.15	0.15	0.12	0.15	0.15	0.15	0.03
typ	0.05	1.2	0.5	0.01	0.01	0.1	0.08	0.10	0.05	0.04	0.04	0.01	0.005

All-weld mechanical properties

Typical values as welded			min	typical
Tensile strength		MPa	480	620
0.2% Proof stress		MPa	400	550
Elongation on 4d		%	22	23
Impact energy	- 30°C	J	27	30*
Hardness cap/mid		HV	--	220/240

* Single values may be lower, particularly after PWHT.

Packaging data

ø mm	TIG
1.2	5kg tube
1.6	5kg tube
2.4	5kg tube
3.2	5kg tube

ER70S-3

Mild steel TIG wire

Product description

Solid copper coated wire for TIG. This is a higher carbon double deoxidised wire with Mn and Si which produces reliable impact properties.

Specifications

AWS A5.18	ER70S-3
BS EN 1668	(W2Si)
BS 2901: Pt1	(A17)
DIN 8559	(WSG1)

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 1

Composition (wire wt %)

	C	Mn	Si	S	P	Cu	Ni	Cr	Mo	V
min	0.06	0.90	0.45	--	--	--	--	--	--	--
max	0.15	1.40	0.70	0.025	0.025	0.4	0.15	0.15	0.15	0.03
typ	0.1	1.1	0.6	0.01	0.01	0.1	0.04	0.04	0.01	0.005

All-weld mechanical properties

Typical values as welded			min	typ
Tensile strength		MPa	480	540
0.2% Proof stress		MPa	400	460
Elongation on 4d		%	22	34
Impact energy	- 30°C	J	27	180
Hardness cap/mid		HV	--	170/200

Packaging data

ø mm	TIG
1.6	to order
2.4	to order

ER70S-6

Mild steel TIG wire

Product description

Solid copper coated wire for TIG. This is a good general purpose filler wire, double deoxidised with higher levels of Mn and Si, providing reliable impact properties.

Specifications

AWS A5.18	ER70S-6
BS EN 1668	(W3Si1)
BS 2901: Pt1	A18
DIN 8559	(WSG2)

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 1

Composition (wire wt %)

	C	Mn	Si	S	P	Cu	Ni	Cr	Mo	V
min	0.06	1.40	0.80	--	--	--	--	--	--	--
max	0.12	1.60	1.15	0.025	0.035	0.4	0.15	0.15	0.15	0.03
typ	0.08	1.5	0.85	0.015	0.01	0.15	0.04	0.04	0.01	0.005

All-weld mechanical properties

Typical values as welded			min	typ
Tensile strength		MPa	480	575
0.2% Proof stress		MPa	400	445
Elongation on 4d		%	22	34
Impact energy	- 30°C	J	27	180
Hardness cap/mid		HV	--	175/220

Packaging data

ø mm	TIG
1.6	5kg tube
2.4	5kg tube
3.2	5kg tube

METCORE DWA 50

All-positional CMn rutile flux cored wire

Product description

Flux cored wire with a rutile flux system for spray transfer at low currents and easy operation in all welding positions, including positional pipework. The wire is designed for standard mild and CMn steels. Suitable for single-sided welds on ceramic backing systems. Low moisture potential giving weld metal hydrogen content of typically < 5ml/100g.

Metal recovery 90% with respect to wire.

Specifications

AWS A5.20	E71T-1M
BS EN 758	T 422 PM1 H5
BS 7084	T521 GPH

ASME IX Qualification

QW432 F-No 6, **QW442** A-No 1

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	V
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 *	typical as-welded	typical 600°C/4h
Tensile strength		MPa	510-650	580	575
0.2% Proof stress		MPa	420	510	485
Elongation on 4d		%	22	29	32
Elongation on 5d		%	18	25	30
Reduction of area		%	--	70	--
Impact energy	0°C	J	--	150	140
	- 20°C	J	27	90	45
Hardness		HV	--	200	--

* As specified by AWS A5.20 E71T-1M as-welded. Since toughness may be reduced by PWHT, batch testing (to order) is advised to confirm specific requirements.

Operating parameters

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 80%.

Current: DC+ve ranges as below:

ø mm	amp-volt range	typical	stickout
1.2	130-300A, 16-32V	232A, 26V	15-25mm

Packaging data

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 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	Cr	Ni	Cu	F	OES (mg/m^3)
36	10	<0.1	<0.1	<0.5	2	5

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METRODE
WELDING CONSUMABLES

DATA SHEET **E-71**

ULTRAMILD

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.

Composition (weld metal wt %)

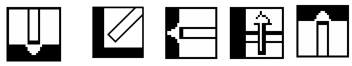
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Nb	V
min	--	--	--	--	--	--	--	--	--	--	--
max	0.03	0.6	0.4	0.015	0.020	0.10	0.30	0.10	0.10	0.05	0.05
typ	0.02	0.4	0.3	0.010	0.010	0.02	0.05	0.01	0.03	0.01	0.01

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)



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

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Pb	F	OES (mg/m^3)
15	3	<0.1	<0.1	<0.1	<0.1	17	5

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DATA SHEET **E-72**

NILSIL

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.

Composition (weld metal wt %)

	C	Mn	Si *	S	P
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

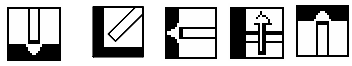
* Analysed silicon will include a small proportion present as non-metallic silicate inclusions. Alloyed silicon is therefore lower than analysed.

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)



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

Fume composition, wt % typical:

Fe	Mn	Cu	Pb	F	OES (mg/m^3)
25	5	<0.2	<0.1	<2	5

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DATA SHEET F-10

LA121 FLUX

Product description

Agglomerated fluoride-basic flux for submerged arc welding low alloy steels.

Basicity Index (according to Boniszewski) is ~3.1. Particle size is 0.2 – 2.0mm. Nominal composition of the flux is:

40%(CaO+MgO) + 25%(CaF_2) + 20%(Al_2O_3+MnO) + 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 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:

2.4mm	350A, 28V, 500mm/min travel speed
3.2mm	450A, 28V, 500mm/min travel speed
4.0mm	600A, 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 <5ml H_2/100g weld metal. This treatment should also be carried out for critical procedures if <5ml H_2/100g weld metal must be ensured.

Fume data

SAW fume is negligible.

Typical weld deposit analysis, wt%

Wire	C	Mn	Si	S	P	Cr	Mo
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

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METRODE WELDING CONSUMABLES

DATA SHEET F-15

LA491 FLUX

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:

40%(CaO+MgO) + 25%(CaF_2) + 20%(Al_2O_3+MnO) + 15%(SiO_2+TiO_2)

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°C for 1-2 hours.

Fume data

SAW fume is negligible.

Typical weld deposit analysis, wt%

Wire	C	Mn	Si	S	P	Cr	Ni	Mo	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® 100X	0.02	0.6	0.4	0.010	0.015	24.5	9.3	3.6	0.21	0.7Cu, 0.7W

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® 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.

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METRODE WELDING CONSUMABLES

DATA SHEET F-20

SSB FLUX

Product description

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°C but for duplex and superduplex this would normally be restricted to 100-150°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® 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°C for 1-3 hours.

Fume data

SAW fume is negligible.

Typical weld deposit analysis, wt%

Wire	C	Mn	Si	S	P	Cr	Ni	Mo	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® 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 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® 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.

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METRODE WELDING CONSUMABLES

DATA SHEET F-30

NiCu FLUX

Product description

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.

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 %)

	C	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.

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METRODE WELDING CONSUMABLES

DATA SHEET F-40

L2N FLUX

Product description

Neutral, calcium silicate, fused flux.

Basicity Index (according to Boniszewski) is ~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 ~0.3% and manganese loss of ~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 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.

Typical weld deposit analysis, wt%

Wire	C	Mn	Si	S	P	Cr	Ni	Mo	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

* 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