Section C : HIGH TEMPERATURE ALLOYS

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

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.

DataSheet	Alloy	Process	Product	AWS Classifications	EN / EN ISO Classifications
300H stainless steel consumables for elevated temperature service					
C-10	308H	MMA	Ultramet 308H	E308H-16	E 19 9 H R 3 2
			Ultramet B308H	E308H-15	E 19 9 H B 4 2
		TIG/MIG/SAW	308S96	ER308H	19 9 H
		FCW	Supercore 308H	E308HT0-1/4	TS308H-FB0
			Supercore 308HP	E308HT1-1/4	TS308H-FB1
C-11	347H	MMA	Ultramet 347H	E347-16	E 19 9 Nb R 3 2
			Ultramet B347H	E347-15	E 19 9 Nb B 4 2
		TIG/SAW	ER347H	ER347	19 9 Nb
		FCW	Supercore 347HP	E347HT1-1/4	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	(E 16.8.2-16)	BS 17.8.2.R
			Ultramet 316H	AWS E316H-16	E 19 12 2 R 3 2
			Ultramet B316H	AWS E316H-15	E 19 12 2 B 4 2
		TIG/MIG/SAW	316S96	ER316H	19 12 3 H
		SAW FLUX	SS300	BS EN SA AF2 AC	-
			SSB	BS EN SA AF2 DC	-

DataSheet	Alloy	Process	Product	AWS Classifications	EN / EN ISO Classifications
High temperature 309 alloys					
C-20	253MA	MMA	Supermet 253MA	-	-
C-21	309	MMA	Thermet 309CF	E309H-16	(E 22 12 R 3 2)
		TIG/MIG	309S94	ER309	22 12 H
High temperature austenitic stainless steel					
C-25	Super 304H	TIG	MT304H	-	-
310 stainless steels for high temperature service					
C-30	310	MMA	25.20 Super R	(E310-16)	E 25 20 R 3 2.
			Ultramet B310Mn	(E310-15)	E 25 20 B 4 2
		TIG/MIG/SAW	310S94	ER310	25 20
C-31	310H	MMA	Thermet 310H	E310H-15	E 25 20 H B 4 2
Consumables for alloys 330 and 800					
C-40	800	MMA	Thermet 800Nb	-	-
		TIG/MIG	21.33.MnNb	-	-
C-41	330	MMA	Thermet R1738H	(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	ENiCr-4	-

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

308H STAINLESS STEELS

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
	SS300	BS EN SA AF2
	SSB	BS EN SA AF2
FCW	**Supercore 308H**	AWS E308HT0-1/4
	Supercore 308HP	AWS E308HT1-1/4

ULTRAMET 308H

RUTILE MMA 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.

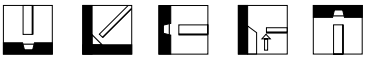
SPECIFICATIONS

AWS A5.4M	E308H-16
BS EN ISO 3581	E 19 9 H R 3 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)



CHEMICAL 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
Typical	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 strength (MPa)		350	445	234	187	156
Elongation (%)	4d	35	45	--	--	--
	5d	30	43	28	51	53
Reduction of area %		--	35	55	63	64
Impact ISO-V(J)	+20°C	--	80	--	--	--
Hardness (HV)		--	190-210	--	--	--

OPERATING PARAMETERS, DC +VE OR AC (OCV: 50V MIN)

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	60	75	100	130
max. A	90	120	155	210

PACKAGING DATA

Diameter (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/m³)
8	5	0.8	5	< 0.2	16	1

ULTRAMET B308H

SOBASIC PIPE WELDING MMA 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.

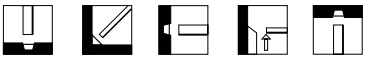
SPECIFICATIONS

AWS A5.4M	E308H-15
BS EN ISO 3581	E 19 9 H B 4 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)



CHEMICAL 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
Typical	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

Typical values as welded	Min.	Typical	High Temperature		
			650°C	732°C	816°C
Tensile strength (MPa)	560	650	298	225	154
0.2% proof strength (MPa)	350	460	223	168	111
Elongation (%) 4d	35	41	--	--	--
5d	30	38	24	48	47
Reduction of area (%)	--	48	60	63	54
Impact ISO-V(J) +20°C	--	100	--	--	--
Hardness (HV)	--	210	--	--	--

OPERATING PARAMETERS, DC +VE

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	60	75	100	130
max. A	90	120	155	210

PACKAGING DATA

Diameter (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/m³)
8	5	0.8	5	< 0.2	16	1

308S96

SOLID WIRE FOR 304H STAINLESS STEEL

PRODUCT DESCRIPTION

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

SPECIFICATIONS

AWS A5.9M	ER308H
BS EN ISO 14343-A	19 9 H
BS EN ISO 14343-B	SS308H

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL 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
Typical	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 strength (MPa)	450
Elongation (%) 4d	43
Impact ISO-V(J) +20°C	> 100
Hardness HV	195/215

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Voltage
TIG	Argon	100A, DC-	2.4	12V
MIG	Ar/2%O_2 or Ar/1-3%CO_2	260A, DC+	1.2	28V
SAW	SS300 or SSB flux	350A, DC+	2.4	30V

PACKAGING DATA

Diameter (mm)	0.8	1.0	1.2	1.6	2.0	2.4	3.2
TIG	--	--	To order	2.5kg tube	To order	2.5kg tube	2.5kg tube
MIG	To order	To order	15kg spool	--	--	--	--
SAW	--	--	--	25kg spool	--	25kg spool	To order

FUME DATA

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

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m³)
32	12	16	8	<0.5	<0.5	3.1

SUPERCORE 308H / 308HP

DOWNHAND AND ALL-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 A5.22M	E308HT0-1/4	E308HT1-1/4
BS EN ISO 17633-B	TS308H-FB0	TS308H-FB1

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL 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
Typical	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 strength (MPa)	--	420	213	177	140
Elongation (%) 4d	30	40	--	--	--
5d	30	36	30	46	40
Reduction of area (%)	--	50	58	69	74
Impact ISO-V(J) +20°C	--	100	--	--	--
Aged at 730°C/1000h	--	90	--	--	--

TYPICAL OPERATING PARAMETERS

Shielding gas: 80%Ar-20%CO_2 or 100% 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. Welding with 100%CO_2 requires approx 3V higher:

Diameter (mm)	amp-volt range	typical	stickout
1.2	120A-22V to 280A-34V	180A-29V	12 – 20mm
1.2P	120A-22V to 250A-32V	150A-25V	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)
13	8	1	7	2	<1	12	1

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

347H STAINLESS STEELS

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 i**n 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	**ER347H**	AWS ER347
FCW	**Supercore 347HP**	AWS E347HT1-1/4

ULTRAMET 347H

ALL-POSITIONAL RUTILE MMA ELECTRODE FOR 321H/347H STAINLESS STEELS

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.

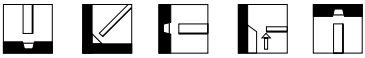
SPECIFICATIONS

AWS A5.4M	E347-16
BS EN ISO 3581	E 19 9 Nb R 3 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)



CHEMICAL 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
Typical	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 strength (MPa)		350	500	283	269	206
Elongation (%)	4d	30	40	--	--	--
	5d	25	37	19	20	7
Reduction of area (%)		--	52	47	38	23

TYPICAL OPERATING PARAMETERS, DC +VE OR AC (OCV: 50V MIN)

Diameter (mm)	**2.5**	**3.2**	**4.0**	**5.0**
min. A	60	75	100	130
max. A	90	120	155	210

PACKAGING DATA

Diameter (mm)	**2.5**	**3.2**	**4.0**	**5.0**
Length (mm)	300	350	350	450
kg/carton	12.0	13.5	12.9	16.5
Pieces/carton	693	417	243	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/m³)
8	5	0.8	5	<0.2	16	1

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

ULTRAMET B347H

BASIC PIPE-WELDING MMA ELECTRODE FOR 321H/347H STAINLESS STEELS

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 A5.4M	E347-15
BS EN ISO 3581	E 19 9 Nb B 4 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

PA/1G PB/2F PC/2G PF/3Gu PE/4G

CHEMICAL 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
Typical	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 strength (MPa)	350	500	263	265	223
Elongation (%) 4d	30	40	--	--	--
5d	25	37	18	14	5
Reduction of area (%)	--	52	43	30	19

TYPICAL OPERATING PARAMETERS, DC +VE

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	60	75	100	130
max. A	90	120	155	210

PACKAGING DATA

Diameter (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

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/m³)
8	5	0.8	5	<0.2	16	1

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

ER347H

SOLID WIRES FOR 321H/347H STAINLESS STEELS

PRODUCT DESCRIPTION

Solid wire for TIG and MIG welding.

SPECIFICATIONS

AWS A5.9M	ER347
BS EN ISO 14343-A	19 9 Nb
BS EN ISO 14343-B	SS347

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL 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
Typical	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 TIG	High Temperature 650°C	732°C	815°C
Tensile strength (MPa)	660	398	312	235
0.2% proof strength (MPa)	450	318	244	184
Elongation (%) 4d	42	23	22	22
5d	40	21	20	21
Reduction of area (%)	67	55	53	52
Impact ISO-V(J) +20°C	125	--	--	--
Hardness cap/mid (HV)	190/230	--	--	--

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon *	DC-	2.4	100A, 12V
MIG	Ar/2%O_2 or Ar/1-3%CO_2	DC+	1.0	190A, 26V

* Also required as a purge for root runs.

PACKAGING DATA

Diameter (mm)	1.0	2.4
TIG	--	2.5 kg tube
MIG	15kg spool	--

FUME DATA

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

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m³)
32	12	16	8	< 0.5	< 0.5	3.1

SUPERCORE 347HP

ALL-POSITIONAL RUTILE FLUX CORED WIRE FOR 321H/347H STAINLESS STEELS

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 A5.22M	E347HT1-1/4
BS EN ISO 17633-A	T 19 9 Nb P C/M 2
BS EN ISO 17633-B	TS347-FB1
APPROVALS	DNV

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL 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	0.3	1.0	0.3	9
Typical	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		High Temperature
	Min.	Typical	732°C
Tensile strength (MPa)	550	630	310
0.2% proof strength (MPa)	350	470	265
Elongation (%) 4d	30	43	24
5d	25	40	22
Reduction of area (%)	--	46	43
Impact ISO-V(J) +20°C	--	70	--

OPERATING PARAMETERS

Shielding gas: 80%Ar-20%CO2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85% argon.

Current: DC+ve ranges as below:

Diameter (mm)	amp-volt range	typical	stickout
1.2	120-280A, 22-34V	180A, 29V (downhand) 160A, 25V (positional)	12-20mm

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

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

16.8.2 FOR HIGH TEMPERATURE 3XXH STAINLESS STEELS

ALLOY TYPE

16.8.2 for high temperature 3XXH stainless steels.

MATERIALS TO BE WELDED

ASTM/UNS	*DIN*	*BS*
304H / S30409	1.4948	304S51
321H / S32109	1.4941	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	**ER16.8.2**	AWS ER16.8.2
FCW	**Supercore 16.8.2/P**	None relevant

SUPERMET 16.8.2

RUTILE MMA 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 A5.4M	E16-8-2-17
BS EN ISO 3581	[E 16 8 2 R]

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL 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
Typical	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 strength (MPa)		--	> 410	225	179	126
Elongation (%)	4d	35	42	--	--	--
	5d	25	42	28	47	43
Reduction of area (%)		--	45	52	59	55
Impact ISO and LE*-V(J(mm))	+20°C	--	> 70 (>1.3)	--	--	--
	- 50°C	--	> 50 (>0.9)	--	--	--

* LE = Charpy lateral expansion, mm (0.38mm = 15 mils)

TYPICAL OPERATING PARAMETERS, DC +VE OR AC (OCV: 55V MIN)

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	60	75	100	130
max. A	90	120	155	210

PACKAGING DATA

Diameter (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/m³)
8	5	0.7	5	0.1	0.2	16	1

E16.8.2-15

BASIC PIPE WELDING MMA 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 A5.4M	E16-8-2-15
BS EN ISO 3581	[E16 8 2 B]

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL 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
Typical	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 strength (MPa)	--	> 410	216	187	132
Elongation (%) 4d	35	40	--	--	--
5d	--	37	27	36	57
Reduction of area (%)	--	35	61	70	75
Impact ISO -V(J) -100°C	--	> 50	--	--	--

TYPICAL OPERATING PARAMETERS, DC +VE. UNSUITABLE FOR AC.

Diameter (mm)	2.5	3.2	4.0
min. A	60	75	100
max. A	90	120	155

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	12.0	13.5	13.5
Pieces/carton	686	397	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/m³)
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 A5.9M	ER16-8-2
BS EN ISO 14343-A	16 8 2
BS EN ISO 14343-B	S 16-8-2

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL 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
Typical	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

As-welded		Typical		High Temperature		
		TIG	SAW	650°C	732°C	816°C
Tensile strength (MPa)		620	630	315	241	173
0.2% proof strength (MPa)		450	360	221	178	147
Elongation (%)	4d	35	29	--	--	--
	5d	--	29	31	36	42
Reduction of area (%)		--	30	67	69	65
Impact ISO-V(J)	-196°C	--	30	--	--	--

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Voltage
TIG	Argon	100A	2.4	12V
SAW	SS300 or SSB flux	350A, DC+	2.4	30V

PACKAGING DATA

Diameter (mm)	1.6	2.4	3.2
TIG	2.5 kg tube	2.5 kg tube	2.5 kg tube
SAW	--	25kg spool	25kg spool

FUME DATA

MIG fume composition (wt %) (TIG and 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 FLUX CORED WIRES 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 is made 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 is designed 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 A5.22M	None applicable
BS EN ISO 17633-B	(TS16-8-2-FM1) nearest classification

ASME IX QUALIFICATION

QW432	F-No --
QW442	A-No 8

CHEMICAL 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
Typical	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 strength (MPa)		--	410	207	180	134
Elongation (%)	4d	35	42	--	--	--
	5d	25	42	30	44	39
Reduction of area (%)		--	50	66	68	79
Impact ISO-V(J) (mm)	+20°C	--	100 (1.8)	--	--	--
	-130°C	--	50 (0.8)	--	--	--
	-196°C	--	45 (0.7)	--	--	--

* LE = Charpy lateral expansion, mm (0.38mm = 15 mils)

OPERATING PARAMETERS

Shielding gas: 80%Ar-20%CO_2 or 100% 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. Welding with 100%CO_2 requires approx 3V higher:

Diameter (mm)	amp-volt range	typical	stickout
1.2	120A-22V to 280A-34V	180A-29V	12 – 20mm
1.2P	120A-22V to 280A-34V	150A-25V	12 – 20mm
1.6	200A-28V to 350A-34V	300A-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/m³)
17	11	1.5	4	4	<1	5	1.2

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

316H STAINLESS STEELS

ALLOY TYPE

For 316/316H materials used at elevated temperatures

MATERIALS TO BE WELDED

ASTM	*BS*	*UNS*
316/316H	316S51	S31609
CF10M	316S52	
	316S53	
	316C16	
	316C71	

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
	Ultramet B316H	AWS E316H-15
TIG/MIG/SAW	**316S96**	AWS ER316H
SAW flux	**SS300**	BS EN SA AF2 AC
	SSB	BS EN SA AF2 DC

17.8.2.RCF

RUTILE MMA ELECTRODE FOR 316H STAINLESS STEEL

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.

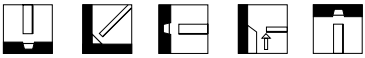
SPECIFICATIONS

AWS A5.4M (E16.8.2-16) Nearest classification

ASME IX QUALIFICATION

QW432 F-No 5
QW442 A-No 8

WELDING POSITIONS (ISO/ASME)



CHEMICAL 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
Typical	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 strength (MPa)	--	> 460	287	197	147
Elongation (%) 4d	--	> 30	--	--	--
5d	25	> 30	28	44	53
Reduction of area (%)	--	> 45	55	61	75
Impact energy -100°C	--	> 50	--	--	--
Hardness HV	--	200	--	--	--

TYPICAL OPERATING PARAMETERS, DC +VE OR AC (OCV: 70V MIN)

Diameter (mm)	2.5	3.2	4.0
min. A	60	75	100
max. A	90	120	155

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	12.6	14.4	14.7
Pieces/carton	684	411	267

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/m³)
8	5	0.7	5	0.1	< 0.2	16	1

ULTRAMET 316H

RUTILE 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 A5.4M	E316H-16
BS EN ISO 3581	E 19 12 2 R 3 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL 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
Typical	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 strength (MPa)	350	450	264	204	152
Elongation (%) 4d	30	35	--	--	--
5d	25	33	32	43	54
Reduction of area (%)	--	50	58	53	60
Impact energy +20°C	--	70	--	--	--
Hardness HV	--	210	--	--	--

TYPICAL OPERATING PARAMETERS, DC +VE. OR AC (OCV: 50V MIN)

Diameter (mm)	2.5	3.2	4.0
min. A	60	75	100
max. A	90	120	155

PACKAGING DATA

Diameter (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

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/m³)
8	5	0.7	5	0.1	< 0.2	16	1

ULTRAMET B316H

BASIC PIPE WELDING MMA ELECTRODE FOR 316H STAINLESS STEEL

PRODUCT DESCRIPTION

MMA electrode – designed and manufactured to give high moisture resistance using a basic flux system and high purity 304L core wire. Ultramet B316H 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. 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). Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E316H-15
BS EN ISO 3581	E 19 12 2 B 4 2

ASME IX QUALIFICATION

QW432	F-No --
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL 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
Typical	0.05	1.0	0.3	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	620	360	240	170
0.2% proof strength (MPa)		350	450	265	200	140
Elongation (%)	4d	30	35	29	44	49
	5d	25	33	26	43	48
Reduction of area (%)		--	50	58	58	45
Impact energy	+20°C	--	100	--	--	--
Hardness	HV	--	210	--	--	--

TYPICAL OPERATING PARAMETERS, DC +VE ONLY

Diameter (mm)	2.5	3.2
min. A	60	75
max. A	90	120

PACKAGING DATA

Diameter (mm)	2.5	3.2
Length (mm)	300	350
kg/carton	12.0	13.5
Pieces/carton	681	396

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/m³)
8	5	0.7	5	0.1	< 0.2	16	1

316S96

SOLID WIRE FOR TIG, MIG AND SAW OF 316H STAINLESS STEEL

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 A5.9M	ER316H
BS EN ISO 14343-A	19 12 3 H
BS EN ISO 14343-B	SS316H

ASME IX QUALIFICATION

QW432	F-No --
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL 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
Typical	0.05	1.8	0.5	0.01	0.02	19	13	2.2	0.15	4

ALL-WELD MECHANICAL PROPERTIES

As welded	Typical
Tensile strength (MPa)	650
0.2% proof strength (MPa)	460
Elongation (%) 4d	35

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Voltage
TIG	Argon	100A, DC-	2.4	12V
SAW	SS300 or SSB flux	350A, DC+	2.4	30V
MIG	Ar + 2%O_2/CO_2	220A, DC+	1.2	26V

PACKAGING DATA

Diameter (mm)	1.2	1.6	2.4
MIG	15 kg reel	-	-
TIG	-	2.5 kg tube	2.5 kg tube
SAW	-	-	25kg spool

FUME DATA

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

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m³)
30	12	15	11	1.5	< 0.5	3.3

SS300 and SSB FLUXES

SUB-ARC FLUX

PRODUCT DESCRIPTION

SS300 and SSB are agglomerated basic fluxes producing weld deposits with minimal Si pick-up and low Mn and Cr losses. SS300 has a BI of ~1.6 and SSB has a BI of ~2.2.

SPECIFICATIONS

	SS300 flux	SSB flux
BS EN ISO 14174	SA AF2 AC	SA AF2 DC

ASME IX QUALIFICATION

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

CHEMICAL COMPOSITION (TYPICAL)

	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 (with SS300/SSB flux)	0.04	1.6	0.6	0.01	0.02	18	13	2.2	0.15

ALL-WELD MECHANICAL PROPERTIES with 316S96

Typical PWHT 690-720°C/1-2h	typical
Tensile strength (MPa)	650
0.2% proof strength (MPa)	460
Elongation (%) 4d	35

OPERATING PARAMETERS

Current: DC+ve ranges as below:

Diameter (mm)	amp-volt range	typical	stickout
2.4	250-450A, 28-32V	350A, 30V	20-25mm

PACKAGING DATA

Metrode SS300 Flux is supplied in sealed moisture resistant 25kg metal drums and SSB Flux in 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

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

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 oxidation resistance.

MATERIALS TO BE WELDED

	wrought
ASTM - ASME	S30815
BS EN 10095	1.4818 X6CrNiSiNCe 19-10
	1.4828 X15CrNiSi 20-12
	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 MMA 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.

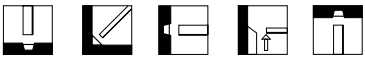
SPECIFICATIONS

There are no applicable national standards

ASME IX QUALIFICATION

QW432	F-No --
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)



CHEMICAL 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
Typical	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 strength (MPa)		550
Elongation (%)	4d	40
	5d	38
Reduction of area (%)		50

TYPICAL OPERATING PARAMETERS, DC +VE OR AC (OCV: 50V MIN)

Diameter (mm)	2.5	3.2	4.0
min. A	50	75	100
max. A	75	120	155

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	11.4	13.5	14.4
Pieces/carton	594	366	261

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/m³)
9	6	1	7	<0.2	17	0.7

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

CONTROLLED FERRITE 309 CONSUMABLES

ALLOY TYPE

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

MATERIALS TO BE WELDED

	wrought	*cast*
ASTM/UNS	S30900 (309)	A351 Grades CH8, CH10, CH20.
	S30908 (309S)	
	S30909 (309H)	.
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.

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Thermet 309CF**	AWS E309H-16
TIG/MIG	**309S94**	AWS ER309

THERMET 309CF

RUTILE MMA 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.

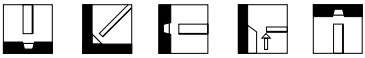
SPECIFICATIONS

AWS A5.4M	E309H-16	
BS EN ISO 3581	(E 22 12 R 3 2)	Cr 20.0-23.0%

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)



CHEMICAL 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
Typical	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 strength (MPa)	350	460
Elongation (%) 4d	30	34
5d	25	31
Reduction of area (%)	--	30
Hardness (HV)	--	210

OPERATING PARAMETERS, DC +VE OR AC (OCV: 70V MIN)

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	60	75	100	130
max. A	90	120	155	210

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	350
kg/carton	13.5	15.0	15.0	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/m³)
9	6	7	1	<0.2	17	0.7

309S94

SOLID WIRE WITH CONTROLLED CARBON AND FERRITE

PRODUCT DESCRIPTION

Solid wire for TIG and MIG welding

SPECIFICATIONS

AWS A5.9M	ER309
BS EN ISO 14343-A	22 12 H
BS EN ISO 14343-B	SS309
UNS	S30980

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL 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
Typical	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 strength (MPa)		415
Elongation (%)	4d	42
	5d	39
Reduction of area (%)		56
Hardness cap/mid (HV)		175/215

TYPICAL OPERATING PARAMETERS

	Shielding	Current	Diameter (mm)	Parameters
TIG	Argon*	DC-	2.4	120A, 14V
MIG	Ar+2%O_2 **	DC+	1.2	260A, 26V

* Also required as a purge for root runs.

** Proprietary Ar, and Ar-He mixtures with <3%CO2 are also suitable.

PACKAGING DATA

Diameter (mm)	1.0	1.2	1.6	2.4
TIG	--	--	2.5 kg tube	2.5 kg tube
MIG	15kg spool	15kg spool	--	--

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

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

SUPER 304H STAINLESS STEELS

ALLOY TYPE

High carbon 304 alloy with copper, niobium and nitrogen additions to provide improved creep performance.

MATERIALS TO BE WELDED

EN 10216-5

1.4907 / X10CrNiCuNb 18 9 3.

ASTM A213

UNS S30432.

Grade 18Cr-9Ni-3Cu-Cb-N in ASME Code Case 2328-1 2003.
VdTÜV material data sheet 550 (2003).

Proprietary alloys include:

Super 304H (Sumitomo)
DMV 304HCu (Salzgitter Mannesmann Stainless Tubes)

APPLICATIONS

This alloy was designed for use as superheater and reheater boiler tube in the latest generation of Ultra Super Critical (USC) coal fired power plant.

The alloy is designed to cope with the latest power plant designs were steam temperatures can be in the region of 600°C; although ASME Code Case 2328-1 specifies allowable stresses up to 815°C.

MICROSTRUCTURE

In the as-welded condition the multi-pass weld metal microstructure consists of austenite matrix with precipitates and carbo-nitrides. During service creep strength is enhanced by the precipitation of copper rich precipitates, Nb carbo-nitride and NbCrN.

WELDING GUIDELINES

For most applications no preheat or PWHT is required. Maximum interpass temperature 150°C and heat input 1.5kJ/mm although these controls may need to be tightened depending on tube dimensions.

RELATED ALLOY GROUPS

This wire can also be used to weld TP347HFG high temperature stainless steel (Nippon Steel & Sumitomo Metal).

PRODUCTS AVAILABLE

Process	Product	Specification
TIG/MIG	**MT304H**	-

HIGH TEMPERATURE ALLOYS

MT304H

SOLID WIRE FOR TIG WELDING OF SUPER STEEL 304H

PRODUCT DESCRIPTION

Straight lengths and spooled wire for manual and automatic TIG welding.

SPECIFICATIONS

There are no national specifications for this wire.

ASME IX QUALIFICATION

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

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Nb	N
min.	0.07	2.5	--	--	--	17.0	14.5	0.7	2.5	0.5	0.15
max.	0.13	4.0	0.40	0.015	0.015	20.0	18.0	1.2	3.5	1.0	0.25
Typical	0.1	3.2	0.2	0.005	0.005	18	16	0.9	2.8	0.7	0.2

ALL-WELD MECHANICAL PROPERTIES

As-welded		TIG	TIG High Temperature		
		Room Temperature	550°C	650°C	750°C
Tensile strength (MPa)		720	528	466	371
0.2% proof strength (MPa)		570	388	371	336
Elongation (%)	4d	30	25	18	7
	5d	28	--	--	--
Reduction of area (%)		47	43	30	16
Impact ISO -V(J)	+20°C	90	--	--	--
	-50°C	80	--	--	--
Hardness cap/mid (HV)		200/240	--	--	--

TYPICAL OPERATING PARAMETERS

	Shielding	Current	Diameter (mm)	Parameters
TIG	Argon	DC-	2.4	120A, 12V

PACKAGING DATA

Diameter (mm)	0.9	1.0	2.0	2.4
TIG	--	--	2.5 kg tube	2.5 kg tube
Spooled	0.7/5/12.5kg spools (To order)	0.7/5/12.5kg spools (To order)	--	--

FUME DATA

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

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m³)
24	18	16	13	1	3	2.8

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

310 STAINLESS STEELS

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/SAW	**310S94**	AWS ER310

25.20 SUPER R

RUTILE MMA ELECTRODE FOR 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 A5.4M	(E310-16)	AWS specification has Mn range of 1.0-2.5%.
BS EN ISO 3581	E 25 20 R 3 2	

ASME IX QUALIFICATION

QW432 F-No 5

(This is nearest because the electrode does not strictly conform to AWS)

QW442 A-No 9

WELDING POSITIONS (ISO/ASME)

CHEMICAL 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
Typical	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 strength (MPa)		350	400
Elongation (%)	4d	30	37
	5d	25	35
Reduction of area %		--	50
Impact ISO-V(J)	+ 20°C	--	80
	- 196°C	--	45
Hardness (HV)		--	200

OPERATING PARAMETERS, DC +VE OR AC (OCV: 70V MIN)

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	60	75	100	130
max. A	90	120	155	210

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	12.0	14.7	14.7	20.1
Pieces/carton	675	435	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/m³)
9	10	2	7.5	<0.2	18	0.6

ULTRAMET B310Mn

ALL-POSITIONAL BASIC MMA ELECTRODE FOR 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 A5.4M	(E310-15)	AWS specification has Mn range of 1.0-2.5%.
BS EN ISO 3581	E 25 20 B 4 2	

ASME IX QUALIFICATION

QW432 F-No 5

(This is nearest because the electrode does not strictly conform to AWS)

QW442 A-No 9

WELDING POSITIONS (ISO/ASME)

CHEMICAL 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
Typical	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 strength (MPa)		350	435
Elongation (%)	4d	30	36
	5d	25	34
Reduction of area %		--	50
Impact ISO-V(J)	+20°C	--	105
	-196°C	--	75
Hardness (HV)		--	220

OPERATING PARAMETERS, DC +VE

Diameter (mm)	2.5	3.2	4.0
min. A	60	75	100
max. A	90	120	155

PACKAGING DATA

Diameter (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/m³)
9	10	2	7.5	<0.2	18	0.6

310S94

SOLID WIRES FOR TIG, MIG AND SAW OF 310 STAINLESS STEEL

PRODUCT DESCRIPTION

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

SPECIFICATIONS

AWS A5.9M	ER310
BS EN ISO 14343-A	25 20
BS EN ISO 14343-B	SS310
UNS	S31080

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 9

CHEMICAL 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
Typical	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 strength (MPa)	355
Elongation (%) 4d	27
Impact ISO-V(J) -196°C	70
Hardness cap/mid (HV)	185

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon*	DC-	2.4	100A, 12V
MIG	Ar/2%O_2 **	DC+	1.2	260A, 29V
SAW* **	SS300 or SSB flux	DC+	2.4	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

Diameter (mm)	0.8	1.2	1.6	2.4	3.2
TIG	--	--	2.5kg tube	2.5kg tube	2.5kg tube
MIG	15kg spool	15kg spool	--	--	--
SAW	--	--	25kg spool	25kg spool	--

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

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

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/UNS

A351, A608 Grade HK40

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 A5.4M	E310H-15
BS EN ISO 3581	E 25 20 H B 4 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No --

WELDING POSITIONS (ISO/ASME)

CHEMICAL 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	0.70	0.025	0.030	28.0	22.0	0.50	0.50
Typical	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 strength (MPa)		350	550
Elongation (%)	4d	10	20
	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

Diameter (mm)	2.5	3.2	4.0
min. A	60	75	100
max. A	90	120	155

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	11.4	13.5	14.4
Pieces/carton	546	384	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 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/m³)
12	6	2	8.5	<0.2	<0.2	16	0.6

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

CONSUMABLES TO MATCH CAST & WROUGHT ALLOY 800

ALLOY TYPE

Austenitic heat resisting consumables to match alloy 800.

MATERIALS TO BE WELDED

ASTM

A351 CT15C

BS

NA15, NA15H

BS EN & DIN

1.4850, 1.4859, 1.4876

UNS

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).
E2032Nb (Engemasa).

wrought:

Incoloy 800, 800H, 800HT (Special Metals).
Sanicro 31 (Sandvik).
RA330 (Rolled Alloys).
Nicrofer 3220 (VDM).

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:
$P \leq 9$ 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 <150°C preferred. Usually welds are not heat treated however in elevated temperature service the HAZ of welds in alloys 800/800H/800HT with progressively increasing levels of Ti+Al may be susceptible to stress-relaxation cracking. For pressure boundary welds designed for >538°C, ASME VIII UNF-56 requires PWHT >885°C/1h + 1h/25mm (eg. 900°C/3h), or solution annealing.
API 560 currently does not require PWHT but some specifiers may require it for particular operating conditions.

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 D-11), 625 (data sheet D-20) and 617 (data sheet D-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

THERMET 800Nb

BASIC 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 --

WELDING POSITIONS (ISO/ASME)

CHEMICAL 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
Typical	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 strength (MPa)	210	410
Elongation (%) 4d	--	> 33
5d	25	> 32
Reduction of area (%)	--	46
Impact ISO-V(J) +20°C	--	> 55
Hardness (HV)	--	170-220

* Minimum tensile properties based on wrought alloy 800H.

OPERATING PARAMETERS, DC +VE ONLY

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	60	75	100	130
max. A	90	120	155	210

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	320	320	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/m³)
4	6	6	2	< 0.2	< 0.2	18	0.8

21.33.MnNb

SOLID TIG/MIG WIRES 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/MIG welding of 800 type alloys.

SPECIFICATIONS

There are no national specifications for this electrode.

ASME IX QUALIFICATION

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

CHEMICAL COMPOSITION (WELD METAL 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
Typical	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

As welded	Min. *	Typical, TIG
Tensile strength (MPa)	520	640
0.2% proof strength (MPa)	210	420
Elongation (%) 4d	--	27
5d	--	25
Impact ISO-V(J) +20°C	--	40

* Minimum tensile properties based on wrought alloy 800H.

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon*	DC-	2.4	100A, 12V
MIG	Ar/2%O_2 **	DC+	1.2	220A, 29V

* Also required as a purge for root runs.

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

PACKAGING DATA

Diameter (mm)	1.2	1.6	2.0	2.4	3.2
TIG	--	To order	To order	2.5kg tube	2.5kg tube
MIG	12.5kg spool	--	--	--	--

FUME DATA

Fume composition (wt %) typical

Fe	Mn	Cr[3]	Ni	Cu	OES (mg/m³)
40	15	18	20	< 1	2.5

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

HIGH CARBON 18/37 HEAT RESISTING AUSTENITIC ALLOY

ALLOY TYPE

0.45%C-17%Cr-38%Ni high carbon austenitic heat resisting steel often called 18/37 or 37/18 alloy.

MATERIALS TO BE WELDED

ASTM / ASME	*BS*	*DIN*
A297 HT & HU	3100 Gr 330C11	1.4865
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 with 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**	(E330H-16) BS 15.35.H.R

THERMET R17.38H

BASIC 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 A5.4M (E330H-16) Thermet R17.38H has higher C, Cr & Ni than AWS specification.

ASME IX QUALIFICATION

QW432 F-No 5

(This is nearest because the electrode does not strictly conform to AWS)

QW442 A-No --

WELDING POSITIONS (ISO/ASME)

CHEMICAL 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
Typical	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 strength (MPa)		--	520
Elongation (%)	4d	10	16
	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.

TYPICAL OPERATING PARAMETERS, DC +VE OR AC (OCV: 70V MIN)

Diameter (mm)	2.5	3.2	4.0
min. A	60	75	100
max. A	90	120	155

PACKAGING DATA

Diameter (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/m3)
4	7	4	5	<0.1	<0.2	16	1

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

HP10CB AUSTENITIC CAST ALLOYS

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 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 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 F-No --
QW442 A-No --

WELDING POSITIONS (ISO/ASME)

CHEMICAL 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
Typical	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 strength (MPa)		300	460
Elongation (%)	4d	20	34
	5d	20	32
Reduction of area (%)		--	42

TYPICAL OPERATING PARAMETERS, DC +VE

Diameter (mm)	2.5	3.2	4.0
min. A	60	75	100
max. A	90	120	155

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	320	350
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/m³)
4	6	2	7	<0.1	<0.2	18	0.7

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

HP40Nb CAST ALLOYS

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)
E2535Nb & E2535Nb-MA (Engemasa)

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**	--
TIG/MIG	**25.35.4CNb**	--

THERMET HP40Nb

BASIC MMA 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.

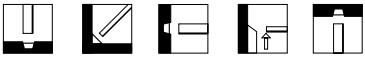
SPECIFICATIONS

No relevant national specifications.

ASME IX QUALIFICATION

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

WELDING POSITIONS (ISO/ASME)



CHEMICAL 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
Typical	0.43	1.7	0.9	0.010	0.010	25	35	0.1	1.1	0.08

* Does not always comply to obsolete classification BS2926: 25.3.5H.Nb.B which requires Si<1.0%. Please contact technical department for supply according to BSEN 2926: 25.3.5H.Nb.B.

ALL-WELD MECHANICAL PROPERTIES

As welded	**Min. ***	**Typical**
Tensile strength (MPa)	600 (450)	740
0.2% proof strength (MPa)	-- (250)	560
Elongation (%) 4d	-- (5)	15
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

Diameter (mm)	**2.5**	**3.2**	**4.0**	**5.0**
min. A	60	75	100	130
max. A	90	120	155	210

PACKAGING DATA

Diameter (mm)	**2.5**	**3.2**	**4.0**	**5.0**
Length (mm)	300	320	320	450
kg/carton	11.1	12.3	12.0	12.3
Pieces/carton	519	348	228	153

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life.
Direct use from tin is satisfactory for longer than a working shift of 8h.
Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.
For electrodes that have been exposed:
Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.
Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended.
Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

FUME DATA

Fume composition (wt %) typical

Fe	**Mn**	**Ni**	**Cr**	**Cu**	**Mo**	**V**	**F**	**OES (mg/m³)**
4	6	7	7	< 0.5	< 0.1	< 0.1	18	0.7

25.35.4CNb

SOLID TIG AND MIG WIRES FOR MATCHING HP40NB ALLOYS

PRODUCT DESCRIPTION

Solid wire for TIG, auto-TIG and MIG welding.

SPECIFICATIONS

There are no national specifications for this wire.

ASME IX QUALIFICATION

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

CHEMICAL COMPOSITION (WELD METAL 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	--	--
Typical	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

As welded		Min. *	Typical, TIG
Tensile strength (MPa)		450	760
0.2% proof strength (MPa)		250	515
Elongation (%)	4d	5	12
	5d	--	13
Reduction of area (%)		--	11
Hardness cap/mid (HV)		--	211/263

* Minimum tensile properties based on wrought alloy 800H.

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

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon	DC-	2.4	100A, 12V

PACKAGING DATA

Diameter (mm)	1.2	1.6	2.0	2.4	3.2
TIG	--	2.5kg tube	2.5kg tube	2.5kg tube	2.5kg tube
Spooled wire normally used for automatic TIG	12.5kg reel	--	--	--	--

FUME DATA

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

Fe	Mn	Cr^3	Mo	Cu	OES (mg/m^3)
35	13	26	< 0.5	< 0.5	2

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

HIGH CARBON 35Cr-45Ni-1Nb ALLOYS

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)
E3545Nb-MA (Engemasa)

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

BASIC 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.

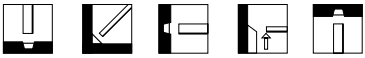
SPECIFICATIONS

No relevant national specifications.

ASME IX QUALIFICATION

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

WELDING POSITIONS (ISO/ASME)



CHEMICAL 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
Typical	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 strength (MPa)	245	550
Elongation (%) 4d	3	6
Hardness (HV)	-	270

* Minimum values are for static castings.

OPERATING PARAMETERS, DC +VE

Diameter (mm)	2.5	3.2	4.0
min. A	70	85	110
max. A	95	120	160

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	300	350
kg/carton	9.9	10.5	12.6
Pieces/carton	450	252	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 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/m³)
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 welding.

SPECIFICATIONS

There are no national specifications for this wire.

ASME IX QUALIFICATION

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

CHEMICAL COMPOSITION (WELD METAL 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	1.6	0.015	0.02	38	48	1.3	0.50	0.15	0.15	bal
Typical	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

As welded	Typical, TIG
Tensile strength (MPa)	690
0.2% proof strength (MPa)	550
Elongation (%) 4d	3
Hardness (HV)	280

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon	DC-	2.4	120A, 12V

PACKAGING DATA

Diameter (mm)	1.2	2.4	3.2
TIG	12.5kg spool	2.5kg tube	2.5kg tube

FUME DATA

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

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m³)
15	5	28	28	<0.5	<0.5	1.8

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

HIGH CARBON 25Cr-35Ni-WCo ALLOYS

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

BASIC MMA ELECTRODE FOR MATCHING HIGH CARBON AUSTENITIC CAST 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 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 national specifications for this electrode.

ASME IX QUALIFICATION

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

WELDING POSITIONS (ISO/ASME)

CHEMICAL 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
Typical	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 strength (MPa)	240	610
Elongation (%) 4d	3	8.5
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.

TYPICAL OPERATING PARAMETERS, DC +VE

Diameter (mm)	2.5	3.2	4.0
min. A	70	85	110
max. A	95	120	160

PACKAGING DATA

Diameter (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/m³)
3	6	8	7	<0.2	2	22	0.7

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

ALLOY 22H HEAT RESISTANT AUSTENITIC STAINLESS STEELS

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

BASIC ALL-POSITIONAL MMA ELECTRODE

PRODUCT DESCRIPTION

Basic all-positional 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 --

WELDING POSITIONS (ISO/ASME)

CHEMICAL 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
Typical	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 strength (MPa)		--	590
Elongation (%)	4d	--	7
	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.

TYPICAL OPERATING PARAMETERS, DC +VE

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	70	85	110	140
max. A	95	120	160	200

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	260	310	310	310
kg/carton	10.5	12.0	13.5	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/m³)
3	6	9	7	<0.2	22	0.7

METRODE PRODUCTS LTD
HANWORTH LANE, CHERTSEY
SURREY, KT16 9LL, UK
Tel: +44(0)1932 566721 / Fax: +44(0)1932 565168
Email: info@metrode.com
Website: www.metrode.com

SPECIAL ELECTRODE FOR IN-657

ALLOY TYPE

50Cr-50Ni alloy for high temperature corrosion resistance.

MATERIALS TO BE WELDED

Inco IN-657, IN-671
ASTM A560 Grade 50Cr-50Ni-Cb
DIN 2.4678, 2.4680, 2.4813
Paralloy N50W (Doncasters Paralloy)
Duraloy 50/50Cb

APPLICATIONS

Nimrod 657 (formerly 50.50.Nb) was developed in conjunction with Inco to match their proprietary cast alloy IN-657 produced by licenced foundries world-wide. It is also suitable to weld the Ti-bearing wrought version IN-671.

Alloy 657 with its high chromium content has exceptional resistance to hot corrosion (800-950°C) by fuel ash containing vanadium pentoxide and alkali metal sulphates arising from the combustion of low grade heavy fuel oils.
IN-657 castings are used in a wide range of components in oil-fired furnaces and boilers such as tube sheets, tube hangers, supports and spacers in ships, power stations, refineries, and petrochemical plants.

MICROSTRUCTURE

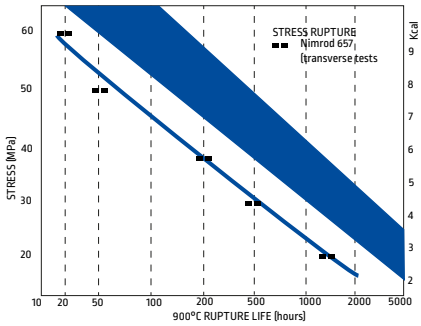
Very careful control of chromium and niobium is maintained to minimise the risk of weld metal cracking. The microstructure of IN-657 castings and Nimrod 657 weld metal consists of two phases: a chromium-rich alpha phase (bcc) and a nickel-rich gamma phase (fcc). The precise structure obtained is complicated by thermal history and composition, but has an important effect on the control of weld metal cracking.
At lower chromium and niobium contents, the primary dendrites which form during solidification are gamma phase and this tends to promote sensitivity to solidification cracking. Higher chromium and niobium contents result in a primary alpha dendritic phase which is less ductile and hence more prone to cold cracking during cooling.
An undesirable but infrequent eutectic phase may also occur. The composition of both weld metal and castings is therefore carefully balanced to minimise detrimental microstructural components and so reduce the risk of cracking. Carbon and nitrogen also reduce ductility and are kept as low as practicable.

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

NIMROD 657

BASIC MMA ELECTRODE FOR ALLOY 657/671

PRODUCT 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 A5.11M ENiCr-4

ASME IX QUALIFICATION

QW432 F-No 43

WELDING POSITIONS (ISO/ASME)

CHEMICAL 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
Typical	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 strength (MPa)	--	570-725	330-400
Elongation (%) 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.

TYPICAL OPERATING PARAMETERS, DC +VE OR AC(OCV:70V)

Diameter (mm)	2.5	3.2	4.0
min. A	70	85	110
max. A	95	120	160

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	300	350
kg/carton	10.5	11.4	12.0
Pieces/carton	450	261	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/m³)
1	2	2.5	8	0.1	0.1	23	0.6