ULTRAMET B

BASIC COATED STAINLESS STEEL ELECTRODES

CONTENTS

		Page
1.	Introduction	1
2.	Product Range	3
3.	Features and Benefits	4
4.	Properties	5
5.	Practical Considerations	6
6.	Application Studies	7
	Appendix Weld Procedure Records	

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1. INTRODUCTION

Pipework joining is one of the most common and critical welding operations in the construction of plants for the offshore oil/gas, petrochemical and chemical process industries. Although a great deal of the pipework may be carbon steel, there is a growing usage of stainless steels and more exotic alloys, not only to withstand increasingly severe process environments and satisfy more onerous safety requirements, but also to gain the benefits of reduced operational lifetime costs.

Welding of stainless steel pipe falls into two broad categories: those joints that can be rotated, and those which must be welded in-situ. Where pipework sub-assemblies can be rotated, the welding

operation can be carried out in the flat position to take full advantage of gravity. Thus weld deposit geometry can be controlled with high deposition rate welding processes, and the associated large size weld beads. This presents an opportunity to use semi- and fully-mechanised welding processes capable of combining non-stop, full circumferential welding operation with high current, fast melt-off joint filling.

This production route is predominantly confined to workshop fabrication of simple single-axis sub-assemblies using mechanised welding plant. With more complex configurations, and non-rotatable weld joints often encountered with final installation of pipework systems on-site, the arc welding process options are reduced. Only those which can operate effectively and reliably in other than the downhand (gravity)position can be used. For these situations, manual welding using the tungsten inert gas (TIG) and manual metal arc (MMA) processes is one of the most effective options.

Manual welding in position is a potentially difficult operation, especially with pipework where the welder has to skilfully negotiate a continuous change in angle of approach around a 360° circumference. MMA electrodes, by virtue of their optimised flux covering offer an effective solution.

A development project by Metrode Products Ltd aimed at the formulation of flux covered stainless steel welding electrodes which would ease production of such high integrity welds has resulted in the Ultramet B range. Suitable for welding all the standard 300 series grades of austenitic stainless steel pipe, Ultramet B electrodes meet the twin objectives of weld joint reliability and maximum productivity. Their main features are:

- operability that allows complete control of a molten weld pool to give a flat profile deposit combined with satisfactory fused penetration

- clean release of weld deposit's protective slag layer.

These attributes virtually eliminate the need for inter-run grinding to remove residual slag and dressing of uneven weld beads. Both aspects are essential to a weld's final radiographic acceptability in terms of freedom from slag inclusions which could threaten mechanical performance in service. With increasing pipe wall thickness, the demand for weld integrity intensifies, not only in terms of soundness of the multi-run welding operation but also the metallurgical 'cleanliness' of the deposit. With Ultramet B electrodes, this is achieved by the refining capacity of the fully basic 'B' type flux covering which also results in welds with improved fracture toughness. This is particularly relevant to the utilisation of stainless steels with design requirements down to cryogenic temperatures.

The new Ultramet B electrodes are intended to cover many of the site requirements of the process plant industry's fabrication of standard austenitic stainless steels in structural, pipework, fittings and vessel installations with welds made both positionally and downhand.

2. PRODUCT RANGE

The Ultramet B product range is shown in Table 1 along with national specifications and nominal deposit analyses.

Table 1: Specifications and nominal analysis

Electrode	Specifications		Nominal Analysis wt %						Ferrite
	AWS A5.4	BS EN 1600	C	Mn	Cr	Ni	Mo	Other	FN
Ultramet B308L	E308L-15	E19 9 L B 42	0.03	1	19	10	-	-	5
Ultramet B347	E347-15	E19 9 Nb B 42	0.03	1	19	10	-	0.5Nb	7
Ultramet B316L	E316L-15	E 19 12 3 L B 42	0.03	1	19	12	2.6	-	5
Ultramet B309L	E309L-15	E 23 12 L B 42	0.03	1	23	13	-	-	12
Ultramet B316NF	-	E 18 15 3 L B 42	0.03	3	18	16	3	0.15N	Nil
Ultramet B904L	E385-15	E 20 25 5 Cu NLB 42	0.03	2	21	25	5	1.8Cu	Nil
Ultramet B308H	E308H-15	E 19 9 H B 42	0.05	1	19	10	-	-	3
E16.8.2-15	E16-8-2-15	(E16 8 2 B)	0.05	2	16	8	1.2	-	3
Ultramet B310Mn	(E310-15)	E 25 20 B 42	0.1	3	26	21	-	-	Nil

Note: Products also available to special order – Ultramet B347H (347 with 0.04-0.08%C), Ultramet B309Mo, Ultramet B209 (AWS E209-15) and Ultramet B316LCF (a 316L for cryogenic applications).

The Ultramet B308L, B347 and B316L electrodes are the main Ultramet B grades available, which are designed for welding the standard austenitic stainless steels 304/304L, 321/347 and 316L respectively. To complete the range of standard 300 series stainless steel there is also an Ultramet B309L for dissimilar joints, buffer layers and for joining clad pipe.

The Ultramet B316NF is a fully austenitic type with a modified 316L composition primarily designed for applications requiring non-magnetic weld deposits. The Ultramet B316NF also finds uses for cryogenic applications, with useful properties down to –269°C (-452°F) and for service in nitric acid. The Ultramet B904L is another fully austenitic alloy which is used for joining matching 904L corrosion resistant base materials.

The three remaining Ultramet B products are all designed for high temperature applications. The

Ultramet B308H and E16.8.2-15 (an Ultramet B electrode but without the Ultramet B name) are both used for welding 300H stainless steels for service in the temperature range 400-800°C (750-1470°F). They mainly find applications in the petrochemical and chemical process industries and there is further information available on their use in refinery cat crackers in another Technical Profile. The final type, Ultramet B310Mn, is mainly used for welding furnace equipment and heat shields of matching 25%Cr-20%Ni (310) composition, which are used for their oxidation resistance at temperatures up to ~1200°C.

Finally there is another group of electrodes which share the Ultramet B design, that is the duplex and superduplex electrodes 2205XKS, Zeron 100XKS, 2507XKS and Ultramet B2553. The applications and properties of these consumables are covered in detail in the Technical Profile on Duplex Ferritic-Austenitic Consumables and are therefore not detailed here.

3. FEATURES / BENEFITS

What are the attributes of the Ultramet B electrodes that make them so special? It is recognised that there have been significant advances in other arc welding processes, particularly flux cored arc welding, but the flexibility, adaptability and simplicity of the MMA process means it still has an important part to play in site fabrication where the complexities of equipment and shielding gases need to be avoided.

3.1 Positional welding capability

The Ultramet B flux design and inherent characteristics of the basic slag system provide superb weld pool control. This means that the weld metal goes where the welder puts it and achieves minimum convexity even in the 5 to 7 o'clock position of a 5G/6G pipe butt joint. This performance is maintained even under high interpass temperature conditions, and throughout the length of the electrode. This feature is particularly important when access is restricted under site conditions.

3.2 Slag release

The general positional welding capability of basic coated stainless steel electrodes is widely acknowledged but the biggest break-through with the Ultramet B range is the achievement of exceptional slag release and bead finish. The beads have a consistent bead ripple with clean slag release leaving no secondary slag. This virtually eliminates the need for post weld dressing and reduces welder non-arc time (downtime) to a minimum.

3.3 Weld quality

The usability of the Ultramet B electrodes combined with easy slag removal results in welds of high radiographic quality. The outstanding operability and welder appeal of the Ultramet B electrodes enable welds of high quality and cosmetic appearance to be produced by any competent welder. The basic slag system produces metallurgically very clean weld metal with excellent properties.

4. PROPERTIES

Unlike CMn, low alloy and duplex stainless steel weld metals, the basic coated austenitic electrodes do not produce enhanced properties over their rutile counterparts. The typical properties achieved with the Ultramet B consumables are given in Table 2. The only electrode to show properties significantly different to the rutile type is Ultramet B309L which gives better impact values. The high purity, low silicon and low oxygen weld metals produced with the Ultramet B electrodes may offer advantages over the rutile electrodes for some more specialist applications.

Table 2: Typical Mechanical Properties

Electrode	UTS MPa	0.2% proof MPa	Elongation		RA %	Hardness cap/mid HV	Impact		
			4d %	5d %			+20°C J	-50°C J	-196°C J
Ultramet B308L	590	440	44	40	60	190/210	-	80	40
Ultramet B347	640	470	36	33	50	195/220	-	80	-
Ultramet B316L	615	475	36	34	50	195/220	-	80	-
Ultramet B309L	650	505	36	34	45	205/225	75	60	-
Ultramet B316NF	600	450	36	35	50	190/210	-	-	50
Ultramet B904L	620	435	39	38	60	190/200	-	90	50
Ultramet B308H *	650	470	40	38	45	190/220	100	-	-
Ultramet E16.8.2-15 *	650	450	42	40	45	190/220	80	-	-
Ultramet B310Mn	620	440	36	34	50	180/210	100	-	65

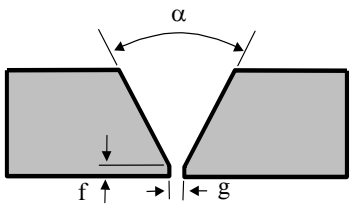
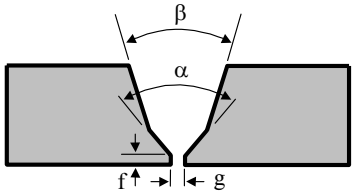
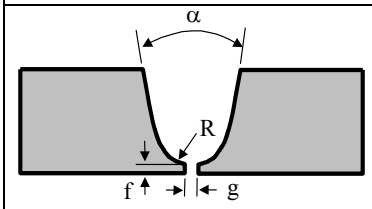
* Further high temperature data on these products can be found in the Technical Profile on cat crackers.

5. PRACTICAL CONSIDERATIONS

The Ultramet B range of electrodes is manufactured in 2.5, 3.2 and 4.0mm diameter because they are primarily used for positional welding. For specific applications (see 6.3) the 5.0mm diameter has been manufactured to order. The 4.0mm diameter is usable positionally but for 5G/6G pipework, the maximum diameter would normally be restricted to 3.2mm.

5.1 Joint Preparations

Figure 1: Joint Preparations

	Wall Thickness mm (in)	*Included angle, α (°)*	*Included angle, β (°)*	*Root gap, g mm (in)*	*Root face, f mm (in)*
	2 – 3 (0.08–0.12)	70 – 90	-	2 – 3 (0.08-0.12)	0.5 – 1.5 (0.02-0.06)
	> 4 (>0.16)	70 – 80	-	2 – 4 (0.08-0.16)	0.5 – 1.5 (0.02-0.06)
	> 20 (>0.8)	70 – 80	15 – 20	2 – 4 (0.08-0.16)	0.5 – 1.5 (0.02-0.06)
	> 20 (>0.8)	15 – 30	***Radius, R mm (in)*** 4 – 6 (0.16-0.25)	2 – 4 (0.08-0.16)	0.5 – 1.5 (0.02-0.06)

Ultramet B electrodes would normally only be used for the fill and capping runs of a pipe joint. The root runs would generally be deposited using the TIG process. For double-sided joints in plate or large diameters with internal access, Ultramet B could be used throughout with a backgrind/ gouge prior to welding the second side.

5.2 Parameters

The Ultramet B electrodes operate on DC+ only, they will not run on AC. Full current ranges are given on the individual data sheets, but typical currents ± 10% are:

2.5mm	75A
3.2mm	95A
4.0mm	120A
5.0mm	180A

6. APPLICATION STUDIES

To provide an indication of the wide range of projects Ultramet B electrodes have been used on, a number of applications studies are presented here.

6.1 Ultramet B316L

Relatively thick section 316L pipes were to be welded on site at a chemical processing plant which would entail numerous joints in the ASME 5G/6G position. The Ultramet B316L electrode was selected because of the excellent weld pool control it allowed in position. Just as importantly, the easy slag release reduced post weld dressing and downtime to a minimum. See weld procedure record UMB316L-01.

6.2 Ultramet B309L

The requirement was for a dissimilar electrode capable of being used on site in all welding positions, but which also maintained good impact properties down to –46°C (-51°F). The selection of Ultramet B309L met all the requirements on this dissimilar joint between CMn steel and superduplex stainless steel. See weld procedure record UMB309L-01.

6.3 Ultramet B309L & Ultramet B347

The requirement was for a combination of consumables to surface thick CrMo base material (for a hydro-desulphuriser) which could then be stress relieved at 690°C(1275°F)/5-7 hours and still have sufficient ductility to pass bend tests.

Both the Ultramet B309L and B347 were manufactured with special ferrite controls. This analytical control in conjunction with clean low silicon weld metal produced the desired results, enabling the clad samples to pass a 180° bend test after stress relieving.

6.4 Ultramet B316NF

The rutile coated Ultramet 316NF had been extensively used for welding 316L used in the fabrication of minesweepers where magnetic permeability <1.01 was required. However, the rutile electrode was not suitable for positional welds, which presented problems since some joints could not be rotated into the flat position. The use of the basic Ultramet B316NF electrode overcame this problem, enabling joints to be completed in the vertical position with the workpiece fixed.

6.5 E16.8.2-15

Following a cat cracker refurbishment using flux cored wire, a consumable was required to carry out the final positional welds on site. The base material was 304H and Supercore 16.8.2 had been used extensively for the shop welds. The E16.8.2-15 electrode was an obvious choice for the site welds and provided the required adaptability, and all-positional capability for this difficult site environment.