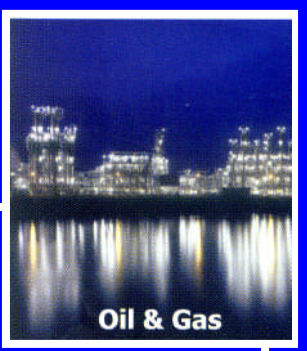
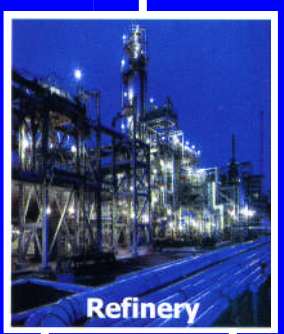
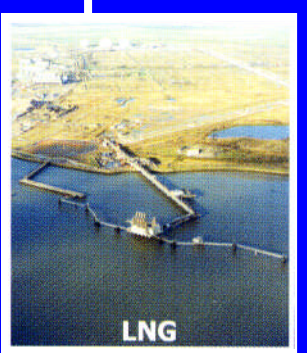
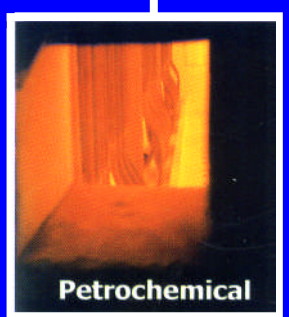
METRODE
WELDING CONSUMABLES

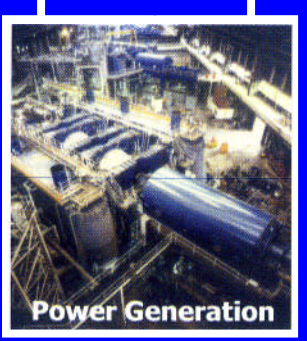
Welding Consumables for the ENERGY Market











The Driving Forces Behind ;

High Alloy Welding Develoment

The 3 E's

Energy	**Increasing world demand for ;** **Oil / Gas / Coal,** **Nuclear power,** **Renewable sources.**
Environment	***Reduced CO emissions*** ***Reduced pollution*** ***Improved waste management***
Efficiency	***Higher temperatures*** ***Higher pressures*** ***Greater yields*** ***&*** ***Life -Cycle Costing***

Stainless Steel SMAW Electrodes

Flux Coating Characteristics

Acid Rutile

AWS : EXXX-17

- silicious, fluid slow-freeze slag,
- spray-arc metal transfer,
- maximum operability & weld appearance,
- best ; downhand welding,
- DC^+ or AC power,

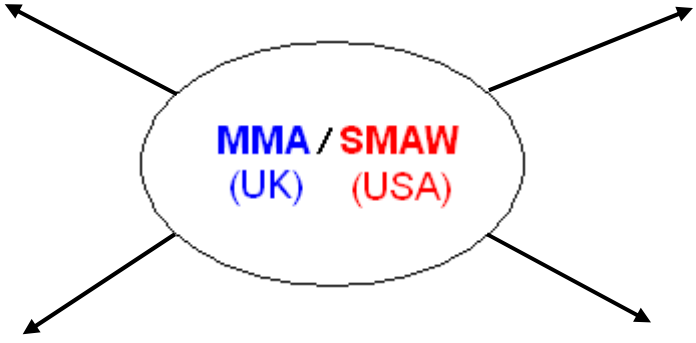
eg. ***Supermet***

Rutile

AWS : EXXX-16

- lower slag fluidity,
- good all-round operability,
- better scope for positional weld pool control,
- best ; positional welding,
- better weld properties,
- DC^+ or AC power.

eg. ***Ultramet***



Basic

AWS : EXXX-15

- viscous, fast-freeze slag,
- fully positional weld pool control,
- maximum weld 'cleanliness',
- highest integrity weld deposits,
- high resistance to moisture regain & weld porosity.
- DC^+ power.

eg. ***Ultramet B***

Rutile

AWS : EXXX-16

- special faster-freeze rutile slag,
- positive, penetrating arc,
- fully positional pipework operability (ASME 5G/6G),
- suitable for open root pass welding, without backpurge.
- DC^+ or AC power.

eg. ***Ultramet P***

Metrode's Gas Shielded Flux Cored Wires

Standard 1.2 & 1.6mm, and 1.2mm **'P'** grade pipework positional wires.
Rutile flux filled ; designed for use with Argon + 20 – 25% CO_2

Supercore	*Cormet*
308L & 308LP	1
308LCF	1V
308H & 308HP	2 & 2L
347 & 347HP	5
316L & 316LP	9
316LCF	M91
316NF	23
16.8.2 & 16.8.2P	
317LP	
2205 & 2205P	
Z100XP	
2507 & 2507P	
2507Cu & 2507CuP	
309L & 309LP	
309Mo	
20.9.3 & 20.9.3P	
410NiMo	
F91 & F92	

Welding Consumables for the ***ENERGY*** Market

Oil / Gas Exploration & Production

Typical applications ;

Sub-sea wellhead manifolds
Xmas tree valve systems
Seawater pipework
Pump bodies, rotors, impellors, shafts
Seperator vessels
Sub-sea pump motor casings
Platform firewall / blast walls
Umbilical pipelines
Flowlines
Pipeline bundles
Process pipework

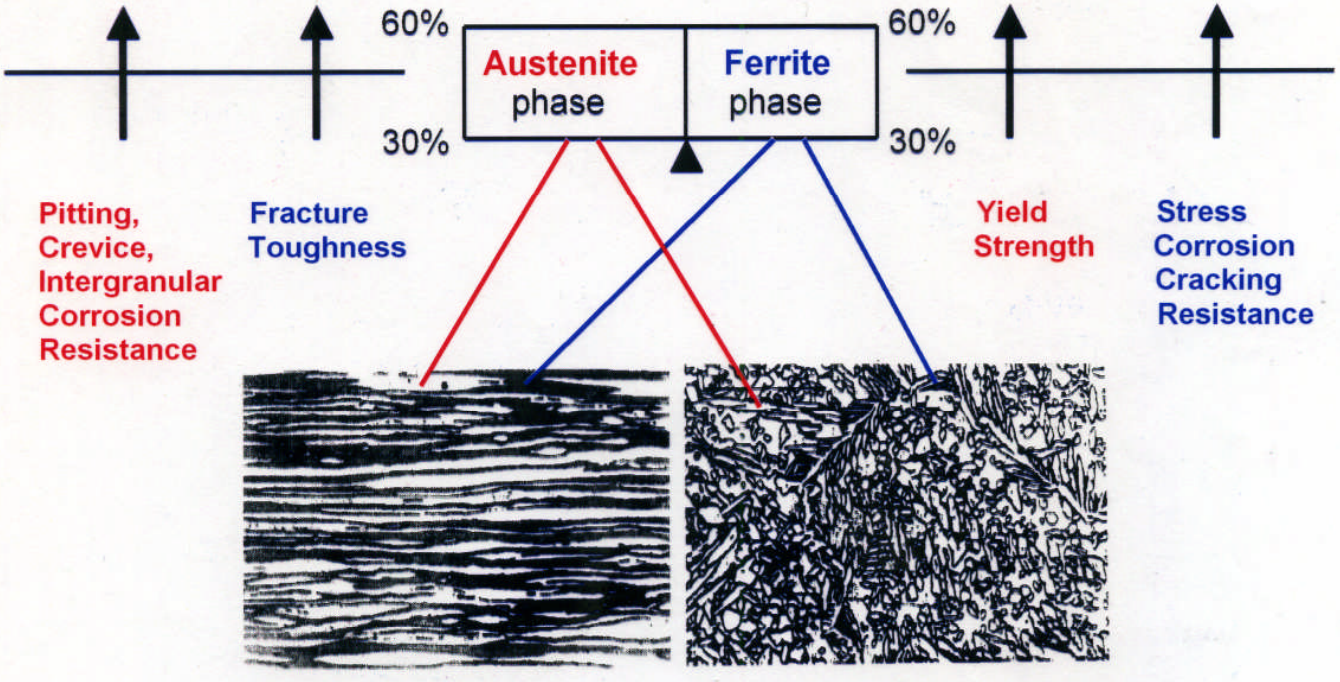
- **Welding duplex & superduplex stainless steels**
- **Testing duplex stainless steel welds**

Duplex & Superduplex Stainless Steels

Key Characteristics

- High corrosion resistance ;
  - pitting and crevice attack,
  - chloride induced Stress Corrosion Cracking
  - sulphide .. ..
  - hydrochloric, phosphoric, sulphuric acids
- High mechanical strength (~ x 2 PS cf. 300 Series) and potential weight saving
- Abrasion resistance ;
  - surface wear
  - erosion corrosion & corrosion fatigue
- Fatigue resistance
- Low thermal expansion

Duplex & Superduplex Stainless Steel for Balanced Performance



Typical Wrought Duplex Alloy Grades v_s 316L S/S

	UNS	Cr	Ni	Mo	Cu	W	N	PRE_N*	CPT* (^{0}C)	min.YS (MPa)
316L Austenitic	S31603	17	12	2.5	-	-	-	23	15	170
Utility Duplex	S32304 S32101	23 21	4 1.4	0.1 0.1	- -	- -	0.1 0.2	25 25	18 20	400 450
Standard Duplex	S31803 S32205	22 23	5 5	2.8 3.2	- -	- -	0.14 0.18	34 35	30 33	450 450
Super Duplex	S32750 S32760 S32550 S39274	25 25 26 25	7 7 7 7	3.8 3.5 3.5 3	- 0.7 1.8 0.3	- 0.7 - 2	0.24 0.23 0.25 0.26	41 40 41 42	70	550

* PRE_N = Pitting Resistance Equivalent : %Cr + 3.3 x%Mo + 16 x %N
(PRE_w, including role of Tungsten = %Cr + 3.3 x (%Mo + 0.5%W) + 16 x %N)

* Critical Pitting Temperature ; according to *ASTM – G48A, Method A* pitting test

Duplex Stainless Steels

Product Forms

Plate, sheet & strip

Extruded tube & pipe

Longitudinally welded thick wall pipe

Forging

Flanges

Welded fittings ; Tees & elbows

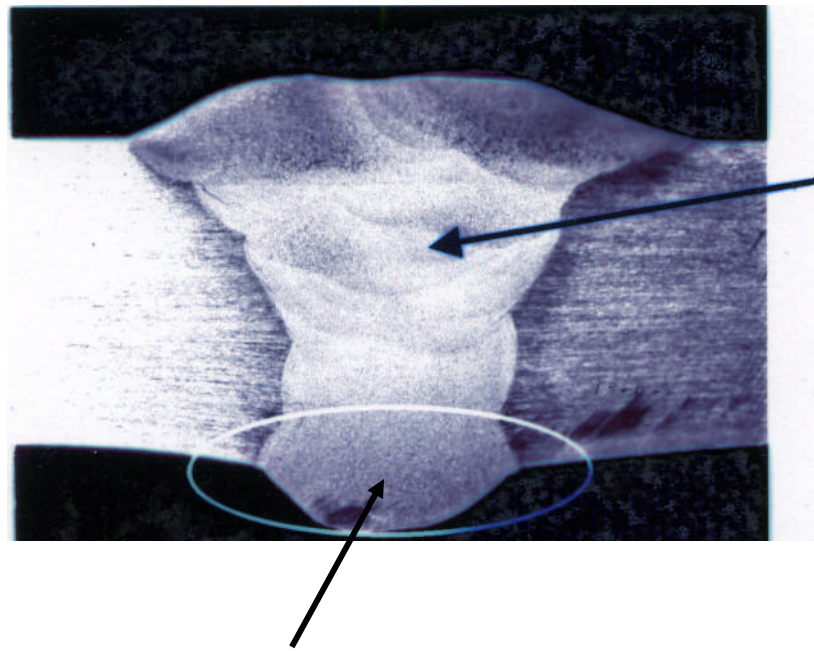
Castings (pumps)

Wires & bar

Hot Isostatically Pressed (HIP) components

Finish supplied in the Solution Annealed +WQ condition

Ultimate Duplex Butt Weld Objectives



Body of weld :

Matching
strength
&
toughness

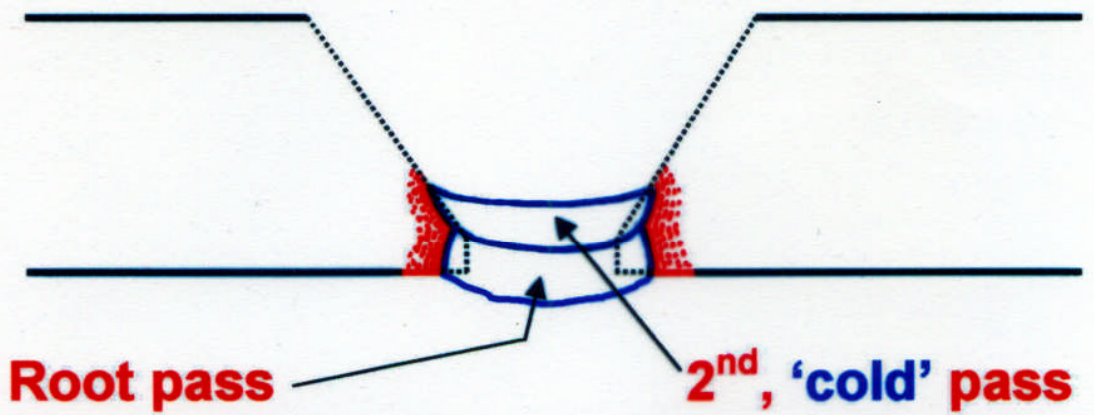
Root Weld Metal & HAZ :

- balanced Austenite / Ferrite phase levels,
- restricted hardness,
- freedom from secondary phase precipitations,
- freedom from surface oxidation,
- resistance to pitting corrosion attack

} **360^0 !!**

“Failure of the root = Failure of the system !!”

Critical region of a Pipe Butt Weld



Establishes ; quality of root underbead & HAZ microstructure

Determines ; degree 'reheat damage' at root & HAZ surfaces

2 key weld beads controlling root corrosion resistance !!

" Welder training material " ;

Duplex & Superduplex

Stainless Steel Welding

----------II----------

Procedural Guidelines
for
Welding Operatives

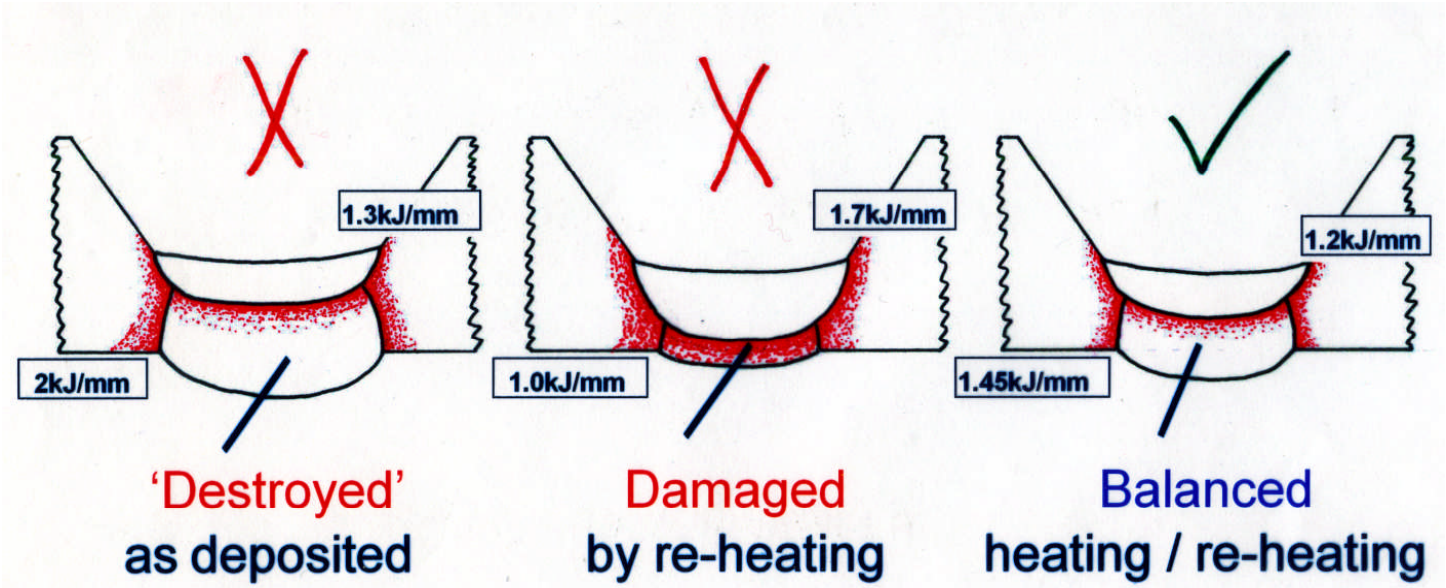
"Recommendations designed to ensure
routine production of welded joints
capable of meeting clients' specified requirements"

Manual GTAW Deposition of Root Passes

Key Procedural Aspects

- Consistent joint fit-up and alignment,
- Efficient gas back-purge system & procedure,
- Disciplined arc energy / heat input control,
- Maximum interpass temperature control,
- Weld run-out-length ; limitation & consistency,
- Balanced root & 2nd 'cold pass weld bead sizes.

" *Getting it wrong*" & "*Getting it right* "



Filler Wires for GTAW of Duplex Stainless Steels

'Over-matching' composition wires for a balanced weld microstructure

	Utility Duplex	Standard Duplex	Super Duplex
Product	ER329N		Zeron 100X
AWS Class'n	ER2209		ER2594
BS EN Class'n	22 9 3 NL		W 25 9 4 N L
Sizes Available ; - 1m lengths - Minispools	1.2, 1.6, 2.0, 2.4, 3.2 mm 0.8, 1.0, 1.2 mm		1.6, 2.4. 3.2 mm 0.8, 1.0, 1.2 mm

Practical considerations :

- No 1 process for manual deposition of pipework weld root passes.
- **ER329N** displaced by **Zeron 100X** for root passes, with Standard Duplex s/s welding, to secure meeting pitting corrosion test requirements.
- Pure Argon gas shielding (torch & purge) can be replaced with Argon + 2.5%Nitrogen to secure pitting test requirements at 40^{0}C.
- 3.2 mm wire very popular for high productivity manual joint filling stage.
- 0.8 & 1.0 mm wire (0.7kg) recommended for Orbital GTAW.
- 1.2 mm wire (15kg) poular for mechanised Hot Wire GTAW.
- 1.0 & 1.2 mm wires (15kg) popular for Auto GMAW.

SMAW Electrodes for Duplex Stainless Steels

Standard & Utility Duplex	Superduplex
Supermet 2205 Rutile General purpose ; Downhand	***Zeron 100XKS*** * Basic All-positional, eg. fixed pipework Maximum weld toughness
Ultramet 2205 * Rutile All-positional ; Structural*	***Ultramet 2507*** * Rutile All-positional ; Structural*
2205XKS * Basic All-positional, eg.fixed pipework Maximum weld toughness	***2507XKS*** * Basic All-positional, eg. fixed pipework Maximum weld toughness

Supermet 2506Cu Copper-bearing rutile coated / downhand electrode for similarly alloyed Duplex & Superduplex castings

* *AWS & BS EN* conforming electrodes.

Practical considerations :

- Primarily used for joint filling applications.
- Similar composition and corrosion resistance to that of GTAW weld metal.
- Some root pass welding and repair applications on site, eg. pipelines ; 2.5mm used where GTAW welding + back-purging not readily applicable.

GMAW, FCAW & SAW Consumables for Duplex S/S

<table>
<tr><th></th><th>Standard & Utility Duplex</th><th>Superduplex</th></tr>
<tr><td>GMAW
Solid wire
1.0 & 1.2mm</td><td>ER329N *</td><td>Zeron 100X *</td></tr>
<tr><td rowspan="3">FCAW
Rutile flux
1.2mm</td><td>Supercore 2205 *
Downhand & HV welding

Supercore 2205P *
All-positional ; fixed pipe</td><td>Supercore Z100XP
All-positional ; fixed pipe

Supercore 2507
Downhand & HV welding

Supercore 2507P
All-positional ; fixed pipe</td></tr>
<tr><td colspan="2">Supercore 2507Cu & 2507P
Downhand & HV welding of Copper-bearing castings</td></tr>
<tr><td rowspan="2">SAW</td><td>ER329N + SSB *</td><td>Zeron 100X + SSB/LA491*</td></tr>
<tr><td colspan="2">1.6 & 2.4mm wires + basic / agglomerated fluxes</td></tr>
</table>

* AWS & BS EN conforming consumables

Practical considerations :

- Pulsed GMAW recommended ; Ar + 30 – 40%He + 2CO_2 gas shielding.
- FCAW : Ar + 20 to 25%CO_2 gas shield recommended
  100%CO_2 ; Suitable for downhand grade wires (Need +3V)
- SAW : Generally 2.4mm wire most popular. 1.6mm wire + tightened parameters may be preferred when welding Superduplex

25Cr Superduplex Pipe Butt : 22Cr Filler Metal

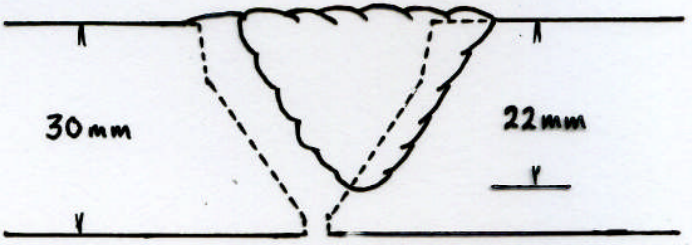
10" Ø x 30mm wt SAF 2507 pipe

1. Original weld :

Zeron 100X GTAW root (5), Ar + 2%N_2 6G
Supercore 2205P FCAW fill (35), 1.2mm, Ar + 20%CO_2 (2.5%O_2)
(Typically ; 140 - 160A, 23 - 24V)

Note ;	*0.2PS*	*UTS*	*El*	*CVN*
Pipe	562 MPa	843 MPa	39%	Spec : 45J (35) @ -46° C
Supercore 2205P	630 ..	800 ..	30..	AWM : 64J (62) @ -50° C

2. *22mm deep WM / HAZ partial excavation*



3. Repair Weld

Supercore 2205P FCAW fill (21), 1.2mm, Ar + 20%CO_2 (2.5%O_2)
(Typically ; 150 - 170A, 22 - 23V)

Hardness	*Toughness*	*Ferrite*	*Pitting Test*
HV10	CVN -50° C	Weld Metal	G48A, 35° C
Repair fill	Weld mid-T		(7mm thick specimen)
WM : 278	83, 70, 78 J (77)	Fill Cap : 37%	1 pass
HAZ : 315		Root : 44%	1 fail
PM : 285			

25Cr Superduplex Pipe Butt : 22Cr Filler Metal

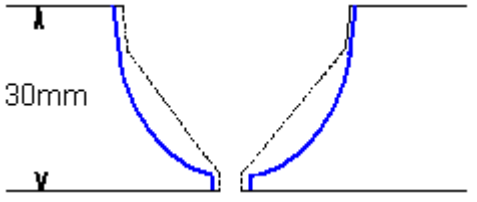
10" Ø x 30mm wt SAF 2507 pipe

1. Original weld :

Zeron 100X	GTAW	root (4),	$Ar + 2\%N_2$	6G
2205XKS	SMAW	fill, (32),	3.2mm	

Note ;	*0.2PS*	*UTS*	*El*	*CVN*
Pipe	562 MPa	843 MPa	39%	Spec : 45J (35) @ -46^0 C
2205XKS	699 ..	857 ..	30..	Weld : 82J (78) @ -50^0 C

2. *Full penetration excavation*



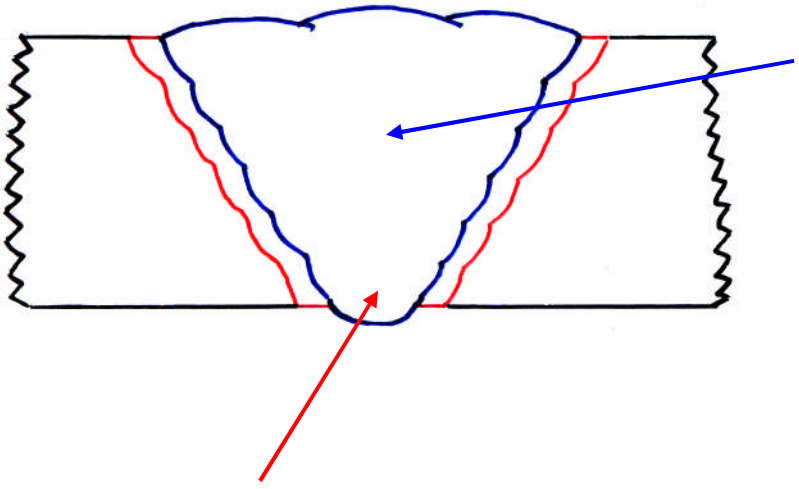
3. Repair Weld

Zeron 100X	GTAW	root (6),	$Ar + 2\%N_2$	6G
2205XKS	SMAW	fill, (36),	3.2mm	

Hardness	*Toughness*	*Ferrite*	*Pitting Test*
HV10 Root	CVN -50^0 C weld mid-T	Weld Metal	G48A, 35^0 C (7mm thick specimen)
WM : 312	46, 44, 39J (43)	Root : 43%	1 pass
HAZ : 315		Cap : 44%	1 fail
PM : 285			

Tests on Duplex S/S Butt Weld Joints

Fundamental requirements for all Weld Procedure Qualifications, eg. as per NORSOK Standard M-601



Body of weld :

Tensile strength :

WM to exceed PM minimum strength level.

Charpy Impact toughness :

WM & HAZ to meet client's specified min'm requirements ; eg. 27J @ -46^{0} C

Weld root zone :

Macro X-section :

WM & HAZ check for complete fusion and freedom from cracks.

Micro-examination, eg. x400

- to check WM, HAZ and PM Ferrite / Austenite phase balance, eg. to meet 30% min / 70% max limits.
- to examine for brittle, weak corrosion resistance secondary phase precipitations, eg. Sigma phase.

Vickers Hardness, eg. HV10

WM & HAZ to meet specified acceptance levels, for example ;
310max (28HRc) for standard duplex, or 330max (32HRc) for superduplex, for 'sour service' applications.

Corrosion Test :

24h rapid accelerated corrosion test, to establish that pipe weld internal surface can meet specified pitting corrosion resistance requirements.

GTAW Process Qualities

- Stable, easily controllable arc ; wide current range
- Pulsed arc version available for extra control
- Flexible independence of heat source & filler metal
- Operates in all welding positions
- Suitable for widest range of alloys arc welded
- Ideal for restricted accessibility welding
- Highest manual weld radiographic quality
- Reliably highly quality weld deposits

SMAW ; Positional Joint Filling ?

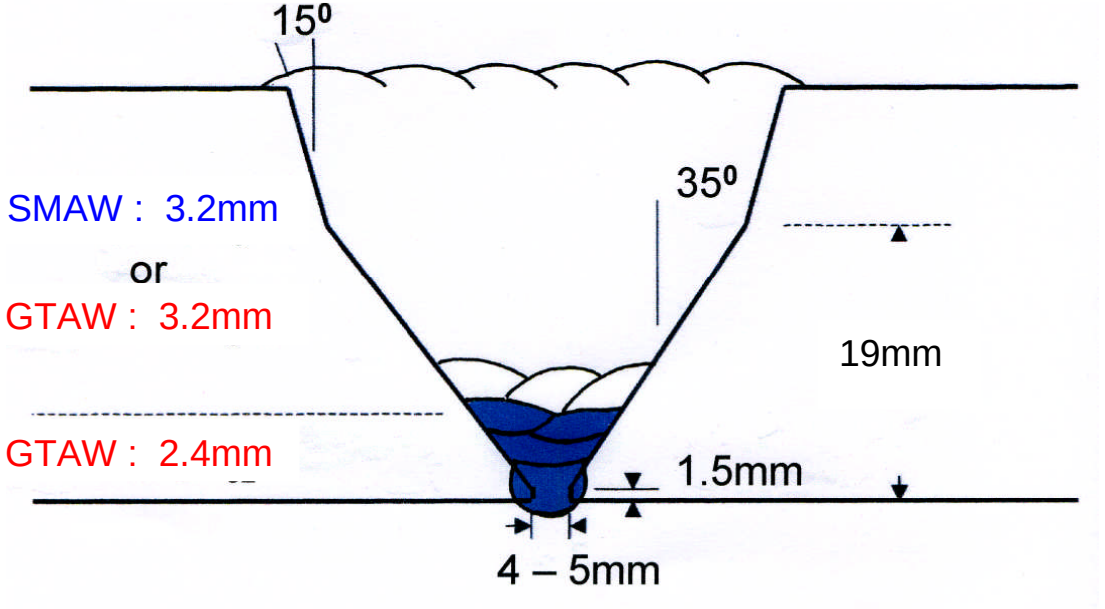
- Relatively easy process control
- Amps range per rod ; assists *Fill + Fusion control*
- Specific positional pipework electrodes available
- Fullest formulative flexibility ; optimised performance

- Basic flux coating ; challenging ‘welder friendliness’
- Electrode overheating ; reduced effective rod burn-off
- Limited run-out-length ; frequent stop / starts
- Frequent deslagging + dressing ; significant downtime

25Cr Superduplex S/S Pipe Butt Weld

High pressure seawater injection pipework

14” dia. x 25mm wt, ASME IX : 5G



SMAW v_s GTAW Welding Productivity

Joint filling ; 14” diam. x 25mm wt superduplex butt joint

SMAW @ 90A (Total 26 beads)		GTAW @ 220A (Total 30 beads)
8	Weld runs / circ.	4
208	Total stop/starts	120
1.40 kg/hr	Deposition Rate	*1.0 kg/hr*
194 min	Arc Time	*268 min*
123 min	Downtime	*77 min*
317 min	Production Time	*345 min*
39 %	% Downtime	*22%*

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

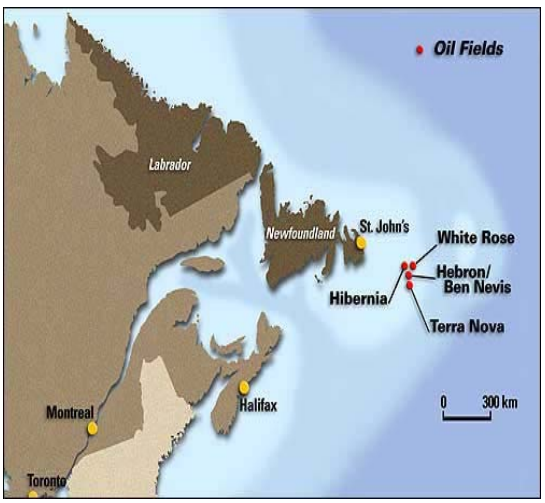
Metrode Superduplex Consumables for Terra Nova Topside Construction

Metrode's Zeron 100X Solid Wires and 2507XKS electrodes were selected for welding the 25Cr superduplex pipework in the topside modules for the Terra Nova FPSO (floating, production, storage and offloading) vessel.

The pipe spools were fabricated by PCL Industrial Constructors Inc at the Bull Arm Fabrication and Construction Site in Trinity Bay, Newfoundland. The FPSO entered service in 2001 in the Terra Nova Oilfield located some 350km east south east of St John's Newfoundland.

The Korean-fabricated vessel is double-hulled and built with 3,000 tons of extra steel to protect it against icebergs. At 192m long and 45.5m wide it is one of the largest vessels ever built for an offshore oil project.

Terra Nova is estimated to hold more than 400 million barrels of recoverable oil and has potential for another 100 million barrels in an undrilled adjacent block.



Pictures courtesy of Terra Nova

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Web Site Path at www.metrode.com for further information
B-61.pdf for Zeron 100X - key in zeron in the search box
B-62.pdf for 2507XKS - key in 2507 in the search box

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Thomas Broadbent & Sons Limited
Centrifuges using Zeron 100XKS electrodes

The remarkable properties of Zeron 100, especially its high corrosion resistance and excellent mechanical properties, have confirmed the material as the standard for critical offshore applications. It is interesting, therefore, to note that these characteristics have been identified for use on-shore in the power generating industry. As part of the environmental challenge to reduce sulphur dioxide emissions, two coal fired power stations in the UK have been fitted with flue gas desulphurisation units (FGD's).

The process involves the use of limestone to react with the acidic components in the flue gas, producing a byproduct of calcium sulphate which has to be extracted and dried by the use of centrifuges.

Thomas Broadbent & Sons Ltd of Huddersfield, are the UK's leading designer and manufacturer of centrifuges for the process and chemical industries, designed and fabricated centrifuges for this purpose.

Zeron 100 was chosen because of the necessity of achieving long term reliable service despite the aggressive, corrosive conditions existing in the plant and Metrode **Zeron 100XKS** electrodes have been used throughout.

These electrodes combine the necessary corrosion resistance and mechanical properties with an excellent operability, producing weld beads of good profile and finish.

BROADBENT

08/02

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Key zeron in the search box in the product information section

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Supercore 2205P Positional Flux Cored Wire - 'Pumped up in South Africa'

Metrode's Supercore 2205P ø1.2mm was selected by Fabritech of Pelindaba in South Africa to fabricate a custom designed pump in Duplex Stainless Steel for a contract in Turkey for Sulzer Pumps.

The whole pump was fabricated using Supercore 2205P which yielded high integrity welds and excellent visual appearance.

Sulzer's welding Engineer, Harold Krause commented: -

"I have never before experienced a stainless steel flux cored wire that has performed beyond expectations in operator appeal in all welding positions. At least 25% of the welding was done in the overhead position with the wire performing up to the task."

75%Ar-25%CO_2 was used as the shielding gas in this application.

The pump during fabrication in the workshops of Fabritech

Finished Assembly

Pictured Left,
Chris Eibl - Rockweld
Mark Golding—Metrode

Rockweld, PO Box 988, Kempton Park, Johannesburg, S.Africa
Contact Chris Eibl on email chris.eibl@afrox.boc.com

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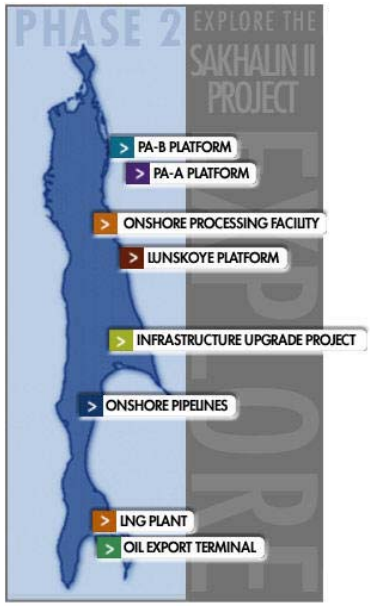
Web Site Path at www.metrode.com
Data Sheet B-60.pdf on this product can be found by keying in supercore 2205p in the product information search box.

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Metrode Consumables for the Sakhalin II Project



Russia is already the world's largest exporter of natural gas. Now, the development of vast reserves offshore of Sakhalin Island, on the doorstep of Asia's growing economies, will repeat that success in the Russian Far East.

Sakhalin II is an integrated oil and gas development that will require investment of almost US$10 billion. It involves installation of an offshore platform on the Piltun feature of the Piltun Astoskhskoye field and the installation of a single large platform at the Lunskoye gas field.

These platforms, as well as the Molikpaq, will be linked to the shore by offshore pipelines. The oil and gas will then be transported via 800 km onshore pipelines to Prigorodnoye, in the south of Sakhalin Island, the site of a new LNG plant and oil and LNG export terminals.

Metrode have, so far, supplied over £200,000 of consumables to a major fabricator in South Korea who are manufacturing the main offshore platform. Products include: -

Low Alloy	**E10018D2** & **MnMo**
Duplex	**2205XKS, Supercore 2205P** and **ER329N**
Nickel Base	**62-50**
	HAS C22

Phase2, Lunskoye Platform

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Data on all these welding consumables can be found in the product info section on our website

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Zeron 100X Superduplex MIG Wire Used for Kvaerner Eureka

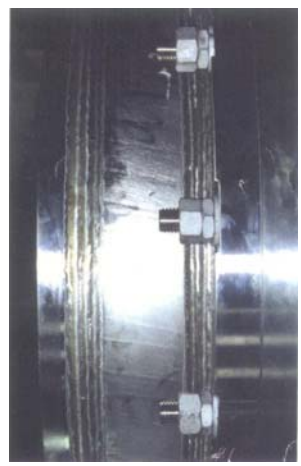
Hayward Tyler Engineered Products of Luton, Bedfordshire, England, used **Metrode Zeron 100X** to fabricate submersible motor covers to be supplied to Kvaerner Eureka as drivers for their seawater lift pumps on the Sleipner West Project.

Material selection called for Superduplex Zeron 100 to be used throughout.

Welding was carried out using Metrode 1.0mm **Zeron 100X MIG** wire and Helishield 101 gas.

Satisfactory impact properties, G48 corrosion testing, hardness and weld metal ferrite contents were achieved.

All NDT examination was acceptable with no single repair being required.



General view of motor casing

MIG weld with Metrode Zeron 100X

08/02

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Surrey
KT16 9LL
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Key in zeron in the search box in the product information section

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Heatric
Printed Circuit Heat Exchangers

Heatric Limited design and manufacture the market leading Printed Circuit Heat Exchanger (PCHE's)

First introduced in 1985, Heatric's compact Printed Circuit Heat Exchangers (PCHE's) are a proven technology for demanding heat exchange duties.

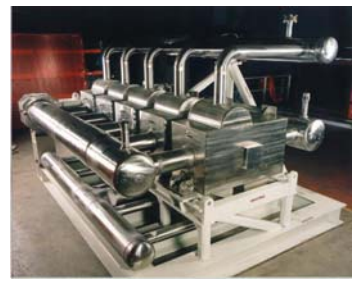
Their unique combination of compactness and versatility results in an unmatched capacity to undertake physically, chemically and thermodynamically demanding duties in limited space and in locations which may not be feasible for shell and tube type exchangers.

PCHE's support a high level of heat exchange complexity including capabilities such as multi-fluid/ multi-phase/ high-effectiveness exchange. A unique fabrication coupled with a range of corrosion resistant construction materials extends PCH application beyond conventional plate and plate-fin exchangers throughout the hydrocarbon and chemical processing industries.

Major PCHE Advantages

- Four to six times smaller than conventional heat exchangers.
- Pressure capability in excess of 500 bar (7000psi)
- Extreme temperatures from cryogenic up to 800˚ C (1500F)
- High efficiency heat exchange
- Multi-fluid integration.

Heatric Limited
46 Holton Road
Holton Heath
Poole
Dorset BH16 6LT
UK



Metrode supply a range of welding consumables to Heatric for the production of PCHE's including: -

Duplex stainless steel TIG and MIG wires.

Superduplex stainless steel TIG

Stainless steel TIG, MIG and Sub Arc Wires

Nickel Base TIG Wires

04/05

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METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Metrode duplex and superduplex consumables Used during fabrication of 3 integrated topside decks Caspian Sea Development

Despite its long history of producing oil, Azerbaijan still possesses considerable oil and gas deposits. Today, four off-shore oilfields produce the lion's share of Azerbaijan's output: "Guneshli," which yields 57 percent of Azerbaijan's current oil production, "Chirag," "Azeri," and "Kapaz."

During the Soviet period, these fields were left largely untapped because of the expense and difficulty of drilling at great depths under the sea. Since independence, the Azerbaijan International Operating Company, a twelve-company consortium dominated by BP-Amoco, is developing the three largest Azeri oilfields.

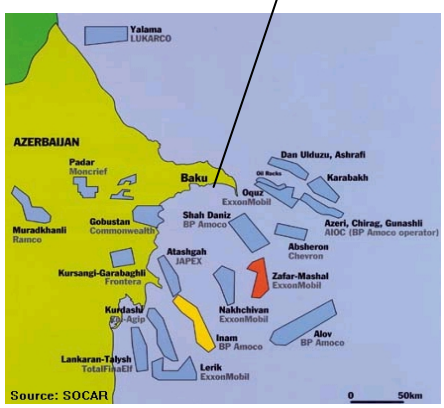
The entire Caspian Sea is around 30m below sea level and while the mean water depth as a whole is 208m, this is considerably shallower to the north-east. The field, 75km SSE of Atyrau, lies in just 3.7m of water.Temperatures can fall below -20°C in winter and a coating of ice, several metres thick, forms in this part of the Caspian Sea for many months of the year.

McDermott Caspian Contractors Inc. the Caspian arm of J. Ray McDermott, completed fabrication, load out and sailaway of an integrated deck, weighing more than 15,500MT. The deck was fabricated under a contract to the Azerbaijan International Operating Company for Phase 1 of the full field development of the ACG field in the Caspian Sea. Further contracts, for phase 2 and 3, still in operation, were awarded to fabricate two integrated topside decks, West Azeri and East Azeri, each weighing approximately 17,085ST. The two decks will support drilling facilities, living quarters, power generation and other process equipment and facilities.

Metrode have, and continue to supply, a range of duplex and superduplex stainless steel consumables to McDermott and the Amec/Tekfen/Azfen consortium.

Zeron 100X solid wires, 2507XKS MMA, SSB Sub arc flux
ER329N solid wires, 2205XKS MMA, Supercore 2205 FCW

Caspian Sea and major oilfields. Decks are being fabricated at the Baku Deepwater Factory in Azerbaijan



Integrated deck fabricated by McDermott Caspian Contractors Inc.

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Web Site Path at www.metrode.com
Key duplex or superduplex in the search box to view the complete range of consumables for offshore oil and gas.

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

JBD Engineering in Malaysia select Metrode Supercore 2205P to fabricate Gas Coolers

JBD Engineering (M) Sdn Bhd (formally ATJOI Sdn Bhd) selected Metrode Flux Cored Wire, **Supercore 2205P E2209T1-4** to fabricate Gas Coolers for use in the Oil & Gas and Petrochemical Industries.

The wire was originally selected for the following reasons: -

- Competitive Price
- Prompt delivery from stock
- High quality
- Knowledgeable sales personnel
- Excellent technical back-up

The wire was used on a semi-automatic set up and JBD reported that the product performed excellently with no repairs required. Productivity was improved and most importantly the ferrite % was in the required range.

The wire was supplied through Metrode's local distributor who formed an important link in the supply and back-up process.

Jepko Weldmaterials Sdn Bhd
16 Main Street, Subang N/V
40000 Shah Alam, Selangor
Malaysia

The gas coolers during fabrication in the JBD Engineering Workshops.

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Data Sheet B-60.pdf on this product can be found by keying in supercore 2205p in the product information search box.

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Metrode Duplex Stainless Steel Consumables used for The York Millennium Bridge

Officially opened on Tuesday, April 10th, the elegant 140m long York Millennium Bridge crosses the River Ouse on the southern boundary of the City. Its pioneering design by Whitby Bird & Partners won the York Millennium Bridge Trust competition for a pedestrian/cycle bridge. It is the first such structure to exploit the high strength of 22Cr Duplex stainless steel to work to the limits of contemporary technology. The inherent corrosion-resistance, strength and toughness of 22Cr duplex steel mean that weight-savings can be safely made, particularly in offshore structures where it is more commonly found.

Meldan Fabrications of Barton-on-Humber selected Metrode's **Supercore 2205P** flux cored wire and **2205XKS** electrodes to fabricate the slender, 80m long, 40-tonne arch from which the main weight of the 200 tonne bridge is suspended. The 600mm wide 200mm thick arch sections, many cut from a single 20m sheet of Duplex stainless steel, are highly polished, and represent a bicycle wheel, set 50º to the horizontal. Between the springing points, stainless steel cables above the deck represent the spokes. These, together with a rigid box below, which mimics the hub of the bicycle wheel, stabilise the structure.

Much of the steelwork was fabricated at Meldan Fabrications' site in Immingham, and brought to York for final assembly at a riverside site before it was lowered onto a pontoon, floated into place and lifted by jacking rams and cranes by main contractors C Spencer Ltd of Barrow-on-Humber into its permanent position in late October 2000.

The severe flooding of the winter delayed the official opening with the unprecedented rise in the river levels only a few days after the bridge had been fixed in position, rendering groundwork impossible for several months.

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Key in duplex in the search box to view data sheets on all Duplex welding consumables available from Metrode

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Buzzard Field Development - UK North Sea
Zeron 100X TIG Wire specified

EnCana (U.K.) Limited operates the Buzzard development - one of the U.K.'s most significant development projects in the past decade.

In June 2001, EnCana Corporation announced encouraging results from a discovery in Block 20/6 in the UK Central North Sea, some 100 kilometres northeast of Aberdeen. The well, drilled by EnCana Corporation's UK subsidiary, EnCana (U.K.) Limited using the semi-submersible rig Ocean Nomad (see photo below), initially encountered a 400-foot gross oil column, which tested at 6,547 bbl/d and one MMcf/d of gas. A subsequent sidetrack extended the oil bearing sands 4,400 feet to the east and increased the gross oil column to 750 feet.

Not only is it one of the largest North Sea discoveries in recent years with over a billion barrels of oil in place; it is also one of the fastest to be sanctioned for development by UK authorities. The field has been approved for development a mere 30 months after it was discovered.

Metrode are supplying considerable volumes of **Zeron 100X** during the fabrication of the Utilities and Production Decks for the Buzzard Field.

BP have been awarded the contract to transport and process oil from EnCana (U.K.) Limited's Buzzard field through the Forties Pipeline System. This is the biggest field to enter the Forties Pipeline System for 10 years and first oil from Buzzard is expected to start flowing through the system in late 2006, rising to a plateau rate of around 180,000-190,000 barrels per day. The physical connection to the Forties System will be made by means of a new 18" diameter pipeline link and a sub-sea hot tap into the main sealine about 60 kms from the Scottish Coast. Production from fields using the system will not be affected during the course of the tie-in work, which is scheduled to be carried out in summer 2004. The Forties Pipeline System is owned by BP and commences at the Forties Charlie platform with landfall at Cruden Bay, Aberdeenshire. The pipeline then continues to the processing terminal at Kinneil, adjacent to BP's Grangemouth complex in central Scotland. Crude oil is shipped from the Hound Point terminal on the Firth of Forth.

The Forties Pipeline System was constructed for the development of the Forties Field and first production occurred in 1975. In the early 1990's the Forties system was expanded to 1150 thousand barrels per day capacity with a focus on providing pipeline transportation to companies developing and operating fields throughout the North Sea.

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Key Zeron in the product info search database to view data sheets on Zeron 100X and related products

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Metrode ER329N & SSB Flux used for Duplex Stainless Steel Separator Vessels

Visual inspection of set through nozzle weld

Motherwell Bridge Fabricators Ltd have completed fabrication to BS 5500 of nine separator vessels in duplex stainless steel, using submerged arc consumables manufactured by Metrode Products Ltd.

The vessels were fabricated in duplex stainless steel. The unique combination of strength and corrosion resistance of this material enables savings to be made in top weight and provides long term service under aggressive operating conditions. The vessels design must also allow for the possibility of low temperature service in blow down conditions.

A testing regime was carried out that included fracture mechanics testing and measurement of CTOD values at –20°C in addition to the normal Charpy impact testing and G48 corrosion tests. The required values of 0.25mm at –20°C and 40 Joules at –40°C were comfortably exceeded.

The fabricated vessels were between 7m and 12m long, using material in the range 8mm to 25mm thickness and with internal diameters up to 3m. The vessels were for the BP Andrew and Shell Pelican fields. Longitudinal and circumferential seams were all welded using Metrode's ER329N 2.4mmø sub arc wire and SSB flux, requiring substantial quantities of consumables over a five month period.

For these duplex fabrication contracts Motherwell Bridge Fabricators utilised their segregated fabrication area, to avoid cross contamination from other materials. The combination of these conditions, the skills of the Motherwell Bridge workforce and the quality and consistency of the Metrode welding consumables resulted in welds which were not only excellent in appearance, but required no repairs.

Some of the separator vessels during fabrication in the Motherwell Bridge Fabricators dedicated segregated area for duplex fabrication

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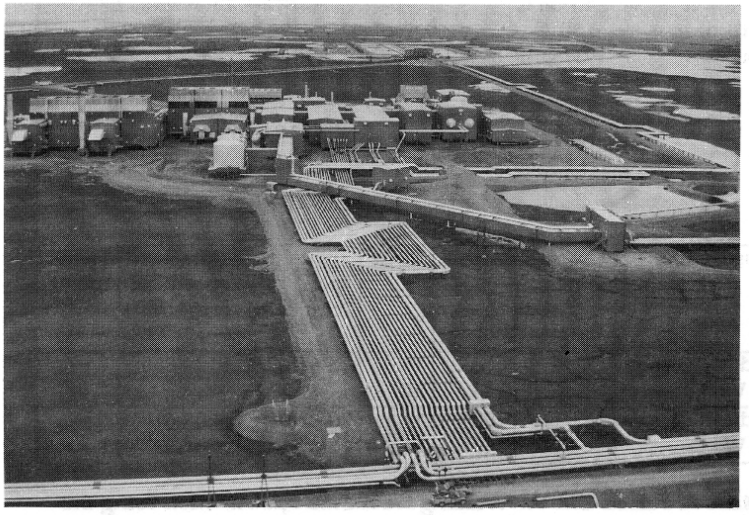
Key in er329n and ssb in the search box to view data sheets, stocks and related technical information on these products.

Welding Consumables for the ***ENERGY*** Market

Oil / Gas Flowline Welding



- Duplex & Superduplex s/s solid pipe,
- CRA clad and lined CMn pipe,
- 13Cr supermartensitic s/s pipe,
- Austenitic s/s pipe

Sub-Sea Flowline Fabrication

- Sub-sea inter-connecting pipeline ;
  Eg. wellhead to platform, riser pipework, transport lines.

- Generally involved with oil/gas wellstream transport, whilst of a 'corrosive' nature, through to processing stage.

- Competitive range of pipe material options available ;
  - CMn (API5LX grade) + CRA lining ;
    316L - 904L - 825 - 625

  - Solid 22Cr type duplex & 25%Cr type superduplex,

  - Solid 13%Cr supermartensitic s/s.

- Flowline production onshore ;

  - Fabrication of long sections, eg. 5km, towed offshore to site.
    or
  - butt welded pipe coiled on to a large reel, loaded on a laybarge (eg, Apache type), transported to site for unreeling offshore.

- Flowline fabricated offshore on the laybarge ;

  (1) 6m long pre-fabricated pipe SA butt welded at 'double-ending' station (rotated) to the side of main line ⟶ 12m lengths,
  (2) 12m lengths auto-'PGMAW' butt welded on the main line (fixed position), either ;
  S-lay, welded (5G/PF), & fed off back of barge via 'stinger' unit.
  or
  J-lay, welded (2G/PC), & fed vertically down to the sea bed

Welding Solid & CRA Lined Pipe : 5G / PF Position

Typical welding processes employed

- Manual GTAW, using 2.4mm (& 3.2mm) filler wires
  - Argon gas shield & purge.

- Automatic GMAW ; using a variety of pulsed metal transfer systems.
  - specially designed shielding gas mixtures, based on Ar-He-CO_2 , for optimum fast downhill arc operability and weld pool control.
  - predominantly 1.0mm filler wire (some use of 1.2mm),
  - welding predominantly V↓ ; ie. 12 ⟶ 6 o'clock semi-orbital,

- Major operators :

  - Saipem : STT process for root pass ; 1.0mm wire,
    Presto 'PGMAW' system for joint fill ; 1.0mm wire.
    Welding all V↓

  - Serimax : In-house 'PGMAW' technology
    1.2mm wire, welding all V↓

  - Subsea 7 : On-shore pipeline welding yard at Wick (Scotland)
    Extensive use of manual GTAW,especially for fabrication of pipe bundles, + some auto PGMAW

  - Technip Offshore ; On-shore pipeline welding yard at Evanton (Scotland), + auto-'PGMAW' pipeline welding yard at Orkanger (Norway)

  - Allseas (Netherlands) ??

CRA Pipeline Welding : Typical Filler Metals Used

GTAW & PGMAW

- Solid 22Cr Duplex s/s : ER329N
- Solid 25Cr Superduplex s/s : Zeron 100X
- CMn API 5LX65 + 316L s/s : ER329N

(309L / 309MoL ? Limited capacity concerning ;

- root corrosion resistance ; Chloride pitting resistance and weak CSCC,
- overall weld toughness, at typical – 30^{0}C specified,
- borderline strength versus typical 470MPa of X65 grade pipe.

CMn API 5LX65 + Alloy 825 : 62-50

CMn API 5LX65 + Alloy 904L : 62-50

CMn API 5LX65 + Alloy 625 62-50

62-50 Ni-base offers ;

- high alloy composition, for accommodating dilution effects,
- superior, chloride pitting resistance for root bead security,
- flexibility of supply, general availability and relatively lower cost.

Where there is a requirement for extra edge of weld metal strength, with welding X65 grade pipe, Has C22 wire can be considered a suitable alternative. It offers a tough, Nb-free, high Mo weld metal, with recognised lower sensitivity to hot cracking than the 625 alloy.

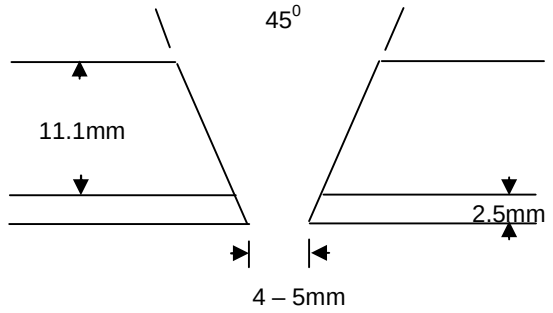
Welding Procedure Qualification Record

Manual GTAW Butt Weld in Lined Pipe (Ref : Subsea 7 : BP / Bruce II Pipe Bundle)

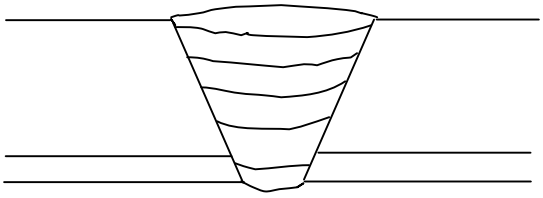
Consumables		Base Material			
Welding process :	**GTAW**	Parent Material:	**API 5L X65**	**+**	**ASTM A312**
- Consumable:	**ER329N**		**CMn pipe**		**316L s/s liner**
- Specification:	**AWS : ER2209**				
Welding process :					
- Consumable:		Thickness:	**11.1mm**		**2.5mm**
- Specification:		Outside Diameter:	**219mm**		

Joint Details		Joint Position	
Joint Type:	**Single-side V-butt**	Welding Position:	**ASME 5G / BS EN PF**
Manual/Mechanised:	**Manual**		

Joint Sketch



Welding Sequences



Welding Details

Run	Process	Consumable	Diameter mm	Current A	Voltage V	Type of current / Polarity	Travel Speed mm/min	Heat Input kJ/mm
Root	**GTAW**	**ER329N**	**2.4**	**132– 138**	**11 - 13**	**DC⁻**	**50 – 61**	**1.44 – 2.0**
2	**..**	**..**	**..**	**186– 193**	**12 - 13**	**..**	**120 – 125**	**1.14 – 1.2**
3	**..**	**..**	**3.2**	**210 – 213**	**13 - 14**	**..**	**123**	**1.59**
4	**..**	**..**	**..**	**205 – 213**	**13 - 14**	**..**	**105 – 113**	**1.58**
5	**..**	**..**	**..**	**205 – 220**	**13 - 14**	**..**	**90 – 95**	**1.85 – 1.9**
Cap	**..**	**..**	**..**	**150 - 165**	**12 - 13**	**..**	**60 - 67**	**1.73 – 1.9**

Shielding gas ;	Argon (99.9%)
Flow rate ;	11 – 14 lpm
Purge gas ;	Argon (99.9%)
Flow rate ;	Sufficient to achieve < 0.5%O_2 in bore

Preheat Temperature:	16^{0}C
Interpass Temperature:	150^{0}C

Post-Weld Heat Treatment and/or Ageing:	NA
Temperature:	NA
Time:	NA

Notes:

1. Hi-Lo ; 0 – 0.5mm
2. Root pass welded via 4 segment weld runs
3. Back-purge removed after 2nd pass ; replaced by continuous internal air cooling
4. Total butt weld production time ; 95 min

Weldable 'Super 13Cr' Martensitic S/S Pipe

Key Features

C	Mn	Si	Cr	Ni	Mo	Cu	N
0.01	1.2	0.2	12	6.5	2.5	0.5	0.01

Extra low C, strong, tough martensitic s/s microstructure

Supplied in the Quenched & Tempered condition

- Strength : 80 - 100 ksi (550 – 690 MPa) Yield Strength
- Toughness : 75 ft.lbf @ -110^{0}F (100J @ -80^{0}C)
- Corrosion resistant ; sweet, mildly 'sour', CO_2 environments
- Erosion resistant
- Weldable without post-weld stress relief
- 50% cheaper than duplex s/s and other CRA systems

METRODE
WELDING CONSUMABLES

Weldable 'Super 13Cr' Stainless Steel

Applications

Oil / gas in-field flowlines

Flowline bundles

On-shore reeling / offshore reel laying

Laybarge welding & laying

Onshore < $^{1}/_{2}$" > Offshore

METRODE
WELDING CONSUMABLES

Welding *Super 13Cr* Stainless Steel

Weld Filler Metal Options & Typical Weld Properties

Zeron 100X Superduplex S/S, eg. Pulsed GMAW

Yield Strength : 720 MPa (RT) 600 MPa (280^{0}F / 140^{0}C)

Toughness : 110 ft.lbf (150J) @ -22^{0}F (-30^{0}C)

Pitting & SCC Resistance : 'Sour', high H_2S media

'Matching 13Cr Supermartensitic S/S : eg. Pulsed GMAW

Yield Strength : 950 MPa (RT)

Toughness : 50 ft.lbf (70J) @ -22^{0}F (-30^{0}C)

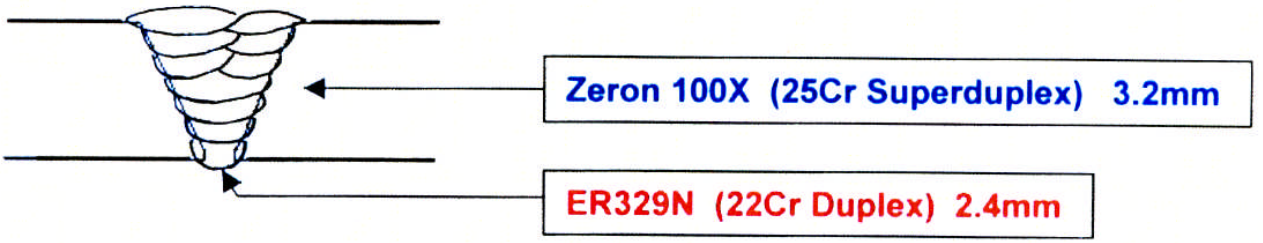
Pitting & SCC Resistance : 'Sweet' and slightly 'sour' media

Welding *Super 13Cr* Stainless Steel

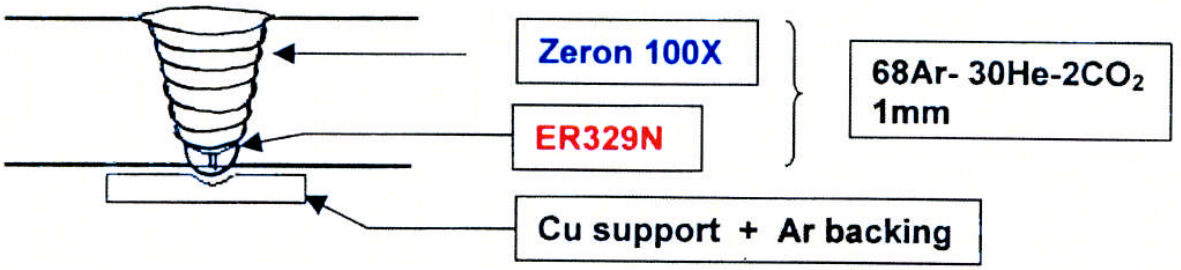
Typical Weld Procedural Approach

2 principal oil /gas welding process routes :

1. **Manual GTAW ;** Root and Fill



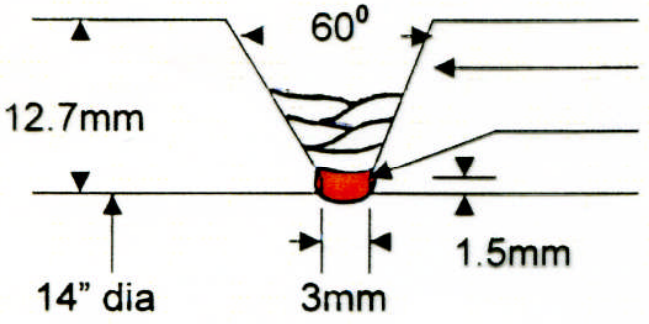
2. **Automatic PGMAW ;** Root and Fill



SMAW Root Welding of Alloy Pipework

Tie-in welding of 13Cr Supermartensitic s/s gas pipeline :
(Floating barge, laying 15km pipe over river delta swampland)

Why SMAW ? Root alignment control + gas-backing



ASME : 5G
Zeron 100X, 2.4mm, GTAW
Ultramet 2205, 2.5mm, Rutile, DC+

- Plan A ; Rutile 25Cr superduplex SMAW fill ; Rejected, insufficient CVN
- GTAW welding over a rutile SMAW deposit ; X-ray soundness OK
- No serious service corrosion aspects. 13Cr material because pipeline bends prevented 'pigging' internal corrosion assessment

METRODE
WELDING CONSUMABLES

Welding Super 13Cr Material

Zeron 100X GTAW Weld Metal Suitability?

- Matching strength up to 300°F
- Weld toughness down to -100°F
- Excellent, overmatching, corrosion resistance
- Not 'damaged' by rapid post-weld stress-relief
- Meets specified 'low-hydrogen' requirements
- Full range of welding consumable types
- Manual & mechanised welding capability
- Reliable track record to date

METRODE
WELDING CONSUMABLES

Stainless Steel Welding Consumables

for

Liquid Natural Gas (LNG)Applications

"How to achieve good cryogenic toughness in stainless steel welds"

Specially formulated electrodes & wires
to deposit weld metal with ;

- carefully balanced Cr and Mo alloy levels,
- low, controlled ferrite (CF) phase microstructure,
- reliable fracture toughness down to – 196 ^{0}C,
  ("cryogenic temperature")

Suitable for the fabrication of vessels and pipework involved with the handling and processing of liquid gases.

"LNG is big business"

Demand : Million Tonnes Per Annum (MTPA)

	2007	2015
	150	**375**

	Now	Future plans
Gas Liquefaction Plants ;	**~50**	**+46** (Under construction)
LNG Carrier Vessels ; (capacity up to 145,000m^3)	**~268**	**+140** (New-build over 4yrs)
LNG Reception Terminals ;	**54**	**+135** (new or expanded)

+

Extensive requirement for ;

- Transport pipework,
- Storage tanks
- Re-gasification plants

Gas Liquefaction Temperatures

Gas	Temperature, ^{0}C (^{0}F)	
Ammonia	-33	(-27)
Propane (LPG)	-45	(-49)
Carbon Dioxide	-78	(-108)
Acetylene	-84	(-119)
Ethane	-88	(-126)
Ethylene	-104	(-155)
Methane (LNG)	-163	(-261)
Oxygen	-183	(-297)
Argon	-186	(-303)
Nitrogen	-196	(-320)
Hydrogen	-253	(-423)
Helium	-269	(-452)

Liquid Natural Gas is colourless, odourless, non-corrosive and non-toxic.

Liquefaction reduces the volume of natural gas by ~ 600 times, making it more economic to transport long distances to sites where it can be stored prior to re-gasification and local distribution.

Standard Austenitic Stainless Steel Weld Metal Toughness at Cryogenic Temperatures

Achieving reliable performance by product design

ie. CVN test results capable of meeting Lateral Expansion

> 0.38mm / 0.015" / 15mils (US)

Key factors

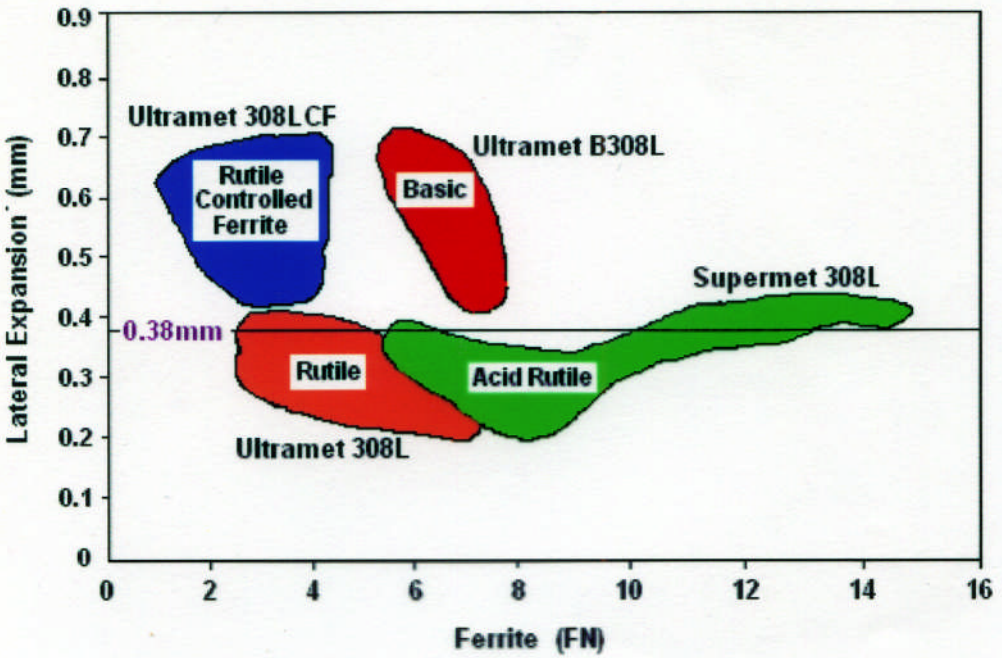
- Weld metal Ferrite phase in the range 2 – 5FN
  (minimising microstructural embrittlement)

- 'Lean' Cr, Mo levels ; balanced Cr_{eq} : Ni_{eq} ratio (Suutala)
  (minimising risks of 'hot cracking' at low FN levels)

- Reduced weld metal residual oxygen content
  (maximising weld metal ductility and toughness)

308L SMAW Electrodes : Charpy V @ -196^{0}C

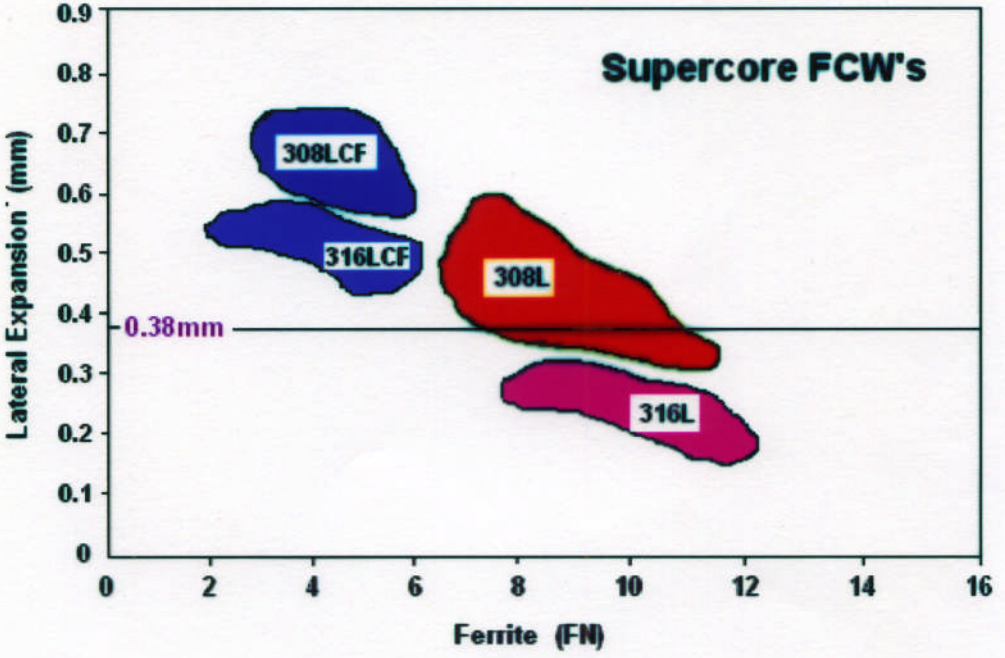
Lateral Expansion versus Weld Metal Ferrite Level



Optimum SMAW Ferrite range, to meet 0.38mm min LE : 2 – 5FN

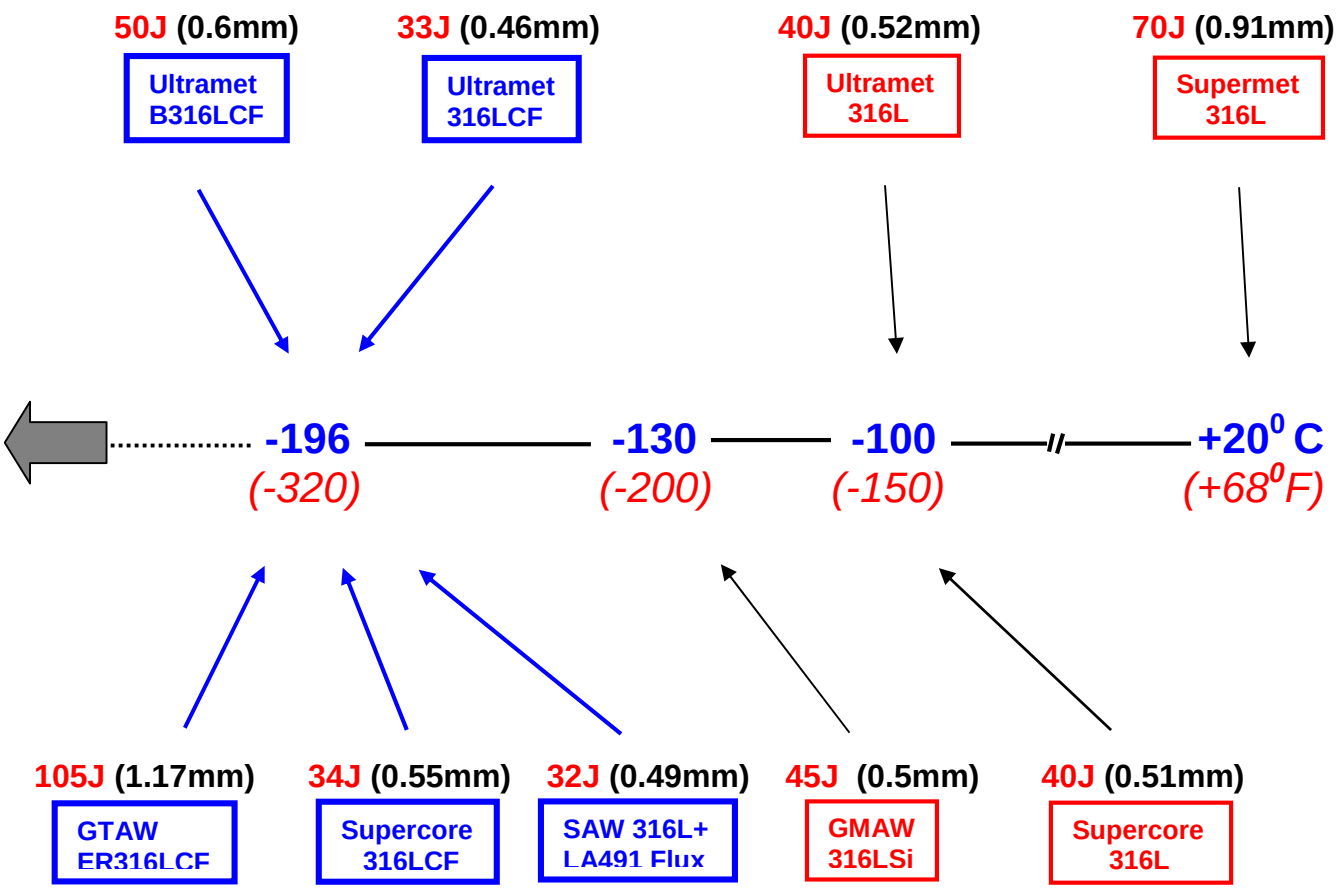
308L / 316L Stainless FCW's : Charpy-V @ -196^{0}C

Lateral Expansion versus Weld Metal Ferrite Level



Special Austenitic Stainless Steel Filler Metals With Cryogenic Temperature Toughness Capability

eg. Type 316LCF

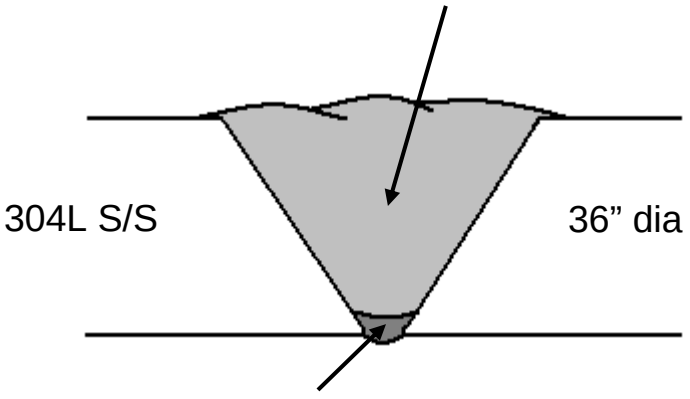


Below ~ -100^0 C ; Lateral Expansion is the significant parameter of fracture toughness, measured against a specified requirement of 0.38mm minimum.

Welding LNG Stainless Steel Pipework

Typical fabrication procedures

Supercore 308LCF, 1.2mm



Lincoln STT GMAW + 1.0mm 308Si wire

Charpy V-Notch toughness tests @ - 196^{0}C

Impact energy : 32, 29, 34, (32) Joules (“42J”)
(10 x 7.5mm)

Lateral Expansion : 0.81, 0.70, 0.73, (0.75)mm (Spec’ 0.38min !!)

Root welding procedure qualifications, by the sub-contactors, included ;

- Rutile 308L SMAW electrodes, 2.5mm,
- Superoot 316L flux cored GTAW wire, 2.4mm

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Metrode Controlled Ferrite Consumables

Ultramet 308LCF and Ultramet 316LCF
AWS A5.4 E308L-16 and E316L-16

Numerous successful procedures have been carried out with the CF SMAW electrodes, and many tonnes of electrodes have been used on projects all round the world. Most of the projects that the electrodes have been used on are pipelines and process pipework, some examples are given here.

The CF electrodes were originally designed over 10 years ago to satisfy the requirements of Mobil/Ralph M Parsons for the SAGE (Scottish Area Gas Evacuation) project terminal at St Fergus. The plant, run by Exxon-Mobil, has now been processing gas for nearly eleven years. A number of weld procedures were completed covering different welding processes and pipe sizes.

More recently tonnage quantities of the CF consumables have been used in Kazakhstan on the Karachaganak Project where the contractors were CCC-Saipem. The CF electrodes were used on 304/316 process pipework.

There has also been significant quantities of pipework welded with the CF consumables on the Mesaieed Q-Chem petrochemical complex in Qatar. The contractors were Snamprogetti and the CF consumables were used specifically on the NGL-4 plant (natural gas to liquids plant) which will produce ethane rich gas feedstock for the ethylene plant.

Significant volumes of Ultramet 308LCF electrodes have been used in 2003 during the construction of The Isle of Grain gas fired power station in the UK.

Metrode has recently developed two new flux cored wires to compliment the electrodes, contact the Technical Department for further information: -

Supercore 308LCF & Supercore 316LCF

The SAGE terminal at St Fergus.

The Scottish Area Gas Evacuation (SAGE) plant processes gas from the Beryl, Brae, Scott and Britannia fields and their associated satellites. The processing facility is the largest and most modern facility of its kind in the UK. The plant has a nominal capacity of 53.3 million cubic meters per day. Daily removal capacity of natural gas liquids (NGLs) is 5,300 tonnes. The plant is connected to the gas National Transmission System via the Transco terminal at St.Fergus and to the NGL processing facilities operated by Shell at Mossmoran and BP at Kinneil.

The Ethylene Plant
Mesaieed Q-Chem
Petrochemical Complex
Qatar

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Key cryogenic in the search box to view details on these and related products

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Metrode Controlled Ferrite Consumables used during construction of The Isle of Grain LNG Terminal, Kent, UK
Supercore 308LCF FCW & Ultramet 308LCF MMA
specifically designed and manufactured for LNG & Cryogenic applications

The storage and distribution of various gases, including liquefied natural gas (LNG), requires materials that have good mechanical properties, particularly toughness, at low temperatures. Gases are generally stored as liquids at low pressure and this requires that the materials used for storage tanks and pipework are capable of withstanding the low temperatures encountered with liquefied gases.

Ultramet 308LCF (E308L-16) and Ultramet 316LCF (E316L-16) are rutile ('16' type coatings) all-positional electrodes suitable for fixed pipework with excellent operability and welder appeal. Ultramet B308LCF (E308L-15) and Ultramet B316LCF (E316L-15) are basic ('15' type coatings) all-positional electrodes suitable for fixed pipework.

The Metrode electrodes are specifically designed and manufactured to consistently meet the stringent demands of cryogenic applications; they are not batch selected standard all-purpose stainless steel electrodes.

The electrodes are batch impact tested at –196°C (-320°F) with an acceptance criterion of 0.38mm (0.015inch) minimum lateral expansion. The BS EN 10204 3.1.B batch certification includes weld deposit analysis, measured ferrite content and Charpy impact properties at –196°C (-320°F).

The Supercore 308LCF (*E308LT1-4*) and Supercore 316LCF (*E316LT1-4*) consumables are all-positional rutile flux cored wires that operate equally well with either Ar-20%CO_2 or 100%CO_2 shielding gas.

The Metrode wires are specifically designed and manufactured to consistently meet the stringent demands of cryogenic applications; they are not batch selected standard all-purpose stainless steel wires.
Metrode's flux cored wires are batch impact tested at –196°C (-320°F) with an acceptance criterion of 0.38mm (0.015inch) lateral expansion.

The BS EN 10204 3.1.B batch certification covers weld deposit analysis, measured ferrite content and Charpy toughness at –196°C (-320°F).

The Isle of Grain facility is owned by National Grid Transco's subsidiary, Grain LNG Limited. The £355million expansion tripled the storage capacity and a second phase, due to be completed in 2008, will again increase the capacity to import and process up to 9.8 million tonnes of LNG, representing 12% of the UK's annual gas demand.

Full details of Metrode's controlled ferrite range of consumables is contained in an in depth technical profile, contact Metrode to request a copy.

Gas shielded flux cored arc welding, Supercore 308LCF, being used for the first time during construction of the Grain-LNG importation facility on the Isle of Grain, UK.
Photograph courtesy of P M Associates UK Ltd.

Isle of Grain LNG importation facility UK

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Web Site Path at www.metrode.com
Key LNG in the search box to view details on the complete range of CF consumables for LNG and cryongenic applications

Application Study

METRODE WELDING CONSUMABLES
A Lincoln Electric® Company

Metrode Products Limited, Hanworth Lane, Chertsey, Surrey, KT16 9LL UK
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Ultramet 308LCF Electrodes used in petrochemical complex

Kuwait Industrial Gases Company, one of Kuwait Oxygen Group of companies announced that a contract for 20 years bas been entered into between Shuaiba Oxygen Company and Equate Petrochemical Company (a joint company between the Petrochemical Industries Company, Bubyan Petrochemical Company, Kuwait Al- Qurain Company and Union Carbide Company an affiliate of the US Dow Chemical Company) to supply the latter with oxygen, nitrogen and compressed air needed for the Olefins II Project to be constructed at its complex at Shuaiba Industrial area.

For this purpose, Shuaiba Oxygen-Company will build and operate an Air Separation Unit with a production capacity of 1,500 tonnes of oxygen daily, to supply the required cases to Equate Petrochemical Company as from the second quarter of 2008.

The Olefins II project encompasses three specific elements:

- A 850,000 metric ton Ethane cracker, owned by The Kuwait Olefins Company (TKOC)
- A 600,000 metric ton Ethylene Oxide/Ethylene Glycol plant using UCC's METEOR™1 Ethylene Oxide Technology, also owned by TKOC
- Expansion of the existing capacity of 600,000 metric ton per annum for Polyethylene by 225,000 per annum, using UCC's UNIPOL™ Polyethylene technology P

Metrode supplied over 2,000kgs of Ultramet 308LCF electrodes and 850kgs of the matching ER308LCF TIG wire, via its agent Bassem International in Kuwait for this project. Foster Wheeler are the engineering and procurement agents for the contract.

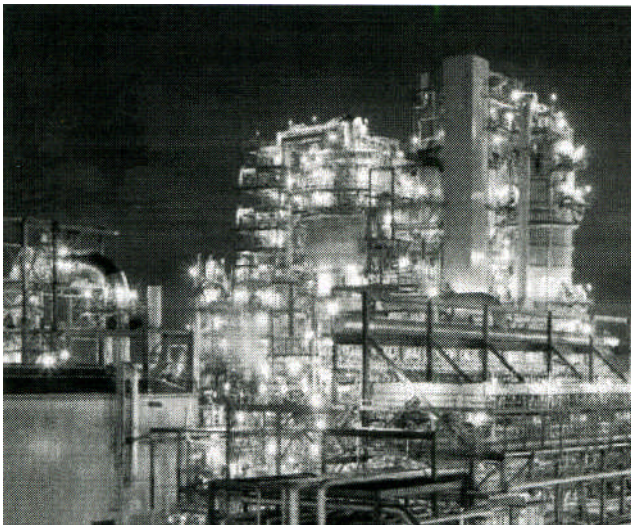
For full details on the complete range of Metrode Controlled Ferrite welding consumables, visit the website at www.metrode.com, or contact us on the numbers above.

Ultramet308LCF	AWS E308L-16	Rutile electrode for cryogenic 304L applications
Ultramet B308LCF	AWS E308L-15	Basic coated MMA pipe-welding electrode
Supercore 308LCF	AWS E308LT1-4	Solid wires for TIG and sub-arc welding
ER308LCF	AWS ER308L	Rutile all positional flux cored wire

Welding Consumables for the ***Energy*** Market

Oil Refining Industry

" The Oil Boilers "



A complex of plants involved in the processing of crude oil feedstock to produce petroleum fuel oils and gases with maximum efficiency and product quality ;

- Distillation column
  Crude oil heated to separate out LPG's, petroleum, naphtha, paraffins, light gas oil and heavy gas oil.

- Fluidised Bed Catalytic Cracker Unit (FCCU)
  Splits heavy oil component of distillation into a range of lighter products, eg, petroleum, jet fuel, gas oils and gases.

- Gas Plant
  Separates and controls cat cracker fuel gases, eg. methane, ethane propane, butane, hydrogen, etc.

- Alkylation Plant
  Processes residual 'light ends', to produce additional fuel gases and petroleum, for maximum refining efficiency.

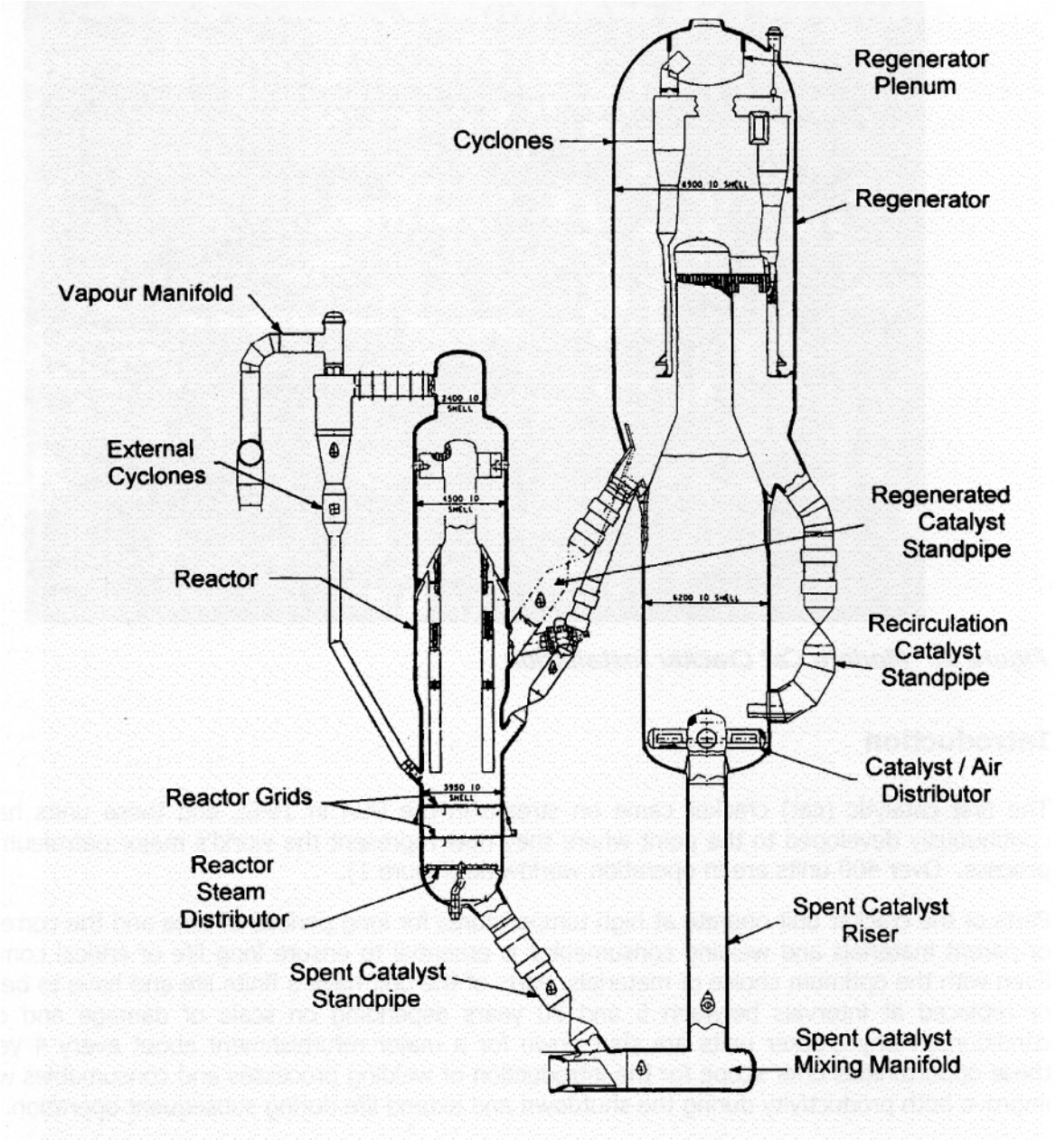
- Catalytic Reformers
  Improving the octane value of petroleum

- Hydrotreater / Hydrodesulphuriser Plant
  Reducing contaminants levels (eg, sulphur) in petroleum fractions.

Materials performance and minimum shutdown repairs are VIP.

Fluidised Bed Catalytic Cracker Unit (FCCU)

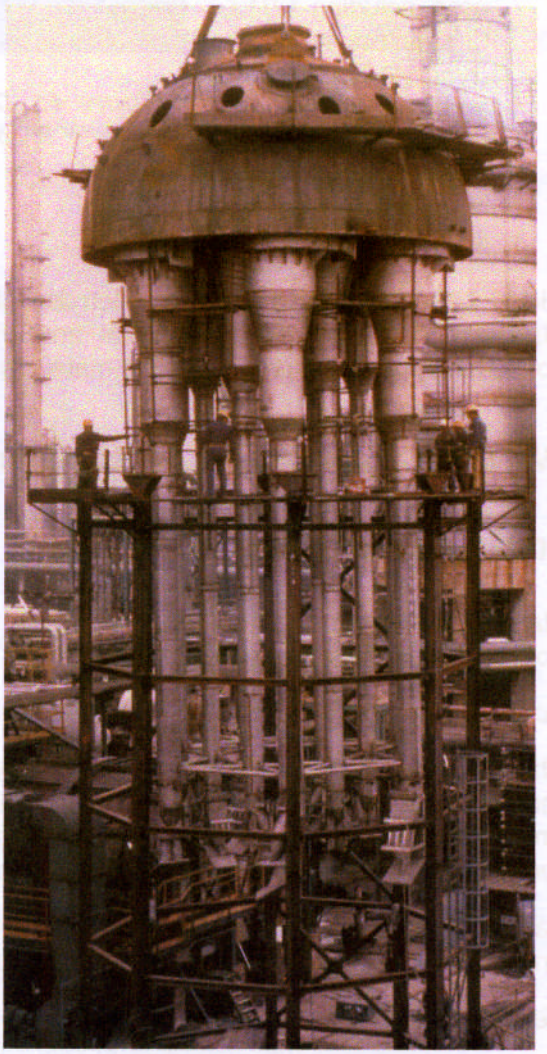
The FCCU processes a mixture of heavy crude oil feedstock, and other residues from the previous distillation stage, to produce a range of lighter products, eg. petroleum jet fuel and light gas oil, etc.



Schematic outline of the Reactor unit, and the Regenerator unit which reactivates the finely divided powder catalyst which is fundamental to the cracking process

304H Type Stainless Steel Components in an FCCU

- **Regenerator cyclones** – contained within the regenerator vessel
- **Reactor cyclones** – may be 304H or CrMo steels and may be located inside the reactor (older units) or outside the reactor
- **Hot gas/catalyst transfer lines and stand pipes** – including expansion bellows.
- **Catalyst distribution system in the regenerator** – this may be an air-grid floor or a tubular manifold
- **Various grids and components in the reactor vessel** – the exact location and design will depend upon the type of unit.



'16.8.2' Austenitic Stainless Steel Filler Metal

"Lean 316H", for elevated temperature applications

	C	Mn	Si	Cr	Ni	Mo	Cu	FN
316H	0.04	0.5	-	17.0	11.0	2.0	-	3
	0.08	2.0	0.9	20.0	13.0	3.0	0.5	8
16.8.2	0.04	0.5	-	14.5	7.5	1.0	-	1
	0.08	2.5	0.9	16.5	9.5	2.0	0.75	6

- Developed c.1950's (USA) for improved weld crack resistance with thick section, high restraint structures in 321H and 347H alloys subject to prolonged service at ~ 650^{0}C.

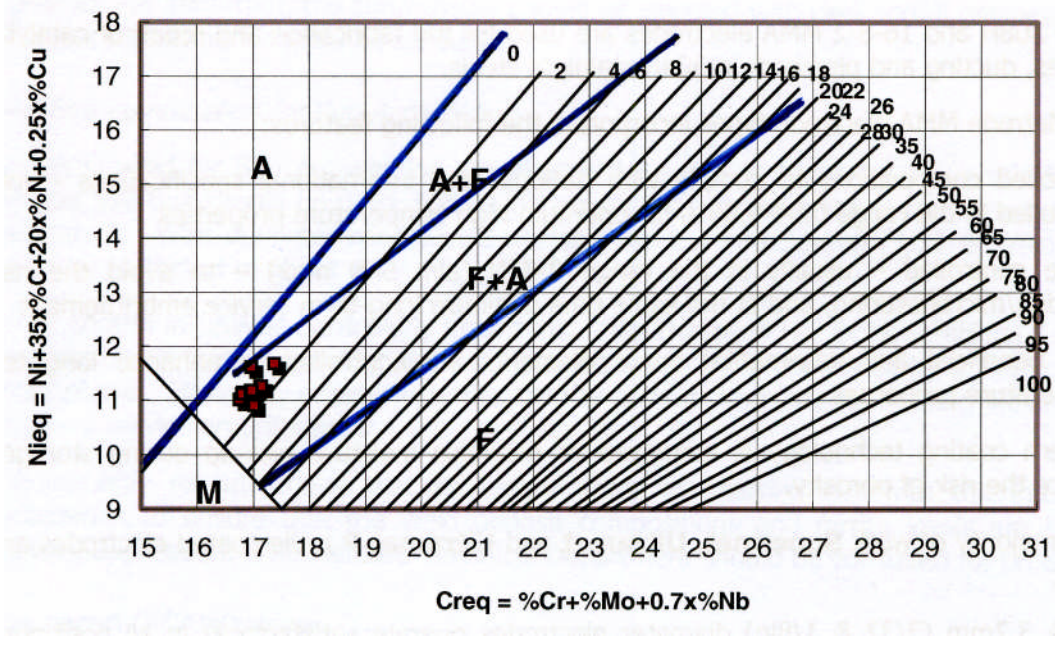
- Basic elements of 16.8.2's design ;

  Cr : ~ 15.5Cr (balanced with ~ 8.5%Ni) optimises weld deposit microstructure ;
  - primary ferritic solidfication, and maximum 'hot crack' resistance,
  - low ferrite level, to minimise sigma phase risks, whilst supporting 'hot crack' resistance and creep rupture ductility

  Mo : ~1.2% Mo assists with balance of weld ferrite role ;

  Solidification cracking with fabrication of thick section material v_s Sigma phase embrittlement, with long term operation at elevated temp.

  Restricted Mo avoids catastrophic oxidation in stagnant oxygen conditions, eg. shutdown periods,



WRC – 92 Diagram

Fabrication of FCCU External Cyclones System

ELF Grandpuit Refinery (Fr) ; Foure Lagadec (Le Havre)

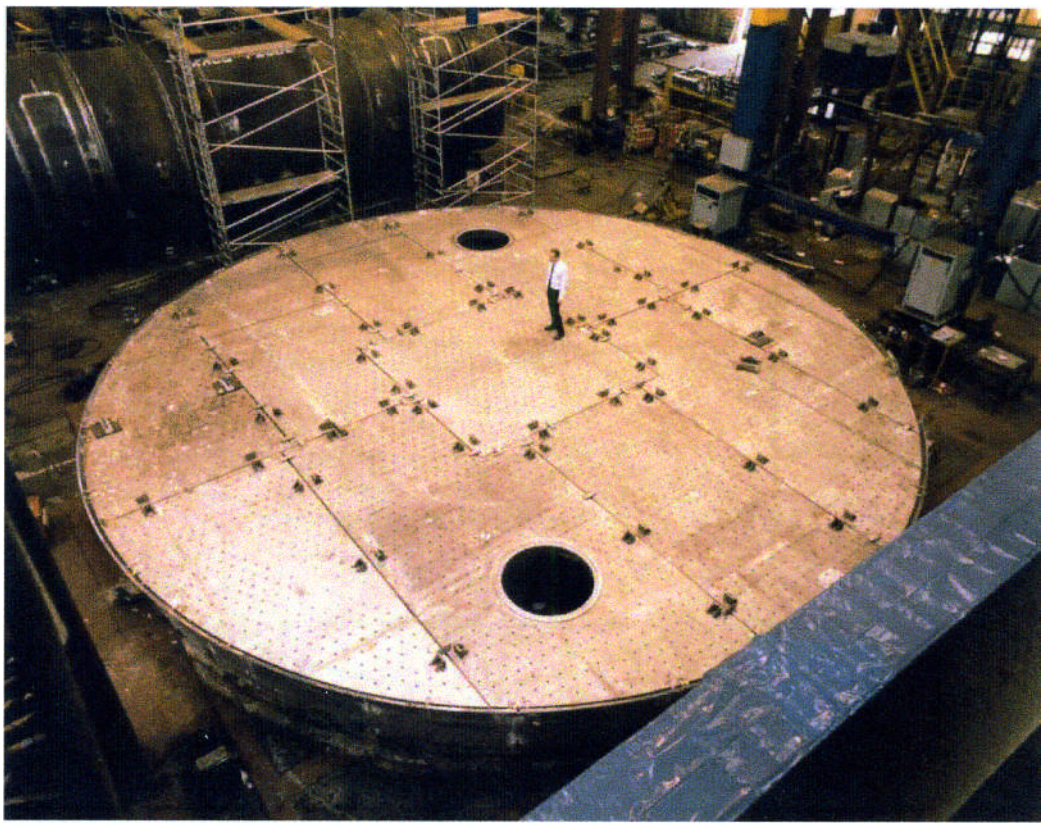
New 304N(H) secondary seperator unit ; 4 sets of 4 (16 cyclones) to replace existing 304H unit which had cracked both in WM and PM.
External cyclones separate residual catalyst from hot gas exiting from the Regenerator.
Gas is passed to a turbo expansion unit (to reduce pressure) before passing to the waste heat boiler. Previously, catalyst was eroding the blades of the turbo unit.

ELF specification included ;
Cr_{eq} - 1.5 x Ni_{eq} > 1.5 (according to Espy Diagram) for 16.8.2 type WM
(308H FM's could not safely meet C < 19.5 (Espy) for 308H type WM)

Project used ; 16.8.2 SMAW, GTAW, GMAW, FCAW & SAW

Fabrication of FCCU Catalyst Support Air Grid

ESSO Fawley Refinery (UK) ; International Combustion (Derby)



38mm thick 308H s/s replacement catalyst support grid for a Regenerator. 14.3m diameter, fabricated in several sections, to very tight tolerances, to ensure flatness when assembled and fitted inside the existing regenerator vessel.
A multitude of holes in the plate allow air to be distributed into the fluidised catalyst bed.
Used extensive quantities of 1.6mm Supercore 16.8.2 FCW ; 1st production batches manufactured at Metrode during fabrication. Site assembly utilised both FCW and Supermet 16.8.2 SMAW

Metrode's Range of 308H and 16.8.2 Filler Metals

- For welding type 304H, 321H, 347H and 316H materials
- Medium C grades (0.04-0.08%C) for creep strength and oxidation resistance, operating in the range ~ 400 – 800^{0}C.
- No Bismuth-bearing raw materials used in formulation of SMAW and FCAW welding consumables, to ensure Bi < 0.002% (20ppm), as required by API 582, and eliminate risks of weld cracking with prolonged service at elevated temperature (eg. >550^{0}C).

	308H	16-8-2
GTAW	308S96	ER16.8.2
SMAW	Ultramet 308H **(Rutile, pipe / root welding, All-positional)**	Supermet 16.8.2 **(Rutile, all-positional)**
	Ultramet B308H **(basic, all-positional)**	16.8.2-15 **(basic, all-positional)**
GMAW	308S96	Contact Metrode
	Gases ; Ar + 2%O_2, Ar + 2- 3%CO_2, or Ar + 38%He + 1- 2%CO_2	
FCAW	Supercore 308H **(downhand)** Supercore 308HP **(all-pos'nal)**	Supercore 16.8.2 **(downhand)** Supercore 16.8.2P **(all-pos'nal)**
	Gas ; Ar + 20 – 25%CO_2, (100%CO_2, downhand only)	
SAW	308S96	ER16.8.2
	SSB basic, agglomerated flux	

16.8.2 consumables are 'approved' and manufactured to the requirements of both ESSO & TOTAL ;

- with Mo specified 1.0 – 1.3 to minimise sigma phase precipitation potential,
- use of basic coated E16.8.2-15 SMAW for pipework welding.

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

ICI Converter at Monomer 8
Ultramet 308H Electrodes

A 22m high, 10m diameter sulphuric acid catalytic convertor fabricated by Wefco Ltd of Gainsborough was part of the massive ICI Monomor 8 Project built on Tee-side, UK. The project represented a £110m investment by ICI in acrylic production.

Environmental protection was a major consideration, with 30% of the expenditure on the Sulphuric Acid Recovery Unit. Designed by Chemitics of Toronto, now part of the John Brown organisation, the SAR unit ensures no acidic waste is disposed of in the North Sea.

Within the convertor shell, heated gas passes through a complex series of catalytic beds. Several tonnes of Metrode **Ultramet 308H** electrodes were used during the fabrication.

The welding underwent over 300 radiographic examinations. This strictly controlled test procedure confirmed the total integrity of the welds throughout the vessel.

ICI engineering expressed complete satisfaction with the completed job.

ICI The Vital Ingredient

Ultramet 308H
AWS E308H-16
BS EN E 19 9 H R

In the same family: -
Ultramet B308H - E308H-15
308S96 solid TIG/MIG/Sub Arc - ER308H
Supercore 308HP FCW - E308HT1-4

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Web Site Path at www.metrode.com
Key in 308H in the seach field to view data sheets on all these products

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

16-8-2 Consumables
ELF Grandpuits Refinery Project
Secondary Cyclone Separation Unit

The requirements for this contract was for welding 304N base metal with the following requirements: -

- Carbon: 0.04-0.06%
- Nitrogen: 0.14-0.18%
- Cr Eq (Espy): 19.5 max
- Yield Strength at 700°C: 173 MPa minimum
- Impact at +20°C: 20 J (average)

The welding consumables considered were 308H and standard 16-8-2 neither of which met all the above requirements. 60% of the welding was semi-automatic (MIG/FCAW & SAW). MMA was to be used for on-site erection with a small quantity of TIG for roots.

Metrode, because of its flexible manufacturing programme was able to offer 16.8.2 consumables that could meet the specification. The weld metal would have;

- better creep behaviour than standard 308H
- Already been approved by Exxon/Mobil
- Successful track record
- The FCW proved more reliable than solid wire for semi automatic mig welding.
- Ready availabilty of consumables meeting the ELF requirements

ELF approved the modified 16-8-2 weld metal and over the life of the project, 2.5t of FCW, 1.3t of MMA and 400kg of soild wires were supplied.

MMA - Supermet 16.8.2 (rutile type)
E16.8.2-15 (basic type)
FCW - Supercore 16.8.2P
Wires - ER16.8.2 (for TIG, MIG & Sub Arc)

Shop Assembly

On-site erection

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Key 1682 in the product information search field to view data on the complete range

The Oil Refining Industry

Typical welding consumable types used for maintenance welding on a refinery

	GTAW	SMAW	GMAW	FCAW
CMn	✓	-	-	-
1CrMo	✓	-	-	-
5CrMo	✓	✓	-	-
9CrMo	✓	-	-	-
308L	✓	✓	✓	✓
308H	✓	✓	-	✓
16.8.2	✓	✓	-	✓
309L	✓	✓	✓	-
309H	✓	-	✓	-
309MoL	✓	✓	-	-
310H	✓	✓	-	-
410	-	✓	-	-
20.70Nb	✓	✓	-	-
AKS	-	✓	-	-
625KS	✓	✓	-	-
65NiCu	✓	✓	-	-
800Nb	✓	✓	-	-

Refinery *Inspection Engineering Department,* and the resident Engineering Contractor's Materials Engineering Department are principal contact areas for welding/materials discussions.

Principal welding operations take the form of scheduled ;

- Major shut downs involving key plants, eg. FCCU, ~ 5 year cycle.
- Minor shut downs of smaller plant items.
- Emergency local repairs (ie. unscheduled)

Welding Consumables for the ***ENERGY*** Market

Petrochemical Process Plant Industry

Typical ***CrMo Alloy Steel*** *Consumables used in R & M*

GTAW	SMAW
1CrMo	Chromet 1 Chromet 1X
2CrMo	Chromet 2 Chromet 2X
5CrMo	Chromet 5
9CrMo	Chromet 9
9CrMoV-N	Chromet 9MV-N

Chromet 2X

2¼%Cr – 1%Mo SMAW Electrode

Version of Chromet 2 with a design based on limiting the level of impurity elements. These can have a deleterious effect on weld metal resistance to embrittlement, and is of particular significance with thick wall, highly restrained structures.
With prolonged exposure to temperatures in the range 400 – 600^0 C impurities segregate to the grain boundary region resulting in reduction in microstructural ductility, which eventually leads to creep cracking.

Weld metal analyses aim to meet Bruscato X (& Watanabe, J) limits specified by the client

Product description

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

Specifications

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

ASME IX Qualification

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

Composition (weld metal wt %)

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

* Mn+Si < 1.10%

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

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

All-weld mechanical properties

PWHT 690°C/1h [1] (SC = step cooled)			min	typical	690°C/5h typical	690°C/5h + SC typical
Tensile strength		MPa	630	700	660	650
0.2% Proof stress		MPa	540	620	560	550
Elongation on 4d		%	17	22	27	25
Elongation on 5d		%	18	19	24	20
Reduction of area		%	--	65	70	65
Impact energy	+ 20°C	J	47 [2]	140	170	170
	- 30°C	J	--	80	140	110
Hardness	(AW)	HV	--	300-320	--	--
	(PWHT)	HV	--	220-250	195	205

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

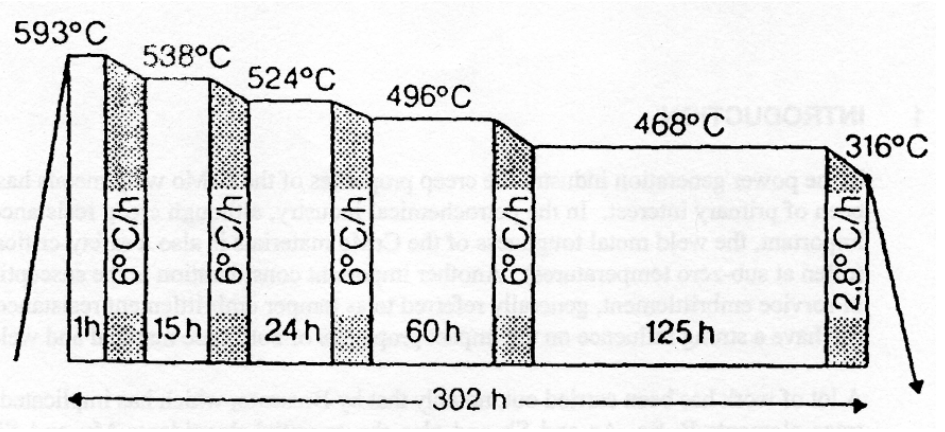
Packaging data

ø mm	2.5	3.2	4.0	5.0
length mm	350	380	450	450
kg/carton	13.5	15.0	18.0	17.1
pieces/carton	681	396	270	156

Assessment of In-Service Embrittlement Susceptibility

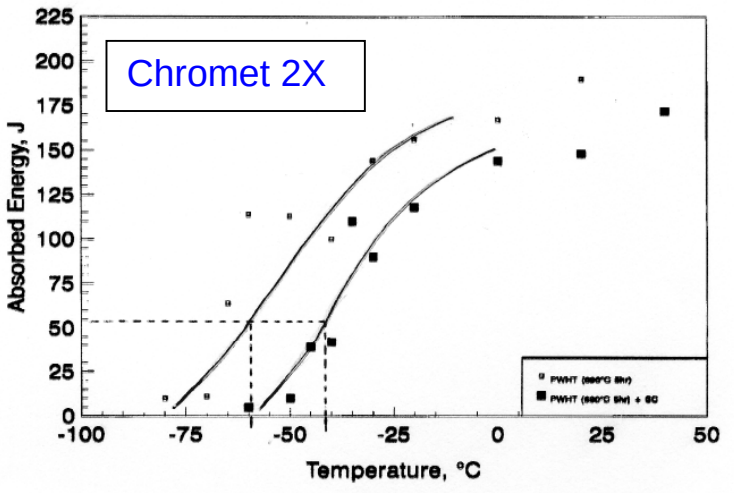
- All-weld metal Charpy toughness transition curves are established ;
  (a) WM stress-relieved at 690^{0}C / 5h,
  (b) WM stress-relieved at 690^{0}C / 5h + Step Cooled heat treatment,

- Typical Step Cooling schedule (as specified by GE) :-



- From Charpy-V transition curves, the shift in 54J (40ft-lb) transition temperature, DT_{54}, is established.
  DT_{54} = T_2 - T_1, where : T_1 = 54J transition temperature after PWHT
  T_2 = 54J transition temperature after PWHT + SC
  DT_{54} is multiplied by a design factor (eg. 3), and added to T_1

  To comply ; T_1 + (3 x DT_{54}) must be lower than **T**^{0}C, which is specified by the client, and can range from +10^{0}C to +38^{0}C. For example ;



T_1 = 54J transition temperature after PWHT = -59°C *(-74°F)*
T_2 = 54J transition temperature after PWHT + SC = -42°C *(-44°F)*
ΔT_{54} = $T_2 - T_1$ = 17°C *(30°F)*

$T_1 + (3 \times \Delta T_{54})$ = -8°C *(+16°F)*

Petrochemical Process Plant Industry

Typical *Low C Stainless Steel* Consumables Used in R&M

GTAW	SMAW	GMAW	FCAW
-	-	ER410NiMo	Supercore 410NiMo
308S92	Supermet 308L	-	Supercore 308L
316S92	Supermet 316L Ultramet 316L	316S92	Supercore 316L
-	Ultramet 347	-	-
318S96	-	-	-
309S92	Ultramet 309L Ultramet B309L	309S92	-
-	Supermet 309Mo	-	-
312S94	29.9 Super R	-	-
ER329N	2205XKS	-	Supercore 2205P
Zeron 100X	Zeron 100XKS	-	-

Petrochemical Process Plant Industry

Typical Medium C Stainless Steel *Consumables Used in R&M*

GTAW	SMAW
308S96	Ultramet 308H Ultramet B308H
ER347H	Ultramet 347H
316S96	17.8.2RCF
ER16.8.2	E16.8.2-15
-	Supermet 253MA

Petrochemical Process Plant Industry

Typical ***High C Stainless Steel*** *Consumables Used In R&M*

GTAW	SMAW
-	Thermet 309CF
-	Thermet 310H
310694	25.20.Super R
21.33MnNb	Thermet 800Nb
-	Thermet 25.35Nb
25.35.4CNb	Thermet HP40Nb
35.45Nb	Thermet 35.45Nb
-	Thermet 22H

Petrochemical Process Plant Industry

Typical Ni-Base Alloy Consumables Used in R&M

GTAW	SMAW
20.70Nb	Nimrod 182KS Nimrod AKS
62-50	Nimrod 625KS
Has C22	Nimrod C22KS
61-70	Nimrod 617KS
65NiCu	Nimrod 190
70CuNi	Cupromet N30

Ni-Base Superaustenitic Alloy SMAW Electrodes

	C	Cr	Ni	Nb	Mo	W	Fe
Nimrod AB / AKS **Nimax A**	0.05	16	69	2	1.5	-	8
Nimrod 182 / 182KS **Nimax182**	0.05	16	65	1.5	-	-	<8
Nimrod 625 / 625KS	0.03	21.5	64	3.5	9	-	<1.5
Nimrod C276 / C276KS	0.02	15	58	-	16	4	5
Nimrod 59KS	0.01	23	60	-	15.6	-	0.4
Nimrod C22KS	0.01	21	58	-	14	3	4

Superaustenitic Stainless Steel Evolution

Parent Alloy	Mo Content	GTAW Filler	PRE_N*
654 SMO	7.5%	Overmatching **Has 59** (16%Mo)	75
254 SMO	6%	Overmatching **62-50** (9%Mo)	50
904L	4.5%	Matching **20.25.4.Cu**	36
317L	3.5%	Matching **ER317L**	31
316L	2.5%	Matching **316S92**	28

Fully Austenitic

Austenite + Ferrite

* $PRE_N = \%Cr + 3.3 \times \%Mo + 3.3 \times \%N$

Welding Super Austenitic Stainless Steels

The Challenge :

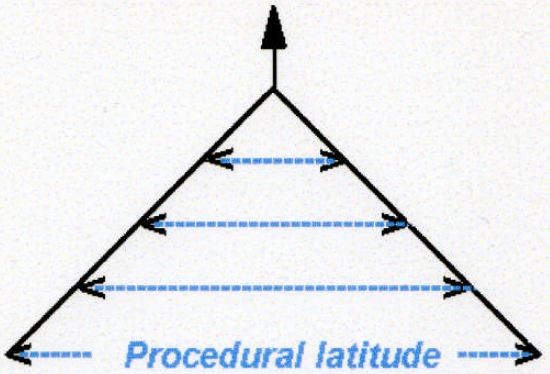
Increasing alloy levels

=

Increased weld performance

+

Increasing "weld zone risks"



The Problems :

'Hot' cracking Micro-fissuring	&	Alloy segregation (varying alloying level)	&	Embrittlement (nitride precipitation)

The Solutions :

- Overmatching Ni-base alloy weld metal, eg. Alloy 625, standard or lower Niobium versions.
- Weld procedures with tight control of arc energy and interpass Temperature.

Weld HAZ = principal risk region

Filler Metals for 6%Mo Superaustenitic S/S

High Mo fully austenitic stainless steel, with superior resistance to crevice and pitting corrosion in chloride-type media service.
eg. seawater heat exchangers, cooling water pipes, and similar equipment.

Typical Parent material : Outokumpu **254 SMO** (UNS S31254) ;

C	Cr	Ni	Mo	Cu	N
.01	20	18	6.1	.7	.20

Recommended filler metals :

Overmatching Mo type 'Inconel' and 'Hastelloy' Ni-base alloys :-

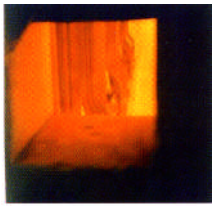
<table>
<tr><td>GTAW
GMAW</td><td>62.50
C .015 Ni 22 Cr 65 Mo 9 Nb 3.5
AWS : ERNiCrMo-3
BS EN : E Ni6625
1.6, 2.4 & 3.2mm</td><td>Has C22
C .003 Cr 21 Ni 56 Mo 14 W 3
AWS : ERNiCrMo-10
BS EN : SN6022
1.6, 2.4 & 3.2mm</td></tr>
<tr><td>SMAW</td><td>Nimrod 625KS</td><td>Nimrod C22KS</td></tr>
<tr><td></td><td colspan="2">Basic coated ; DC+
All-positional ; fixed pipework*
2.5*, 3.2*, 4 & 5mm</td></tr>
<tr><td></td><td colspan="2">20.18.6 matching 6% Mo electrode to parent material.
Rutile coated ; designed for welding & repair of castings downhand.
Post-weld solution annealing must be applied (1120°C)</td></tr>
</table>

Practical considerations :

- Similar controlled GTAW practice as with Duplex stainless steels.
- Pure argon gas shield and purge ; use of Ar – N_2 not recommended.
- Main accent on avoiding Mo segregation in the HAZ.
- Pulsed arc version of GMAW recommended ; with Ar + 30-40%He + CO_2
- SMAW electrodes designed to optimise positional operability & toughness.

Welding Consumables for the ***ENERGY*** Market

Petrochemical Process Plant Industry



Input : *Crude hydrocarbon processed distillates and gases ;*
eg. Benzene, Ethylene, Propylene, LNG

Process Plant : *Heaters, Reactors vessels, Precipitators, Condensers, Distillation Columns, Centrifuges Hydrogen Seperators, Coolers, Storage tanks, Scrubbers, Pipework & Pumps, etc*

Output : *Multi-stage processed hydrocarbon derivatives, in the form of a wide range of organic compounds ;*
eg. Acids, Methanol, Olefins, Aldehydes.

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Metrode consumables for Alloy 825

After a full nine years continuous use in a reactor used for mixing phosphoric acid slurry at the Albright & Wilson Whitehaven Works, a 3 tonne agitator was repaired by Fabrication Technology Ltd of Oldham following identification of erosion of the four 1.5” thick blades.

Metrode Products’ TIG wire and MMA electrodes were used, following extensive suitability testing at Albright & Wilson and Leeds University metallurgists.

Each of the agitator’s blades was removed from the Uranus B6 hub, which was then ultrasonically tested and found to be still sound.

New blades were fabricated in Nicrofer 3127, to the original design and welded to the hub with a TIG root using Metrode **82-50**, followed by Metrode **E825L-15** electrodes. Metrode **Nimrod 625** was used for the capping layer. After dye penetrant and ultrasonic testing, the welds were ground and polished to ensure maximum corrosion resistance.

Nicrofer is a trade name of VDM

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Key 825 and 625 in the search field to view data sheets, current stocks and pricing details on individual products mentioned above.

Application Study

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625 nickel based consumables for Tunisia Gas Project

Earlier this year Metrode supplied over a tonne of Nimrod 625KS electrodes and 62-50 TIG to weld Incolloy® 825 pipe for use on a sour gas application for the Miskar project to extract natural gas offshore from the Tunisian coast for the BG Group.

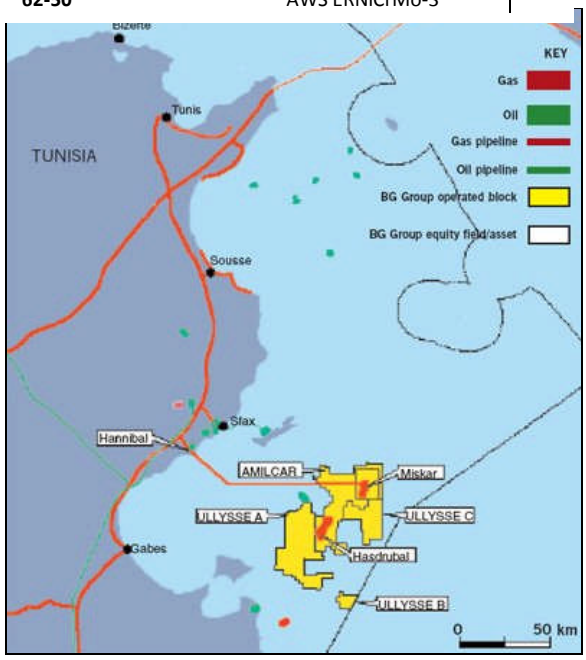
BG Group is in the process of drilling six wells as part of the Miskar infill drilling campaign. The wells will be drilled in phases, with two wells expected to be completed in each of 2007, 2008 and 2009. These wells will further extend the field production plateau. Related projects are underway to upgrade the production facilities to process varying compositions of gas and to de-bottleneck the facilities.

BG Group is the largest producer of gas in Tunisia, supplying approximately 50% of the domestic gas demand from the Miskar field. In addition, BG Group holds two exploration permits in the Gulf of Gabes with a combined surface area of 4 088 square kilometres.

Pipe ø's ranged from 1½" up to 10"
Picture shows work underway in the workshops of Pireco.

625 Products available

Process	Product	Specification
MMA	**Nimrod 625**	AWS ENiCrMo-3
	Nimrod 625KS	AWS ENiCrMo-3
TIG/MIG	**62-50**	AWS ERNiCrMo-3
SAW	**62-50**	AWS ERNiCrMo-3



Hasdrubal Gas Processing Plant, Tunisia

The new Hasdrubal onshore gas processing facility and the Liquefied Petroleum Gas (LPG) production facility will be located on the Tunisian coast between La Skhira and Sfax in Tunisia and is scheduled for completion in 2009. The plant is being constructed in a 50/50 joint venture by British Gas Tunisia Limited (BGT) and Entreprise Tunisienne D'Activités Pétrolières (ETAP), the Tunisian state-owned oil and gas exploration and production company, to exploit the Hasdrubal field, which is situated in the Gulf of Gabes about 110km east of Sfax at a depth of 62m. The project is intended to increase production levels to meet the demand of the domestic gas supply in Tunisia, while still maintaining supplies for generation of electricity.

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Metrode 20.70.Nb MIG wire used to fabricate a carbon steel/Inconel ammonia still column

Metrode 20.70.Nb MIG wire was used extensively during the fabrication of a 3' diameter, 94' high ammonia still column at the ICI maintenance workshop in Northwich.

Complete corrosion resistance and weld integrity was a pre-requisite of the construction and full verification of the wire by standard weld procedure preceded commencement of the contract.

Using the MIG process, 4" thick carbon manganese steel flanges were built up, groove welded at their front face and fillet welded at the back, at each end of four sections, three of carbon steel one of inconel®. Branch pipes were welded to the main shell and the required corrosion resistant flange facings added, again using Metrode 20.70.Nb.

Views of the corrosion resistant ammonia still column during fabrication.

	Process	Product	Specification
Metrode Nickel Base 182 Consumables	MMA	Nimrod 182KS	AWS ENiCrFe-3
		Nimrod 182	AWS ENiCrFe-3
		Nimax 182	AWS ENiCrFe-3
	TIG/MIG/ SAW	20.70.Nb	AWS ERNiCr-3
	SAW flux	NiCr	SA FB2

®Inconel is a registered trade name of Special Metals Inc

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Key 182 into the product info search box to view current data sheets and other useful information.

Welding Consumables for the
Power Generation Industry

Principally, Steam Generating Power Plant

Pipework
Turbine Castings
Steam Chests
Valve Bodies
Boiler Superheaters
In
CrMo and CrMoV Ferritic Creep Resisting Steels

1CrMo and 2CrMo Welding Consumables

Welds predominantly involve butt joints between similar CrMo alloys, and are made using matching composition welding consumables, and a procedure, aimed at achieving a satisfactory metallurgical structure and mechanical performance throughout the 'weld zone'.

Alloy	*Process*	*Consumable*	*AWS*	*BS EN*
1CrMo	*TIG/GTAW*	1CrMo	A5.28 ER80S-G	BS EN 12070 WCrMo1Si
		ER80S-B2	A5.28 ER80S-B2	-
	MIG/GMAW	1CrMo	A5.28 ER80S-G	BS EN 12070 GCrMo1Si
		ER80S-B2	A5.28 ER80S-B2	-
	MMA/SMAW	Chromet 1	A5.5 E8018-B2	BS EN 1600 ECrMo1B
		Chromet 1L	A5.5 E7015-B2L	BS EN 1600 ECrMo1LB
		Chromet 1X	A5.5 E8018-B2	BS EN 1600 ECrMo1B
	SAW	SA1CrMo (wire)	A5.23 EB2	BS EN 12070 SCrMo1
		LA121 (flux)	--	BS EN 760 SAFB1
		LA491 (flux)	--	BS EN 760 SA FB 255 AC
		L2N (flux)	--	BS EN 760 SF CS 2 DC
	FCW	Cormet 1	A5.29 E81T1-B2M	(BS EN 12071 TCrMo1 PM2)
2CrMo	*TIG/GTAW*	2CrMo	A5.28 ER90S-G	BS EN 12070 WCrMo2Si
		ER90S-B3	A5.28 ER90S-B3	-
	MIG/GMAW	2CrMo	A5.28 ER90S-G	BS EN 12070 GCrMo2Si
		ER90S-B3	A5.28 ER90S-B3	-
	MMA/SMAW	Chromet 2	A5.5 E9018-B3	BS EN 1600 ECrMo2B
		Chromet 2L	A5.5 E8015-B3L	BS EN 1600 ECrMo2LB
		Chromet 2X	A5.5 E9018-B3	BS EN 1600 ECrMo2B
	SAW	SA2CrMo (wire)	A5.23 EB3	BS EN 12070 SCrMo2
		LA121 (flux)	--	BS EN 760 SAFB1
		LA491 (flux)	--	BS EN 760 SA FB 255 AC
		L2N (flux)	--	BS EN 760 SF CS 2 DC
	FCW	Cormet 2	A5.29 E91T1-B3M	(BS EN 12071 TCrMo2 PM2)
		Cormet 2L	A5.29 E91T1-B3LM	BS EN 12071 TCrMo2L PM2

Cormet 2 and 2L

$2\frac{1}{4}$%Cr – 1%Mo FCAW Wires

Rutile flux cored wires, with excellent all-positional pipework welding capability.

Are 'approved' by UK and overseas electricity generating operators, and have been utilised extensively for 2CrMo OEM and plant maintenance welding by virtue of several advantages offered over previous processes used ;

- higher productivity compared to SMAW
- all-positional capability, spray mode, without need for synergic PGMAW,
- all-positional capability without lack of fusion defects associated with GMAW
- easier slag detachment than with basic coated SMAW.

Product description

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

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

Specifications

	Cormet 2	**Cormet 2L**
AWS A5.29	E91T1-B3M	E91T1-B3LM
BS EN 12071	(TCrMo2 P M 2)	(TCrMo2L P M 2)

ASME IX Qualification

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

Composition (weld metal wt %)

	C*	Mn	Si	S	P	Cr	Mo	Cu
min	0.05	0.50	0.15	--	--	2.00	0.90	--
max	0.08	1.20	0.50	0.015	0.020	2.50	1.20	0.15
typ	0.06	1.0	0.3	0.01	0.01	2.3	1.0	0.05

* Cormet 2L C ≤ 0.05%, typical 0.04%

All-weld mechanical properties

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

Operating parameters

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

Current: DC+ve ranges as below:

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

Packaging data

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

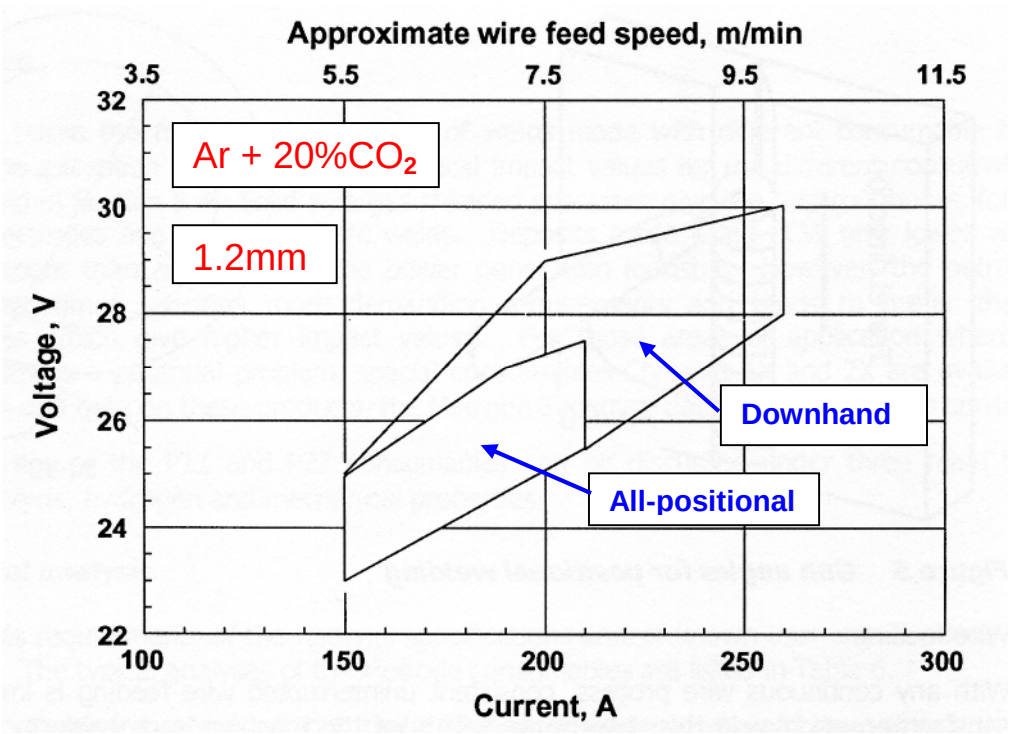
Fume data

Fume composition (wt %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m³)
20	8	< 0.5	1	< 1	< 1	8	5

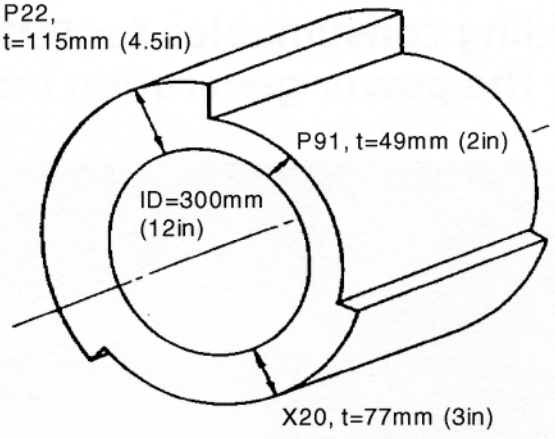
Cormet 2 FCW Application Guidelines

- Recommended for flat and positional welds ; filling V-butts and repair excavations involving material thicknesses ~ 15mm+, and for pipework with diameter ~ 200mm+.
- Designed for use with Ar + 20%CO_2 (+ or – 2%O_2).
  Wire will operate using 100% CO_2, though with slightly coarser arc operability and a minor increase in weld spatter.
- Wire is designed to offer spray metal transfer over its full operational range, with fast wire melt-off/deposition rate and reliable penetration/fusion.
- Welding parameters have a marginal effect on weld metal composition, but of limited significance when welding in the recommended parameter range.



Welding Consumables for P91-Modified 9CrMo Steel

- T91 (tube), P91 (pipe), F91 (forgings) and Gr91 (plate) are major forms of the 9Cr1Mo alloy steel composition, modified with controlled additions of Niobium, Vanadium and Nitrogen.
  These advanced creep resisting steels are already well established for use in plant designed to operate at higher pressures and temperatures, in pursuit of greater thermal efficiency and economy with modern power plants.
- The advantages of such steels is self-evident from a comparison of design wall thicknesses, for a given set of conditions, for P91, P22 and X20 CrMo steels :-



Comparison of required wall thicknesses for equivalent service.

- Progressively being incorporated in fabrication of headers, main steam piping and turbine casings in fossil fuelled power generating plants, either in the form of repairs or upgrading of existing units or construction of new plants in the UK and overseas.
- Metrode have developed a full programme of suitable welding consumables, and many hundred of tonnes of ‘P91’ products have now been supplied into the market worldwide, notably N. America, China and the Middle East.

Welding Consumables for P91

	Process	Specifications
Chromet 9MV-N	MMA (SMAW)	AWS A5.5/ASME SFA 5.5 *E9015-B9* BS EN 1599 *E CrMo91 B*
Chromet 9-B9	MMA (SMAW)	AWS A5.5/ASME SFA 5.5 *E9015-B9*
Chromet 91VNR	MMA (SMAW)	AWS A5.5/ASME SFA 5.5 *E9016-B9* BS EN 1599 *E CrMo91 R 3 2*
Chromet 91VNB	MMA (SMAW)	AWS A5.5/ASME SFA 5.5 *E9015-B9* BS EN 1599 *E CrMo91 B 3 2*
9CrMoV-N	TIG (GTAW)	AWS A5.28/ASME SFA 5.28 *ER90S-B9* BS EN 12070 *W CrMo91*
	SAW	AWS A5.23 *EB9* BS EN 12070 *(S CrMo 91)*
Cormet M91	MCW for MIG (GMAW)	AWS A5.28/ASME SFA 5.28 *ER90C-G (B9)*
Supercore F91	FCW	AWS A5.29/ASME SFA 5.29 *E91T1-B9*
LA491	Sub arc flux	BS EN 760 *SA FB 2 55 AC*
L2N	Sub arc flux	BS EN 760 *SF CS 2 DC*
9CrMoV + LA491	Wire + flux combination	AWS A5.23 *(F62 PZ-EB9-B9)*
9CrMoV + L2N	Wire + flux combination	AWS A5.23 *(F62 PZ-EB9-B9)*

Welding Consumables for Advanced 'CrMo' Steels

➢ **Chromet 92**	SMAW	9%Cr – ½%Mo + W, Nb, V, N (B).
9CrWV	SMAW	Similar benefits and applications as P91,
9CrWV + LA491	SAW	but offering 30% greater rupture strength.
Supercore F91	FCAW	
➢ **Chromet 10MW**	SMAW	For welding European E911 steel. P91 steel with added 1%W, for increased creep strength up to 600°C.
➢ **Chromet 1V**	SMAW	1¼%Cr – 1%Mo - ¼%V.
1CMV	SMAW	Good creep properties up to 580°C
Cormet 1V	FCAW	Corrosion resistant to superheated steam.
➢ **Chromet 23L**	SMAW	For Type 23 , 2¼%Cr steel + W, V, Nb (B)
2CrWV	GTAW	Steel used for water wall boiler tubing.
2CrWV + LA491	SAW	Creep rupture strength x2 that of T22 alloy.
Cormet 23	FCAW	Designed to be suitable for AW application.

Hydro-Electric Power Generation

410NiMo Stainless Steel Consumables

GTAW	SMAW	FCAW
ER410NiMo	13.4.Mo.L.R	Supercore 410NiMo

- Type 410 (13%Cr) filler metal, with added 4.5%Ni – 0.5%Mo
- 'Soft' Martensitic alloy with added ;
  - corrosion resistance,
  - hydro-cavitation resistance,,
  - Sulphide-induced SCC resistance,
  - Sub-zero toughness,

- Used extensively for welding matching alloy forgings (eg. F6NM) and castings (eg, CA6NM) in the fabrication of ;
  - Hydraulic turbine components,
  - Valve bodies,
  - Pump bowls,
  - Compressor cones,
  - Impellers,
  - High pressure flow tube pipework.

- Welding procedures required to meet specified NACE MR0175 hardness limit of <23HRC (255HB) involve a 'double temper' PWHT, typically ; 680^{0}C / 10h + Air cool to ambient + 620^{0}C / 10h.

- Alstom Power ; a prominent hydro-electric power equipment manufacturer at Grenoble (France) and Quebec (Canada) use 410NiMo FCW extensively.

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Cormet Flux Cored Wires
Cost effective for Power Station Outage

One of the major costs facing conventional power stations during outage is the repair of large scale excavations on CrMoV pipework due to creep cracking problems. Several years ago one EGWP (Electricity Generators Welding Panel) in the UK, underwrote a project on FCAW as an alternative welding process to MMA for large scale weld deposit.

The benefits of the flux cored wire process-the productivity of a continuous process, the metallurgical performance and the supportive slag-had already been identified. The panel was tasked with identifying a specific consumable which would: -

1. **Be fully all-postional**
2. **Operate in spray transfer mode in all positions without synergic pulsed equipment.**
3. **Match the composition and properties of UK EGWP 2¼Cr1Mo MMA electrode, and**
4. **Be readily available**

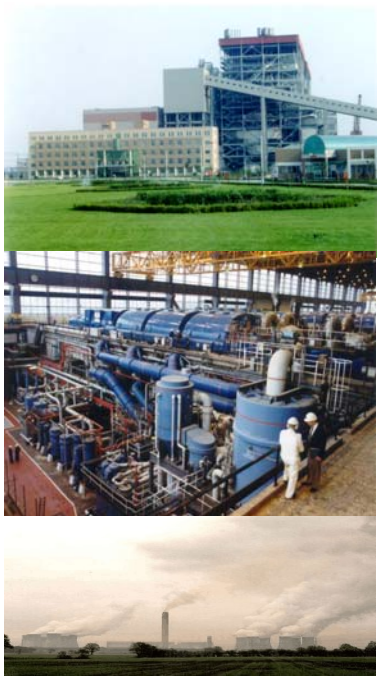
Metrode Products' **CORMET 2**, which is an all-positional 1.2mmø rutile flux cored wire, was selected and subjected to an extensive testing programme. Results showed that **CORMET 2** met the design and performance criteria, achieving a 30% improvement in welding time.

Tight quality control in production of the material combined with appropriate welder training have been identified as essential to realisation of the significant productivity gains achievable with the FCAW process.

Cormet 2 is now an approved product by Innogy (formally National Power) in the UK and has been used in significant volumes both in the UK and worldwide.

The Cormet range has been expanded and continuously developed over recent years to include versions for 1¼Cr-½Mo (**CORMET 1**) and several higher Cr specials, eg **CORMET M91**. A related product, **Supercore F91** (for P91 steels) has also been sold worldwide with huge success.

Innogy Cormet



Cormet has been used in power generating plant worldwide

Also available: -
Cormet 5 - AWS E81T1-B6
Cormet 9 - AWS E81T1-B8
Supercore F92 - for P92 steels
Cormet 23 - for T23 steels

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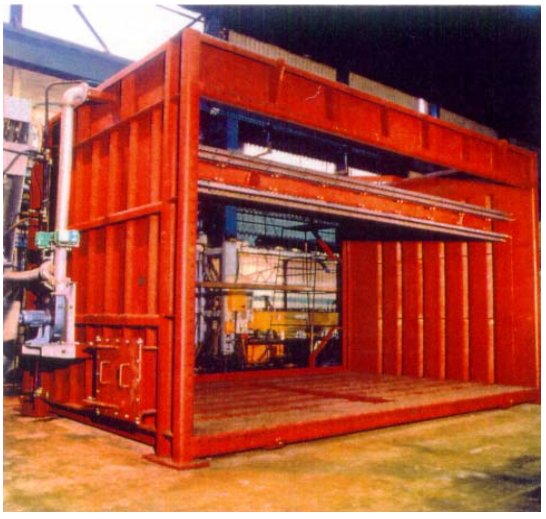
Web Site Path at www.metrode.com
Key in cormet in the search box to view data sheets and related technical information or follow the link from: alloy family to low alloy steels to cr-mo creep resisting to view all products in the Power Zone.

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

A diverting task for Cormet 2 Flux Cored Wire

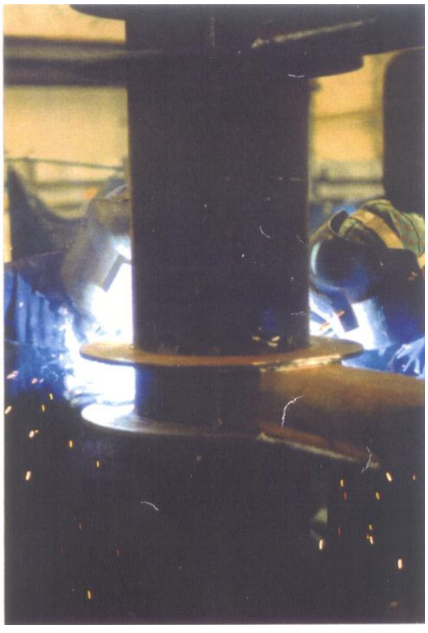
Cormet 2 flux cored wire was chosen for welding 6.5m x 3m diverter valves, part of a gas turbine fabrication contract for the export market by the Fabrication Division of Wahlco Engineered Products Ltd of Chesterfield.



Regular users of Metrode consumables, Wahlco have achieved considerable productivity improvements with stainless steel flux cored wires, which were used for the stub shafts of the diverter valve. Despite some anticipated welder resistance to the change of process, 1.2mmø Cormet 2 rather than solid wire was chosen for the diverter valves to further improve efficiency.

Cormet 2's creep-resisting properties were essential, since all the waste heat gases from the turbine, at temperatures typically around 580°C, pass through the diverter valve. It will be located between the turbine and a waste heat recovery boiler, from which the gases are vented to the stack.

Acceptable weld quality was verified through MPI testing prior to and after stress relief.



Cormet 2 - AWS A5.29 E91T1-B3M

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Key in cormet in the search box to view data sheets and current stocks

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

P91 Consumables used for Radiant Section Reformer Coils Chromet 9MV-N MMA and 9CrMoV-N TIG

Whilst P91 has been extensively used within the power generation, it's use in the hydro-carbon industries is relatively new. Western Australian based fabricator Specialised Welding (WA) has recently completed and delivered three radiant section reformer coils to the Altona Refinery (ExxonMobil) in Victoria.

The coils were fabricated from 125nb ASTM A355 grade P91 pipe, 350 & 450nb ASTM A355 grade P22 headers with ASTM A312 grade 310 support legs and 253MA hanger brackets. These materials required the qualification of welding procedures that met the very restrictive ExxonMobil requirement of 260BHN (max) for butt welds.

All materials were subject to positive material identification at all stages of fabrication. All production welds were registered by QA, all of which being subject to: -

- Strictly controlled welding preheat and interpass temperature
- Post weld heat treatment
- 100% positive material identification (PMI)
- 100% radiography amd magnetic particle testing (RT/MT)
- Hardness survey
- Full document control of welding operation.

Specialised Welding further enhanced their already excellent reputation by: -

- On time delivery of a 'fast tracked' project
- Another 1st in the Australian Welding Technology
- Welding P91 CrMo to below 260BHN
- Dissimilar welding of P91 to P22

Welding consumables for the project were supplied via Metrode's exclusive Distributor in Australia; Specialised Welding Products.

The reformer tubes during fabrication in the workshop of Specialised Welding.

9CrMoV-N
AWS ER90S-B9
Chromet 9MV-N
AWS E9015-B9

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Key P91 in the search field to view details on these and Metrode's full range of consumables.

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Metrode Chromet 9MV-N (P91) Electrodes Powering to success in China

Metrode modified 9CrMo consumables are designed to weld equivalent ‘type 91’ 9CrMo steels modified with small additions of niobium, vanadium and nitrogen to give improved long term creep properties. They are specifically intended for high integrity structural service at elevated temperature so the minor alloy additions responsible for its creep strength are kept above the minimum considered necessary to ensure satisfactory performance.

Assembly work at Huangshi Power Plant, Hubei

A power plant component fabricated by Shanghai Boiler Works using Metrode Chromet 9MV-N

China has become the fastest growing market in the world and with the development of the economy, the demand for electric power has been growing dramatically.

After many years effective marketing effort, Metrode has now firmly established its position in the high alloy consumables industry in China. The P91 range of welding consumables have been particularly strong and during the last few years several hundred tonnes of Chromet 9MV-N have been supplied.

A senior Chinese welding engineer commented “Metrode Chromet 9MV-N is the best P91 electrode we have used”.

Other products in the range, 9CrMoV-N solid wires and Supercore F91 flux cored wire are also being sold in significant volumes.

P91 Range

MMA	Chromet 9MV-N	E9015-B9 - AWS/BS EN
	Chromet 9-B9	E9015-B9 - AWS/ASME
TIG	9CrMoV-N	ER90S-B9
SAW	9CrMoV-N	EB9
FLUX	LA491	SA FB 255AC
	L2N	SF CS 2 DC
FCW	Supercore F91	E91T1-B9

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Key P91 into the search box

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

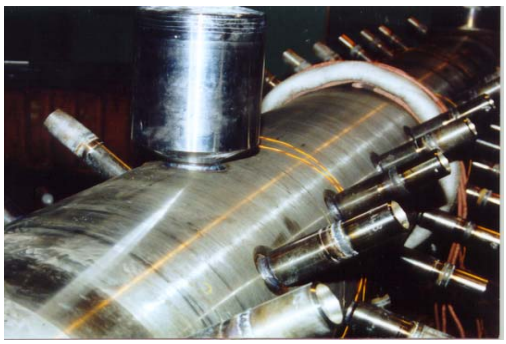
Chromet 9MV-N Electrodes for Header Fabrication

Senior Thermal Engineering Limited at Wakefield have successfully used Metrode **Chromet 9MV-N - E9015-B9** electrodes for header fabrication in 9Cr modified steel.

Particular features of the consumables identified were: -

- Excellent all-positional operation
- Good weld profiles and de-slagging.

100% ultrasonic and MPI testing was carried out.



General view of header assembly showing 9CrMo TIG root and Chromet 9 buttering.

The six headers were incorporated into three UK Power Stations, for service at elevated temperatures.

Buttering to standard 9CrMo base steel was carried out using Metrode **Chromet 9 - E8015-B8** electrodes.

Welder using Chromet 9MV-N on fabrication of header

Matching Metrode **9CrMo - ER80S-B8** was used for all root runs. Transition joints to stainless steel were carried out with Metrode **20.70.Nb - ERNiCr-3** nickel base TIG.

Transition joints using 20.70.Nb

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Key in 9cr in the search box and go to the selected products for details on the 9CrMo types, key 182 to go to the details on 20.70.Nb TIG
Note! The details on Chromet 9MVN can be found on data sheet A-17 which covers all P91 types

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

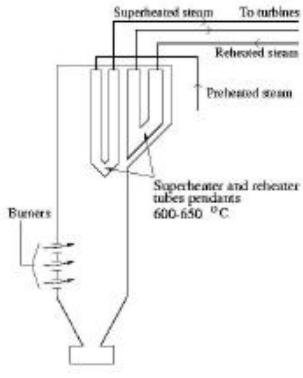
Drax Power – Esshete 1250
Austenitic stainless steels in steam power generating plants

The part of a steam power plant we are interested in can be (that's simplistic) seen as a huge kettle. In the superheater tubes, high pressure 'water' circulates and is heated to temperature around 650°C before being sent to the turbines. There is interest in constantly increasing the service temperature, as this improves the efficiency of the plant.
The material used for superheater tubes must have excellent corrosion and **creep resistance**. *Creep* is a time dependent deformation under a stress which is below the yield stress of the material (that is the stress above which a material undergoes 'instantaneous' plastic deformation).

There are several creep mechanisms, which become predominant under different temperature and stresses. For example, at low stresses and relatively high temperatures, creep deformation will be essentially due to the movements of vacancies (holes in the atomic arrangement) from the region under tension to those under compression, where they have a lower energy.

At higher stresses, *dislocations* can move, but the stress to which they are submitted is not large enough for them to pass the obstacles. To pass the obstacle, they must climb (and this process again involves diffusion of vacancies). Creep resistance is therefore enhanced if there is a fine dispersion of particles in the matrix, that is many obstacle for the dislocations. A way to achieve this which has been exploited for many years is to add to the steel elements like Ti or Nb, which combines with the carbon or nitrogen present in the steel to form a very fine dispersion of particles in the grains. But all precipitates are not beneficial to creep properties, either because they form coarse precipitates on the grain boundaries, or because they remove solute elements from the matrix (elements in solution also contribute to the strength)... It is therefore important to be able to predict which phases one can expect to form for a given composition of steel.

Drax Power Limited owns and operates Drax Power Station, the largest, cleanest and most efficient coal-fired power station in the UK. The output capacity of their six generators is 4,000 megawatts, and currently provide enough power to meet 7% of the UK's electricity needs. The superheater tubes at Drax are made from a special creep resistant austenitic stainless steel called Esshete 1250 and Metrode has recently completed an order for nearly 3 tonnes of matching TIG Wire.



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Ni-Base SMAW Electrode for Welding CrMo Steels

EPRI P87

Basic coated positional SMAW electrode

Product description

MMA electrode with a special basic flux covering on a nickel-iron alloy core wire. The electrode is optimised for DC+ welding in all positions including fixed pipework in the ASME 5G/6G positions.

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

Specifications

Currently no relevant national standard but there is a patent pending.

Materials to be welded

Designed for dissimilar joints between austenitic stainless steels (eg. 304H) and creep resisting CrMo (eg. P91). Suitable for as-welded, PWHT or N+T joints in CrMo steels.

Applications

EPRI P87 electrode is designed for welding high temperature creep resisting CrMo steels, including P91. The electrode can be used for dissimilar applications between CrMo creep resisting steels and austenitic stainless steels. The EPRI P87 electrode is also suitable for joining CrMo steels to themselves.

The EPRI P87 weld metal is also proposed for N+T joints in P91. The weld metal will allow joints to be buttered in the workshop and then subjected to a full N+T heat treatment; joints on the buttered faces can then be completed in the field without the need for PWHT.

The all-weld metal strength at ambient temperature may not meet that of P91 but transverse tests have shown strengths above the P91 base material requirement, and elevated temperature strength exceeds the minimum base material requirement.

Microstructure

High alloy austenite.

Welding guidelines

Preheat and PWHT requirements will be determined by the base material being welded. For example P91 is normally preheated to 200°C and PWHT at 760°C for 2 hours (or time appropriate to material thickness). Alternatively if P91 is subjected to a full N+T the heat treatment would typically be 1060°C/1 hour + 760°C/2 hours.

Additional information

The alloy is balanced to provide excellent resistance to carbide formation at the fusion boundary. The thermal expansion coefficient is also closer to the base material than with standard nickel base weld metals.

Composition (weld metal wt %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Fe
typical	0.1	1.5	0.3	0.008	0.008	9	Bal	2	1	38

All-weld mechanical properties

Typical values			Ambient	Hot strength 593°C	
			as-welded	as-welded	N+T
Tensile strength		MPa	560	530	440
0.2% Proof stress		MPa	360	340	225
Elongation on 4d		%	34	21	25
Reduction of area		%	49	24	33
Impact energy	+20°C	J	80	--	--

Parameters

DC +ve

ø mm	2.5	3.2	4.0
min A	60	70	90
max A	80	110	150

Packaging data

ø mm	2.5	3.2	4.0
length mm	305	355	355
kg/carton	12.6	15.0	14.7
pieces/carton	684	420	264

Storage

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for much longer than an 8h working shift.
For electrodes that have been exposed:
Redry 200-250°C/1-2h to restore to as-packed condition. Maximum 350°C, 3 cycles, 10h total.
Storage of redried electrodes at 100-200°C in holding oven or 50-150°C in heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, >18°C.

Fume data

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	F	OES (mg/m^3)
9	5	6	2.5	<0.5	12	2

Nuclear Power Generation

Nuclear Steam Supply System

eg. Pressurized Water Reactor (PWR)

A global market on the move

Predictions from informed sources ;

“100 new NPS’s requirement for China over next 20 years.”

“700 to 800 NPS’s worldwide requirement over next 20 years,”

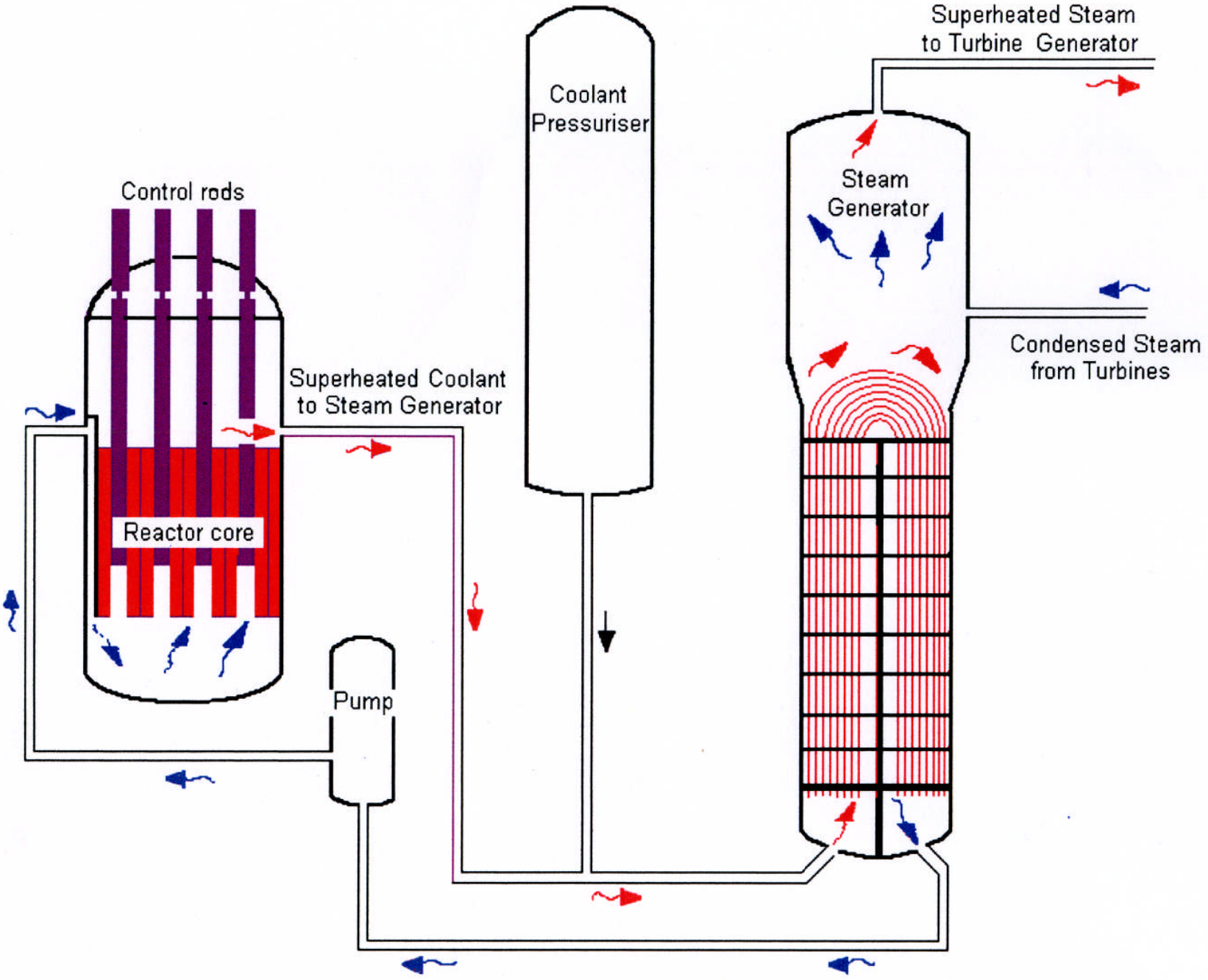
Manufacturing requirement for replacement equipment expected to add to these figures.

Major design & manufacturing companies include ;

- AREVA (Framatome (Fr) + Siemens (G))
- Westinghouse (USA)
- Mitsubishi (Jp)
- Equipos Nuclearis (Sp)
- Ansaldo (It)

METRODE WELDING CONSUMABLES

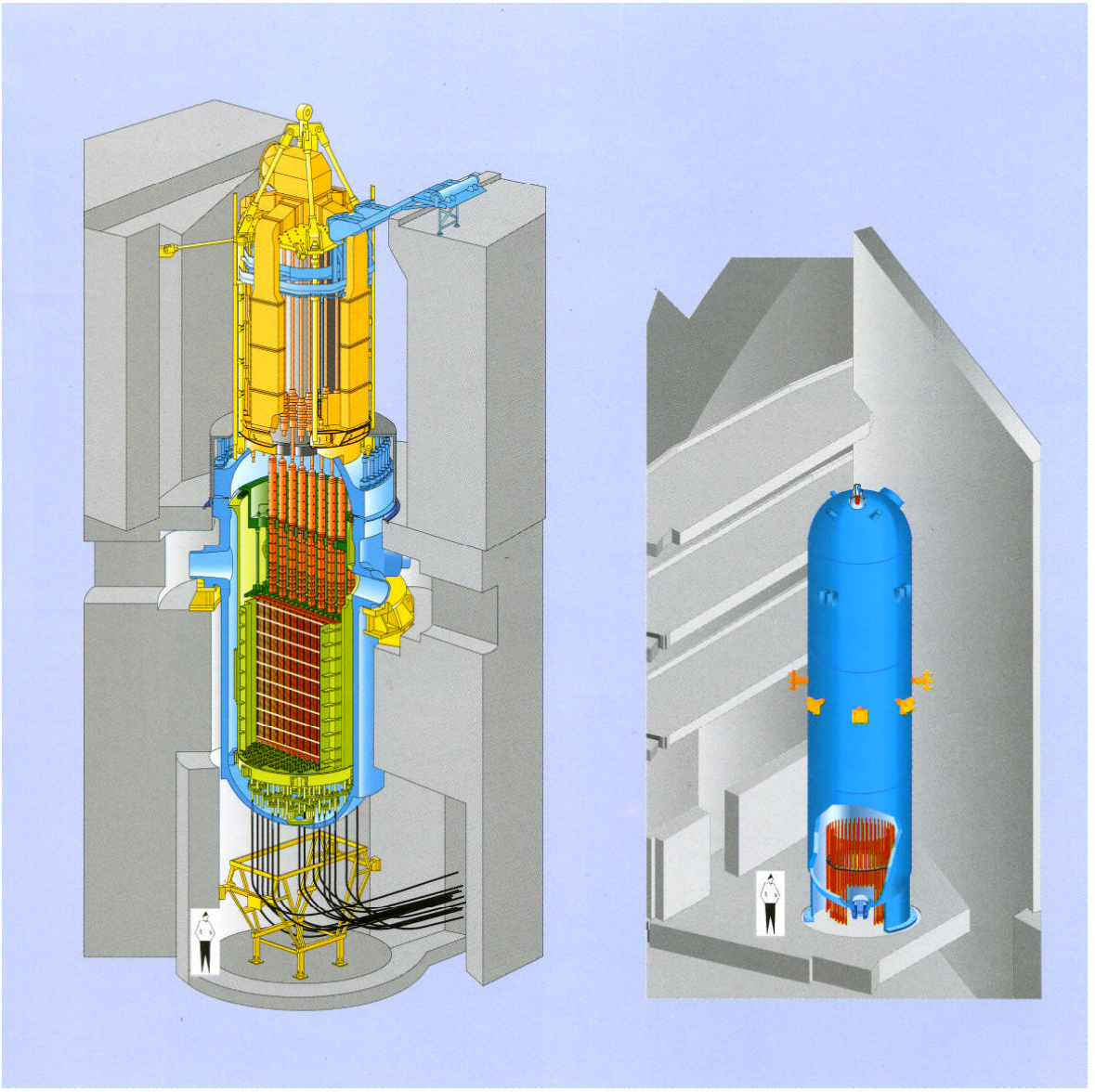
Schematic Outline of Nuclear Steam Generator



Nuclear Steam Supply System

Nuclear Reactor

Pressurizer



Low alloy steel (Ni-Cr-Mo-V) shells

5m Ø, 13m high, 430 tonnes

Wall thickness : 200-275mm

2.8m Ø, 13m high, 113 tonnes

Wall thickness : 110mm

Internal surface of both shells ESSC clad 309L + 308L

PWR Nuclear Power Plant Fabrication at AREVA (Fr)

Major alloy welding consumables types used

309L)
308L) Strip for vessel internal overlaying ;

0.4mm thick x 50, 75 & 150mm wide ;
Electroslag Strip Cladding process (ESSC).

0.5mm thick x 60mm wide ;
SAW strip cladding process.

GTAW wire and SMAW electrodes for attachments

308L & 316L) GTAW wire and SMAW electrodes for attachments
182 type alloy) and repairs.

Grade 690 Ni-base alloy ;

Type 52 0.8mm wire ; Mechanised GTAW butt joints

1.2mm wire ; Plasma + Hot Wire GTAW tubeplate overlaying.

Type 152 2.5, 3.2 & 4mm SMAW electrodes

Application Study

METRODE WELDING CONSUMABLES
A Lincoln Electric® Company

Metrode Products Limited, Hanworth Lane, Chertsey, Surrey, KT16 9LL UK
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Metrode 308L Consumables used on vessel for polyethylene unit

EQUATE

The vessel was fabricated by Heavy Engineering & Construction Company for the Olefins-2 Polyethylene Unit being constructed on the site next to Equate in Safat, Kuwait.

Artist's impression of completed site

It is to be used in the expansion of the existing capacity of 600,000 metric ton per annum for Polyethylene by 225,000 per annum, using UCC's UNIPOL™ Polyethylene technology. Flour Corporation are the consulting engineers and contractors for the project.

Metrode Consumables Used

308S92 Sub Arc Wire ø2.4mm = 650kg
SSB submerged arc flux = 950kg
Supercore 308LP flux cored wire ø1.2mm = 375kg
308S92 TIG Wire ø2.4mm = 10kg

Vessel in the workshop of Heavy Engineering

308 product range – full details on the website

Process	Product	Specification
MMA	**Supermet 308L**	AWS E308L-17
	Ultramet 308L	AWS E308L-16
	Ultramet B308L	AWS E308L-15
	Ultramet 308LP	AWS E308L-16
TIG	**308S92**	AWS ER308L
MIG	**Supermig 308LSi**	AWS ER308LSi
SAW	**308S92**	AWS ER308L
	SSB	BS EN SA AF2
	LA491	BS EN SA FB255
	L2N	BS EN SF CS 2
FCW	**Supercore 308L**	AWS E308LT0-4
	Supercore 308LP	AWS E308LT1-4

METRODE APPLICATION STUDIES

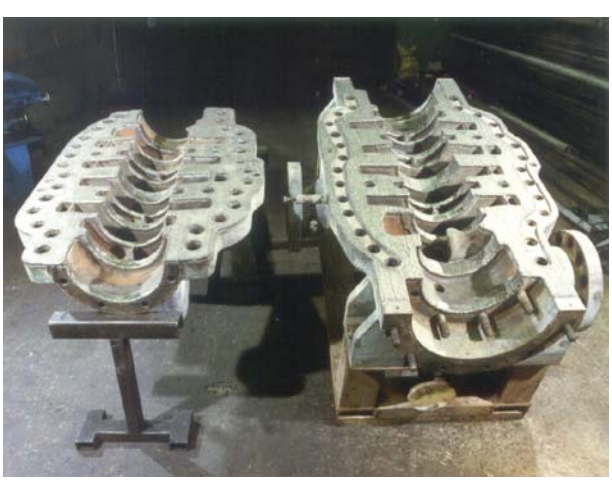
New Pumps for old with Metrode Ultramet Stainless Steel MMA Electrodes

Metrode Products **Ultramet 309L** and **Ultramet 347** MMA electrodes were used in the urgent reclamation of a 5' x 2' pump casing by the Manchester service centre of Weir Engineering Services, a division of Weir Pumps Limited of Glasgow.

The multistage horizontal split pump casing had suffered extensive erosion from the mixture of caustic soda, sand and water pumped during ten years operation in an aluminium smelting plant.

After all joint and bore surfaces had been machined back approximately 3mm, the entire surface area was reclaimed, using **Ultramet 309L** as the buffer layer with **Ultramet 347** for the overlay. After re-machining, the removed pump casing was re-instated, as new, in the aluminium plant.

The smooth operability of both electrode types contributed significantly to the success of the operation, the welding being completed during three solid days and nights of work.



Pump casing after completion of the reclamation using Metrode Ultramet

Ultramet 309L - E309L-16
Ultramet 347 - E347-16

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Key ultramet in the search box

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Columns and Drums for BP Gas Processing Plant
Metrode Stainless Steel Consumables in action

Wellman Robey (previously FKI Babcock Robey) of Oldbury in The West Midlands, completed a significant contract placed by Linde of Germany for columns and drums for use in a BP Gas Processing Plant.

Because of the high temperature processes involved, parts of some of the massive columns were fabricated in stainless steel clad carbon steel, with stainless steel used in the lower temperature areas. One column was all carbon steel.

The picture below is one of the carbon steel/stainless steel columns. The facing (higher temperature) end is carbon steel, internally clad with 347, using Metrode **Ultramet 309Nb** electrodes for the buffer layer and Metrode **Ultramet 347** for the top layer. Major seams were 309/347 sub arc clad. On the upper 308 stainless steel section, Metrode low carbon **Ultramet 308L** rods were used.

Joining the stainless steel to the carbon steel sections necessitated stress relief. Metrode's **Nimrod 182** was used both for the buttering layer prior to stress relief and for the final closure of the joint.

Stainless steel drums of 347 type also formed part of the contract. Sub Arc welding was used for the major seams and Metrode **Ultramet 347** where nozzles and other protrusions made access more difficult.

Ultramet 309Nb - AWS E309Cb-16
Ultramet 347 - AWS E347-16
Ultramet 308L - AWS E308L-16
Nimrod 182 - AWS ENiCrFe-3

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Key in Ultramet or Nimrod in the product info search box to view data sheets and other information.

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

No tolerance for replacement agitator Metrode Supermet 316L, Nimrod AB & Nimrod 182 Electrodes

Specialist fabricators Brolit Welding of Bolton fabricated a replacement agitator vessel, designed to ensure greater resistance to corrosion than the aluminium bronze of the vessel it replaced. After previous successful use of Nicrofer 4221/Alloy 825, the Company and customer decided on this material for all parts of the fabrication which come in to contact with the chemicals during the mixing process.

Drawings were made from the existing vessel, special attention being paid to close engineering tolerances, since the vessel was to fit precisely into the pipes and flanges of the existing process line. A +or-1mm tolerance was allowable for the water jacket to fit into the manifold and for the drive shafts into the gear box mountings.

The 3.5m vessel was 5.5m long and weighed 27 tonne. The internal wall and dished ends were fabricated in 15mm thick Nicrofer 4221 material, completely water jacketed in 316L steel. The agitator blades, connecting rod and shafts were also fabricated in Nicrofer

MMA electrodes from Metrode Products Limited were used for all the welding in the fabrication. The vessel itself was butt and fillet welded throughout using 3.2mm, 4mm and 5mm **Nimrod AB** electrodes. The water jacket was welded with **Supermet 316L** electrodes and **Nimrod 182** was used for the dissimilar welding of the 110mm thick CMn steel flanges and the 316L water jacket to the vessel.

The vessel was placed on rollers to simplify fabrication, although some positional welding to the water jacket in Nimrod 182 was needed towards the end of the project after nozzle assemblies had been fitted and welded into position. A special jig was manufactured to ensure correct alignment of the shafts.

Left - view of agitator, prior to assembly into vessel.

Right - Vessel

Nicrofer is a trade name of VDM

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Key supermet or nimrod in the search box to go to product details and view data sheets.

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Metrode Consumables - where safety comes first

British Steel Engineering (now Corus Process Engineering) Workington plant supplied twenty two Mark II A2 AGR flasks to BNFL (now British Energy) for transport of nuclear spent fuel from power stations for reprocessing at Sellafield.

Fabrication of a flask underway

Stringent testing of the previous flask design included the highly public demonstration in which a flask was 'challenged' by a locomotive travelling at 100mph.

Each flask and lid, using a monolithic design, were machined/fabricated to a final weight of 50 Te, with outside dimensions of 2.5m long x 2.1m wide x 2.3m high.

BSc used Metrode MMA and FCW for welding the vessel, both types of consumable offering sound, economic deposition of weld metal over large areas.

Totally defect-free internal surfaces were required for these vessels, to ensure complete decontamination in an uncomplicated procedure. Integrity of the parent material and weld seams was also necessary, to provide maximum corrosion resistance.

A perfect fit between each flask and its lid ensures efficient containment of the spent fuel product. A 12mm depth of weld material was used to clad the mouth of each flask, varying the weld process between MMA and FCW, procedures for both processes having been approved.

Several passes of Metrode **19.9.L.HE** low carbon electrodes, or **Supercore 308L** (FCW), were used, following the deposition of a buffer layer in **Supermet 309L**. The cladding was machined down to a perfectly fitting surface of 9mm of weld metal, with a tolerance of only +0.2mm.

British Energy
PASSIONATE ABOUT TOMORROW, today

A waste fuel transit flask being lowered into pond 5 at British Energy Sellafield Site.

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Key in supermet or supercore to view product details.
19.9.LHE is now made to special order, contact Metrode on the above numbers for further details.

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Metrode Supermet 316L & 316S92 TIG Used in solvent recovery tank

A 6m x 3.9m solvent recovery tank was constructed by Fabrication Technology of Oldham.

The finished tank, weighing 5 tonnes, was installed in the MMO process plant at Albright & Wilson's works in Whitehaven, Cumbria.

The process plant uses a solvent extraction method to remove impurities from commercial grade phosphoric acid, converting into technical grades used for the manufacture of industrial chemicals, or into the greatly purified food grade. Solvent recovery is an essential part of the operation.

The tank contains up to 66.3m^3 of used solvent at up to 50^{o}C. To ensure resistance to the liquids it was constructed in 5mm to 8mm thick 316 Stainless Steel.

After consumable trials to establish electrodes which would provide matching corrosion resistance, Metrode **Supermet 316L** electrodes and **316S92** TIG wire were selected. Fabtec, already familiar with these electrodes through earlier work, reported, "excellent welding characteristics, giving defect free welds of high quality". Easy slag removal was also noted.

All welds were radiographically tested before the tank was delivered.

Completed tank being prepared for delivery.

Supermet 316L
AWS E316L-17
316S92
AWS ER316L

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Key supermet316l or 316s92 in the search box to view data sheets

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Specialist Non-Magnetic Welding Consumables for Marine Stainless and Superconducting Applications

The use of stainless steels in critical areas of ship construction, particularly those likely to be exposed to corrosive environments, has expanded in recent years. In particular, there has been rapid growth in the construction of bulk chemical carriers with stainless steel tanks, initially in type 316L steels, but more recently in duplex stainless steels where the combination of higher strength and increased corrosion resistance has proved to be advantageous. Metrode manufacture a complete range of welding consumables for all major welding processes for 316L and Duplex stainless.

Another, more specialised, application in shipbuilding for which Metrode offers a range of welding consumables is the use of **fully austenitic** stainless steels for engineering components in mine hunters where a low magnetic profile is an essential requirement.

Metrode offers a range of consumables, listed below, which, with their high nickel and controlled nitrogen contents, give a fully austenitic and **non-magnetic** weld deposit with a maximum permeability of 1.01. In addition, the consumables are designed with a relatively high manganese content which ensures freedom from microfissuring and hot cracking in the ferrite-free weld metal, particularly when used for the fabrication of thicker and more highly restrained components.

The fully austenitic microstructure gives excellent strength and toughness at cryogenic temperatures for joining 304L and 316L **LPG** and **LNG storage vessels**. Useful toughness is also maintained down to liquid helium temperatures -269°C (4°K) for superconducting applications.

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

Superconducting Magnets, manufactured by Tesla Engineering Limited

HMS Bridport one of the Sandown Class Minehunters built by Vosper Thornycroft for the Royal Navy.

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

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Key NF in the product info search field to view all relevant technical information

METRODE APPLICATION STUDIES

Metrode Supercore 316L FCAW
Used to weld limpet coil to reactor vessel

Fabrication Technology Limited of Oldham, used Metrode Supercore 316L to weld a Limpet Coil on to a reactor vessel, manufactured for a leading British chemical company.

The vessel is made from ASTM A240 type 316L stainless steel. The tube was in ASTM A312 type 316L stainless steel, 3.05mm thick, with a nominal bore of 3".

Use of Metrode Supercore 316L flux cored wire produced excellent weld quality with a noticeable economy through reduced production time.

Welding of the limpet coil to the reactor vessel

Specifications & Approvals
Supercore 316L

AWS A5.22	E316LT0-4
BS EN 12073	T 19 12 3 L R M 3
Approvals	TÜV, Germanischer Lloyd

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Key supercore 316l into the search box

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Supercore 316L - E316LT0-4
For continuous fillet welds in 6mm plate

Teddington Engineered Solutions (formally Teddington Bellows) gained the productivity benefits of Metrode's Supercore flux cored wire in the fabrication in ASTM A240 TP316L of a 3.25m diameter circular duct in 6mm thick plate.

Bellows mounting rings in 9mm thick x 25mm wide flat bar were needed on the inner surface of the duct.

The bar was tacked in position and fillet welded to the duct using 1.2mmø Metrode **Supercore 316L** flux cored wire and an Argon/20% CO_2 shielding gas.

The fillet size of 6mm was achieved with a single pass, the duct being mounted on a rotator, tilted to 45%, to give optimum penetration and form.

Mike Musgrave, Technical Manager of Teddington Bellows, reported that "the weld profile was excellent, the deposit virtually self deslagging. The low heat input reduced distortion to a negligible level"

Further components were added to the fabrication, also welded with Supercore 316L. In this case a continuous 3mm leg length fillet was also achieved, with minor adjustments to the welding speed.

Welding bellows mounting ring to the 3.25m dia duct using Supercore 316L

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Key supercore in the search field to view details on all our range of stainless steel flux cored wires

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Supercore 347 Flux Cored Wire In Critical Applications

Springfields, near Preston, Lancashire, is the site of the BNFL's UK fuel manufacturing operations and has been making nuclear fuel since 1946.

Processing several thousand tonnes of uranium a year Springfields has the experience and technology to make fuel for all major designs of nuclear reactor across the globe.

Springfields was the first plant in the world to make civil nuclear fuel for a commercial power station and to date has produced several million fuel elements and provided products and services for over 140 reactors in more than 12 countries.

Springfields selected Metrode **Supercore 347** to fabricate ten magnesium reduction reactor vessels, in 321 Ti stabilised stainless steel. The vessels are used in the processing of uranium.

The particular features identified by BNFL were: -

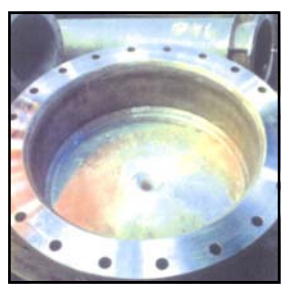
⇒ Weld metal quality

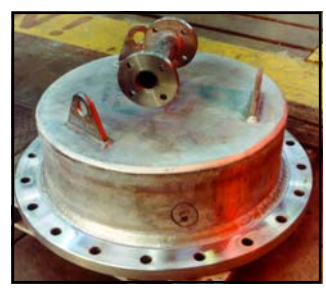
⇒ Consistent and reproducible weld metal chemistry.

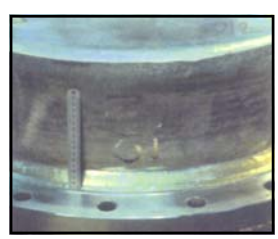
⇒ Welder appeal.

Welding is also carried out to effect repair of vessels already in service. The regular and satisfactory usage of this product further emphasises the consistency of design, manufacturing and operation of the wire by a demanding end user in their own workshops.

BNFL



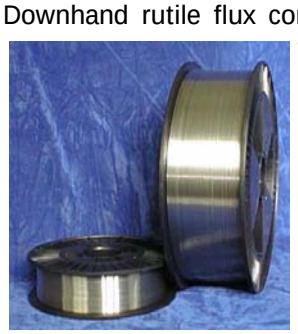




The pictures show the general arrangement of the vessels and the lids and, in detail, the excellent appearance and profile of the weld.

METRODE Supercore

Supercore 347
AWS A5.22 E347T0-4
BS EN 12073 T19 9 Nb R M 3
Downhand rutile flux cored wire for 321/347 austenitic stainless steels



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Key supercore347 in the search field

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

No-Purge Fabrication with Metrode Superoot Flux Cored TIG

Heatfab Services of Ossett, West Yorkshire, found Metrode's **Superoot 316L** Flux Cored TIG Wire enabled them successfully to undertake a particularly complex stainless steel fabrication for British Nuclear Fuels Plc.

In eight rows, along the 7.5m length of a 400mmø, 12mm wall thickness pipe, a total of 180 stainless steel bars were to be positioned, each one extending right through the pipe. 360 bevelled holes had been provided for the precision fixing of each 24mmø bar. Due to the length and diameter of the pipe, it was acknowledged right from the outset that welding could only be undertaken from the outside of the pipe, with full root fusion and an adequate root bead profile being a primary requirement.

However, two major difficulties were encountered. Firstly, the solid bars dissipated heat, resulting in poor root fusion and lack of root bead; and secondly, standard purging procedures would be impossible.

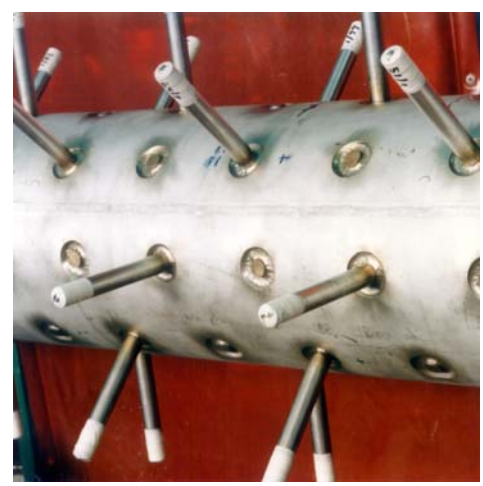
To purge the entire pipe was not practical, as this would prevent internal inspection of each root pass until all welding had been completed and weld integrity could therefore not be guaranteed. Individually purging each weld would necessitate awkward and time-consuming use of a special purge box on the root of every weld.

To overcome the first problem, Heatfab Services developed a weld penetration designed to overcome the heat dissipation problem, allowing full fusion welding of the solid bars into the pipe, ensuring good root profile.

The purging problem was tackled in a joint venture with Metrode Products Limited. The use of Metrode's Flux Cored TIG wire was tested and its suitability for use completely without purging established.

After mechanical tests both the joint design and the use of flux cored TIG were approved by BNFL.

Metrode's 2.2mmø **Superoot 316L** Flux Cored TIG filler wire consistently produced the required root profile, enabling the fabrication to progress efficiently and cost effectively to a successful completion.



Superoot 316L AWS A5.22 R316LT1-5

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Key in superoot in the search box to view data sheets, current stocks and pricing details on this product.

METRODE APPLICATION STUDIES

METRODE WELDING CONSUMABLES

Metrode Superoot 316L
Used for Limpet Coils on food processing vessels

Use of Metrode **Superoot** in the construction and repair of limpet coils on food oil processing vessels at Leon Frenkel Limited of Kent has completely eliminated the requirement for back purging. With conventional TIG techniques, a total purge volume of 15m^3 would have been necessary.

Full penetration, single sided welds were successfully carried out using the 316L grade to full X-ray standards.

Excellent profiles were obtained in the vertical position.

Fig 1 Superoot in operation

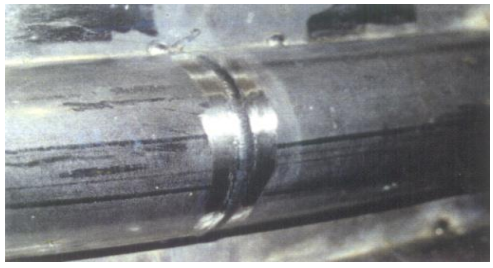

Fig 2 Close up of vertical seam

Subsequent fillet welding, carried out with Metrode **19.12.3.LHE** electrodes gave excellent weld profile and self releasing slag, with the advantage of maximum productivity.

Fig 3 10 tonne vessel in production

Fig 3 Completed header

Branches and flanges on headers, where access and manipulation were restricted, were welded with Metrode **Ultramet 316L** all positional electrodes.

Maintenance engineer Ron Barnes of Leon Frenkel identified an additional benefit of the product in a maintenance environment where frequent stop/starts are unavoidable. In these circumstances, no re-purging is needed when Metrode **Superoot 316L** is used.

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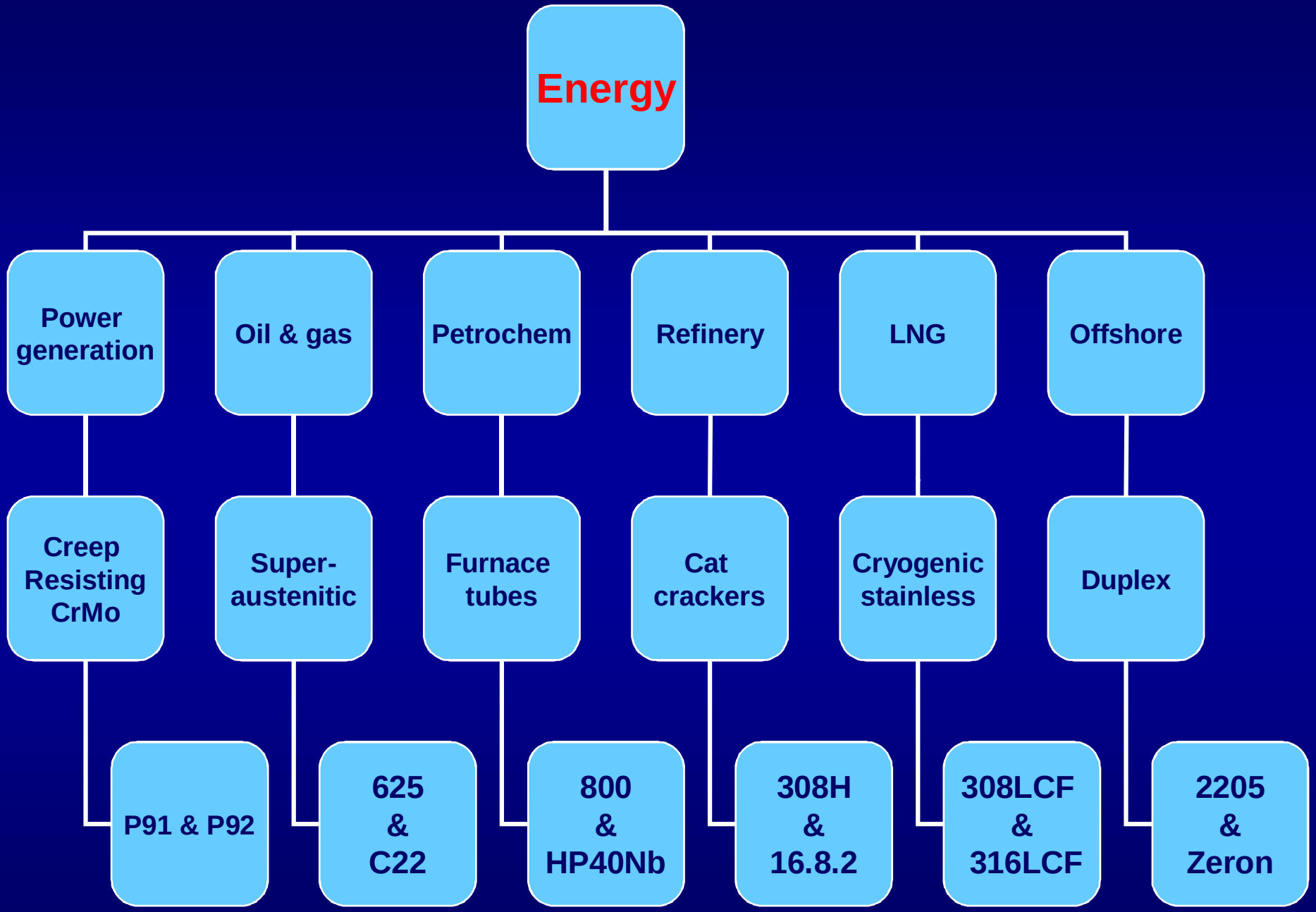
Key in superoot, ultramet or 316l in the search box to view; data sheets, current stocks and pricing details on these products. Contact Metrode for further information on 19.12.3.LHE (high efficiency 316L type MMA electrodes)



LINCOLN ELECTRIC

METRODE WELDING CONSUMABLES