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MARTENSITIC STAINLESS STEEL CONSUMABLES

Stainless steels begin with about 12%Cr, leading to a series of **plain chromium steels** with up to 28%Cr. At 0.1%C the leanest alloy type 410 is just **martensitic**, but transformation hardening is suppressed by increasing chromium in types 430 and 446, which are essentially **ferritic**. Unfortunately, chromium also progressively raises the ductile-to-brittle transition temperature and restricts mechanical properties. However, this is controlled by adding some nickel to form the basis of 12-17%Cr martensitics with greatly improved properties, or 20-26%Cr duplex alloys (eg. data sheets B-60 to B-63).

This section deals with consumables giving compositions and properties close to those of the more common martensitic stainless base materials. All are **low hydrogen** types and most have rutile flux coverings for use in the flat and H-V positions, since welds are more common in plate, forgings and castings than fixed pipework. Post Weld Heat Treatment (PWHT) is mandatory, particularly for tempering the weld and HAZ of martensitic types. Procedural guidelines are given on relevant data sheets.

Excluding specialised proprietary creep-resistant 'super 12%Cr' **martensitic** stainless steels, the most common types can be broadly sub-divided into 3 groups: **plain chromium** (410, 420), chromium-nickel **soft-martensitic** (CA6NM or 410NiMo), and **precipitation hardening** (FV520, 17-4PH or 630). Raising carbon in 410 makes a much harder martensitic cutlery or tool steel type 420. Combining 0.15% carbon with 2% nickel turns ferritic 430 into a much stronger and tougher hybrid 431. Replacing carbon with more nickel in alloys of up to 17%Cr gives tougher and more ductile 'soft' martensitic steels with better weldability. The new **supermartensitics** are an improved extension of this group, which are currently welded using superduplex consumables.

Further additions of copper and other alloying enables these standard and proprietary alloys to be precipitation hardened during heat treatment, making them the strongest of all stainless steels with useful ductility and toughness. Unfortunately, as alloying is raised for strength or corrosion resistance, the as-cooled weld and HAZ may not fully transform to martensite without special PWHT. Not far beyond this limit lie austenitic stainless steels (data sheets B-30 to B-35).

Compared with austenitic stainless steels, procedures for martensitics are complicated by the need for hydrogen cracking control (particularly in thicker sections), and the need for PWHT which is most inconvenient for precipitation hardening types. To overcome the need for PWHT of precipitation hardening types, two simplified alternatives are suggested with some compromise in strength: use a leaner type 410NiMo with single PWHT, or duplex type (data sheet B-60, B-61 or B-62) and no PWHT. If required, the toughness of matching welds in alloy 410 can be improved with a special 13%Cr-1.5%Ni variant, which might also be considered for alloy 431. Again, a dissimilar type such as 309L (data sheet B-50) could be used without PWHT under some conditions.

Ferritic stainless steels are also produced with 12%Cr by lowering carbon and adding Al (alloy 405) or Ti (409). Hybrid **utility ferritics** with controlled martensite (such as Cromweld 3CR12) have emerged more recently; a dissimilar type 309L with no PWHT is usual for these. A specialised group of high purity 18-26% Cr+Mo **superferritics** are ideally welded with matching TIG filler, but rarely encountered. The remaining heat-resistant plain 17-28%Cr ferritics are welded with matching consumables and preferably given PWHT. Better as-welded properties are obtained using a 25%Cr-5%Ni electrode, particularly for the bulk of heavier welds.

The lower strength and non-hardenability of ferritics makes them less prone but not immune to hydrogen cracking. With increasing chromium, ambient sensitivity to brittle cracking increases at notches or stress concentrations, so preheat is often advised for alloys with 17%Cr or more. Grain growth in the HAZ is also a limiting feature of weldment properties particularly ductility and toughness. The possibility of hot cracking in these and martensitic weld metals is poorly documented and in practice does not occur with the low impurity levels typically present.

DataSheet	Alloy	Process	Product	AWS Classifications	EN / EN ISO Classifications
B-10	410	MMA	13.RMP	E410-26	E 13 R 5 2
			13.1.BMP	(E410-15)	(E 13 B 5 2)
		TIG/MIG	12Cr	ER410	13
B-11	410NiMo	MMA	13.4.Mo.L.R	E410NiMo-26	E 13 4 R 5 2
			13.4.Mo.L.B	E410NiMo-25	E 13 4 B 6 2
		TIG/MIG	ER410NiMo	(ER410NiMo)	13 4
		FCW	Supercore 410NiMo	E410NiMoT1-1/4	T 13 4 P C/M 2
B-12	17.4.PH/ FV520	MMA	FV520-1	-	-
			17.4.Cu.RL	-	-
		TIG/MIG	FV520-B	-	-
			17-4PH	ER630	-

STANDARD AUSTENITIC STAINLESS STEEL CONSUMABLES

The stainless steels in most widespread use are **standard austenitic** types. They combine general ease of fabrication with useful properties over a wide range of temperatures. Low carbon and other grades, effectively immune to HAZ corrosion (once known as weld decay), are produced economically by continuous casting, a process which relies on a particular solidification mode that also guarantees welds their resistance to hot cracking.

Consumables in this section are intended to match austenitic stainless steels, and some are modified for special service properties. The majority of electrodes have rutile or acid-rutile flux coverings for ease of use, although improved basic types are gaining popularity for fixed pipework. Many types have family variants optimised for particular user requirements: **Supermet** for downhand and HV welds, **Ultramet** (rutile) for all-positional welding, **Ultramet P** (rutile) and **Ultramet B** (basic) types for pipewelding, **Vertamet** for higher speed vertical-down welding, and Supercore for flux cored wires.

For normal service **below about 400°C**, it is common to weld low carbon 304L with 308L consumables, and Ti-stabilised 321 or unstabilised 304 with Nb-stabilised 347, although either is suitable for any combination of these 19%Cr-9%Ni alloys. Similarly, 19%Cr-12%Ni-2.5%Mo type 316L can be used instead of 318 (Nb-stabilised 316) for 316 and 316Ti as well as parent 316L. **Above about 400°C** 'H' grades are usual, and these high temperature weld metals with >0.04% carbon for strength and stability are covered in Section C. For **cryogenic service**, see below.

Austenitics are not thermally hardenable and in practice are annealed by quenching. Hydrogen is soluble in austenite and does not cause weld cracking. Preheat is not needed or desirable except possibly to eliminate condensation. Interpass and heat input control is usually more important in thinner sections to minimise distortion, since austenitics have lower thermal conductivity and higher expansion rates than lower alloy steels. PWHT is rarely applied, although solution treatment may be specified in procedures for upgrading castings.

Two interrelated issues have generated voluminous literature in connection with welding austenitics: **ferrite** and **hot cracking**. Only a summary is possible here. Fully austenitic weld metal is potentially sensitive to solidification cracking during deposition as well as microfissuring in reheated beads of multipass welds. Its prevention is helped by low heat input, controlling impurities and silicon content and raising manganese (low silica rutile or basic fluxes are more suitable than acid rutile types here). However, when composition balance promotes some weld metal ferrite, and in particular when ferrite is the leading phase formed during solidification, abrupt resistance to cracking occurs - even in contaminated welds. The benefit of ferrite in weld deposits (typically 3-10FN in standard types) has been known for decades and is routinely measured and controlled in electrode production. Alternatively, to predict ferrite from composition, **Schaeffler** (later **Espy**), **DeLong** and latest **WRC** diagrams progressively improve in accuracy. However, the deeper significance of a primary ferritic solidification mode is shown in the **Suutala** diagram: above a Cr/Ni equivalent ratio of 1.5, few welds crack. The new WRC diagram shows this boundary. Since the same principle applies to parent material, the likelihood of cracking in autogenous or diluted welds can be checked - including those in **free-machining** grades with high sulphur or selenium.

An arbitrary ferrite limit of 8-12FN is common, although ASME III (nuclear code) permits up to 18FN and castings often exceed it to raise stress-corrosion resistance. However, for service down to −130°C, a maximum of about 8FN is desirable, or less than 5FN at −196°C. Fully austenitic welds are therefore toughest, but 308L and 316L consumables are available with 2-5FN **controlled ferrite** (suffix CF on data sheets B-37 & B-38) which meet the usual criterion of >0.38mm (15 mils) Charpy lateral expansion. Ferrite is also limited for two other service conditions. For **high temperature** service (300H products in Section C) control of ferrite, carbon and total alloying minimises formation of brittle intermetallic phases. To resist **nitric acid** or the Huey test, molybdenum-bearing weld metal such as 316L must contain no ferrite (suffix NF), because unlike 308L it is preferentially attacked. Modified fully austenitic 316L (data sheet B-33) is also useful for its cryogenic and non-magnetic properties.also useful for its cryogenic and non-magnetic properties.

DataSheet	Alloy	Process	Product	AWS Classifications	EN / EN ISO Classifications
Consumables for high strength low alloy steels requiring tensile strengths from 620MPa up to 825MPa					
B-30	308L	MMA	Supermet 308L	E308L-17	E 19 9 L R 3 2
			Ultramet 308L	E308L-16	E 19 9 L R 3 2
			Ultramet 308LP	E308L-16	E 19 9 L R 1 1
			Ultramet B308L	E308L-15	E 19 9 L B 4 2
		TIG	308S92	ER308L	W 19 9 L
		MIG	Supermig 308LSi	ER308LSi	G 19 9 L Si
		SAW	308S92	ER308L	S 19 9 L
		FCW	Supercore 308L	E308LT0-1/4	T 19 9 L R C/M 3
			Supercore 308LP	E308LT1-1/4	T 19 9 L P C/M 2
			Superoot 308L	R308LT1-5	TS308L-R I1
B-31	347	MMA	Ultramet 347	E347-16	E 19 9 Nb R32
			Ultramet B347	E347-15	E 19 9 Nb B 4 2
		TIG/MIG/SAW	347S96	ER347	19 9 Nb
		MIG	Supermig 347Si	ER347Si	G 19 9 Nb Si
		FCW	Supercore 347	E347T0-1/4	T19 9 Nb R C/M 3
B-32	316L	MMA	Supermet 316L	E316L-17	E 19 12 3 L R 3 2
			Ultramet 316L	E316L-16	E 19 12 3 L R 3 2
			Ultramet 316LP	E316L-16	E 19 12 3 L R 11
			Ultramet B316L	E316L-15	E 19 12 3 L B 4 2
		TIG	316S92	ER316L	W 19 12 3 L
		MIG	Supermig 316LSi	ER316LSi	G 19 12 3 L Si
		SAW	316S92	ER316L	S 19 12 3 L
		FCW	Supercore 316L	E316LT0-1/4	T 19 12 3 L R C/M 3
			Supercore 316LP	E316LT1-1/4	T 19 12 3 L P C/M 2
			Superoot 316L	R316LT1-5	TS316L-R I1
B-33	316NF	MMA	Ultramet 316NF	(E316LMn-16)	E 18 15 3 L R 3 2
			Ultramet B316NF	(E316LMn-15)	E 18 15 3 L B 4 2
		TIG/MIG	ER316MnNF	ER316LMn	20 16 3 Mn L
		FCW	Supercore 316NF	(E316LT0-4)	(T 18 16 5 N L R C/M 3)
B-34	318	MMA	Supermet 318	E318-17	E 19 12 3 Nb R 3 2
		TIG/MIG/SAW	318S96	ER318	19 12 3 Nb
B-35	317L	MMA	Ultramet 317L	E317L-16	E 19 13 4 N L R 3 2
		TIG/MIG	ER317L	ER317L	19 13 4 L
		FCW	Supercore 317LP	E317LT1-1/4	(T 19 13 4 N L P C/M 2)
B-37	308LCF	MMA	Ultramet 308LCF	E308L-16	E 19 9 L R 3 2
			Ultramet B308LCF	E308L-15	E 19 9 L B 4 2
		TIG	ER308LCF	ER308L	19 9 L
		SAW	ER308LCF	ER308L	19 9 L
		FCW	Supercore 308LCF	E308LT1-1/4J	T 19 9 L P C/M 2
B-38	316LCF	MMA	Ultramet 316LCF	E316L-16	T 19 9 L P C/M 2
			Ultramet B316LCF	E316L-15	E 19 12 3 L B 4 2
		TIG	ER316LCF	ER316L	19 12 3 L
		SAW	ER316LCF	ER316L	19 12 3 L
		FCW	Supercore 316LCF	E316LT1-1/4J	(T 19 12 3 L P C/M 2)

309L AND 309MO CONSUMABLES FOR DISSIMILAR WELDING

There are three basic variants of 23%Cr-12%Ni **type 309** consumables: unstabilised, Nb-stabilised and Mo-bearing. All are typically low carbon (< 0.04%C) with ferrite above 10FN and they are essentially over-alloyed versions of standard austenitic consumables 308L, 347 and 316L respectively. The original purpose of this over-alloying was to compensate for the effect of dilution when used as the first buffer layer in welding **stainless-clad mild steel**, for which they are still used. Choice of the appropriate variant is logically related to the alloy required for subsequent and finishing layers.

However, as a consequence of their versatility, types 309L and 309Mo have also become two of the most widely used consumables for **dissimilar metal weld**s. A 309L type is most appropriate where one side of a joint is a stainless steel and the other side mild or low alloy steel. The 12%Cr utility ferritics are also usually welded with this type. Consumables of type 309Mo have considerably greater tolerance to dilution conferred by a higher ferrite content and for many applications they compete effectively with type 312 (data sheet E-22).

Nb-stabilised type 309Nb should be used more cautiously because the presence of niobium can make this weld metal more prone to hot cracking than the others if dilution conditions lead to a microstructure without ferrite. As a result of the embrittlement of ferrite, PWHT is avoided for 309L types unless some reduction of ductility or toughness is acceptable. In conjunction with higher carbon base materials, PWHT can also intensify carbide precipitation at the fusion boundary. Again, there are reasons to suspect that the presence of Nb may exaggerate this effect.

For the above and other reasons, 309L types are not used in weldments for service at temperatures above about 300°C, or lower than about −50°C. In these cases, nickel-base weld metal is used (see data sheets D-10 and D-11). A specially controlled type (suffix CF) is available to match as closely as possible the heat-resisting parent alloy type 309 (data sheet C-21). Also see the 308Mo (armour welding), 307 and 312 types in Section E for general purpose dissimilar welding applications.

DataSheet	Alloy	Process	Product	AWS Classifications	EN / EN ISO Classifications
B-50	309L	MMA	Supermet 309L	E309L-17	E 23 12 L R
			Ultramet 309L	E309L-16	E 23 12 L R
			Ultramet 309LP	E309L-16	E 23 12 L R
			Ultramet B309L	E309L-15	E 23 12 L B
		TIG	309S92	ER309L	W 23 12 L
		MIG	Supermig 309LSi	ER309LSi	G 23 12 L Si
		SAW	309S92	ER309L	S 23 12 L
		FCW	Supercore 309L	E309LT0-1/4	T 23 12 L R
			Supercore 309LP	E309LT1-1/4	T 23 12 L P
B-51	309Mo	MMA	Supermet 309Mo	E309LMo-17	E 23 12 2 L R
			Ultramet B309Mo	E309LMo-15	E 23 12 2 L B
			Vertamet 309Mo	E309LMo-17	E 23 12 2 L R
		TIG/MIG/SAW	ER309Mo	(ER309Mo)	23 12 2 L
		FCW	Supercore 309Mo	E309LMoT0-1/4	T 23 12 2 L R C/M 3
			Supercore 309MoP	E309LMoT1-1/4	T 23 12 2 L P C/M 2
B-53	309Nb	MMA	Ultramet 309Nb	E309Cb-16	BS: 23.12.Nb.R

SUPERAUSTENITIC STAINLESS STEEL CONSUMABLES
LEAN DUPLEX, DUPLEX AND SUPERDUPLEX STAINLESS STEEL CONSUMABLES

Although duplex and superaustenitic stainless steels are distinct alloy groups, they are both designed to resist severe corrosion and in some cases compete with each other. The duplex types have considerably higher strength. All have greatly increased resistance to stress-corrosion compared with the standard austenitics. High resistance to general corrosion and especially pitting in high chloride media is obtained with increased levels of chromium, molybdenum and nitrogen.

Duplex types are sub-divided into three groups based on their typical pitting resistance equivalent, PRE (%Cr + 3.3%Mo + 16%N). **Standard duplex** types with typically 22%Cr have a PRE of around 35 and **superduplex** types with typically 25%Cr have a PRE above 40. Parent material composition and processing is designed to give a microstructure balanced with 50:50 ferrite and austenite. Weld metals have similar composition except that nickel is increased to control ferrite in the as-welded condition within a desirable range of 25-60% for optimum mechanical and corrosion properties. Nitrogen additions also play an essential role in promoting austenite re-formation in weld metal and parent HAZ, as well as raising the pitting resistance.

The third group of duplex alloys, the **lean duplex** types, have a PRE of about 25 with corrosion performance comparable to 316L so they are generally not used in highly corrosive environments. The main use has been for structural applications where the high strength is beneficial. The lean duplex stainless steels are so called because some of the higher cost alloying, particularly Ni, is reduced to lower the cost. The lean duplex types can be welded with standard duplex consumables but matching lean duplex consumables are also offered (data sheet B-59).

In welding standard duplex alloys in general fabrication, procedures similar to the standard austenitics are usually satisfactory. However, these alloys are frequently used for **pipework** in which root corrosion performance is critical and this requires more stringent procedural control. Such controls are even more important for the superduplex alloys. Technical profiles are available which give guidance on these issues.

The **superaustenitic** stainless steels occupy a region of alloying between the standard austenitics and nickel-base alloys. (In nickel base alloys, nickel rather than iron forms the major balance of alloying). Since these alloys are fully austenitic, controlled interpass temperatures and heat input are desirable to minimise any possibility of hot cracking. Note that although a matching electrode type 20.18.6.Cu.R is available for the most common 6%Mo superaustenitic type S31254, this is only used when post-weld solution treatment is carried out. Otherwise S31254, and other superaustenitic alloys, are normally welded with overmatching nickel base types (Section D).

DataSheet	Alloy	Process	Product	AWS Classifications	EN / EN ISO Classifications
B-40	904L	MMA	Ultramet 904L	E385-16	E 20 25 5 CuNL R
			Ultramet B904L	E385-15	E 20 25 5 CuNL B
		TIG/MIG	20.25.4.Cu	ER385	20 25 5 CuNL
B-41	20	MMA	E320LR-15	E320LR-15	-
B-42	825	MMA	E825L-15	-	DIN: EL-NiCr28Mo
		TIG/MIG	82-50	ERNiFeCr-1	BS: NA41
B-45	310L	MMA	25.20.LR	-	-
B-46	310MoLN	MMA	Ultramet B310MoLN	-	E 25 22 2 N L B
B-47	Matching 6%Mo	MMA	20.18.6.Cu.R	-	-
B-59	Lean duplex	MMA	Ultramet 2304	-	-
		FCW	Supercore 2304P	-	-
B-60	Duplex	MMA	Supermet 2205	-	-
			Ultramet 2205	E2209-16	E 22 9 3 N L R
			Supermet 2205AR	E2209-17	E 22 9 3 L N R
			2205XKS	E2209-15	E 22 9 3 N L B
		TIG/MIG/SAW	ER329N	ER2209	22 9 3 N L
		MCW	Supercore M2205	EC2209	T 22 9 3 N L M12 3
		FCW	Supercore 2205	E2209T0-1/4	T 22 9 3 N L R C/M 3
			Supercore 2205P	E2209T1-1/4	T 22 9 3 N L P C/M 2
B-61	Zeron® 100 superduplex	MMA	Zeron® 100XKS	E2595-15	E 25 9 4 N L B
		TIG/MIG/SAW	Zeron® 100X	ER2594	25 9 4 N L
		FCW	Supercore Z100XP	E2594T1-4	TS 2594-F M21 1
B-62	2507 superduplex	MMA	2507XKS	E2594-15	E 25 9 4 N L B
			Ultramet 2507	E2594-16	E 25 9 4 N L R
		TIG	2507	ER2594	W 25 9 4 N L
		FCW	Supercore 2507	E2594T0-4	T 25 9 4 N L R M21 3
			Supercore 2507P	E2594T1-4	T 25 9 4 N L P M21 2
B-63	2553	MMA	Supermet 2506Cu	E2553-16	E 25 9 4 CuNL R
		FCW	Supercore 2507Cu	-	-
-	Matching composition	MMA	Supermet 2506	-	BS: 25.6.2.R
			Supermet 2507Cu	-	-

NUCLEAR APPLICATIONS

The next group consumables are intended for nuclear power applications. There are two types firstly those with an (N) suffix designed to meet the requirements of the French RCC-M Nuclear Construction Code (data sheets B-80, B-81 and B-83). The second group are the Nitric Acid Grade (NAG) 308L consumables designed for spent nuclear fuel reprocessing applications (data sheet B-88)

DataSheet	Alloy	Process	Product	AWS Classifications	EN / EN ISO Classifications
B-80	308L(N)	MMA	Ultramet 308L(N)	E308L-16	E 19 9 L R
			Ultramet B308L(N)	E308L-15	E 19 9 L B
		TIG	308S92(N)	ER308L	W 19 9 L
B-81	316L(N)	MMA	Ultramet 316L(N)	E316L-16	E 19 12 3 L R
			Ultramet B316L(N)	E316L-15	E 19 12 3 L B
		TIG	316S92(N)	ER316L	W 19 12 3 L
B-83	309L(N	MMA	Ultramet 309L(N)	E309L-16	E 23 12 L R
			Ultramet B309L(N)	E309L-15	E 23 12 L B
		TIG	309S92(N)	ER309L	W 23 12 L
B-88	NAG	MMA	NAG 19.9.L.R	E308L-16	E 19 9 L R
		TIG	NAG 19.9.L	ER308L	W 19 9 L

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12%Cr MARTENSITIC STAINLESS

ALLOY TYPE

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

MATERIALS TO BE WELDED

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

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

APPLICATIONS

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

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

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

PWHT

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

13.1.BMP – The optimum properties are obtained after PWHT at around 700°C, close to the Ac1 temperature for this weld metal, which (due to the added nickel) has a lower Ac_1 than plain 410. If needed PWHT time can be extended but higher temperatures may cause re-hardening with fresh martensite formation on cool-out. Superior toughness can be achieved with a double temper (cool to ambient between cycles) and this is recommended to conform to NACE, 22HRC maximum.

PRODUCTS AVAILABLE

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

13.RMP

RUTILE MMA ELECTRODE FOR WELDING 410

PRODUCT DESCRIPTION

Rutile metal powder MMA electrode made on pure low carbon core wire.

Moisture resistant coating giving very low weld metal hydrogen levels.

Diameters above 3.2mm are not recommended for positional welding.

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

SPECIFICATIONS

AWS A5.4M	E410-26
BS EN ISO 3581	E 13 R 5 2

ASME IX QUALIFICATION

QW432	F-No 1
QW442	A-No 6

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

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

ALL-WELD MECHANICAL PROPERTIES

After PWHT		850°C/2h *		745°C/1h **	
		Min.	**Typical**	**Min.**	**Typical**
Tensile strength (MPa)		480	520	520	700
0.2% proof strength (MPa)		250	270	--	610
Elongation (%)	4d	--	36	20	21
	5d	20	34	--	18
Reduction of area %		--	52	--	59

* BS & BS EN PWHT: 840-870°C for 2 hours, furnace cool to 595°C at 55°C/h. max. Air cool to ambient. This gives a relatively low strength condition.

** AWS PWHT: 730-760°C for 1 hour, furnace cool to 315°C at 60°C/h max., air cool to ambient. This gives a higher strength tempered condition more representative of normal fabrication welds.

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

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	70	80	100	140
max. A	110	140	180	240

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	12.6	14.1	14.1	16.8
Pieces/carton	609	378	219	150

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 300 – 350°C/1-2h to restore to as-packed condition. Maximum 420° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Mo	V	F	OES (mg/m3)
20	2	<0.5	3	<0.2	<0.1	<0.1	18	1.7

13.1.BMP

13%CR-1.5%NI BASIC MMA ELECTRODE FOR WELDING 410

PRODUCT DESCRIPTION

Basic low hydrogen metal powder MMA electrode made on pure low carbon core wire.

Moisture resistant coating giving very low weld metal hydrogen levels.

Diameters above 3.2mm are not recommended for positional welding.

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

SPECIFICATIONS

AWS A5.4	(E410-15)	Nearest classifications
BS EN ISO 3581	(E 13 B 5 2)	

ASME IX QUALIFICATION

QW432	F-No 1
QW442	A-No 6

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo *	Cu
Min.	0.02	0.4	--	--	--	11.0	1.0	0.15	--
Max.	0.06	1.0	0.50	0.025	0.030	14.0	2.0	0.50	0.5
Typical	0.04	0.7	0.25	0.01	0.02	13	1.5	0.3	0.05

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

ALL-WELD MECHANICAL PROPERTIES

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

* Tensile properties based on ASTM CA15 and CA15M castings.
Specifications for wrought grades vary in tensile strength 415-700MPa.
** For conformance to NACE a double temper is mandatory.

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

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	70	80	100	140
max. A	110	140	180	240

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	350	380	450	450
kg/carton	12.6	13.5	16.5	16.5
Pieces/carton	570	375	225	144

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 300 – 350°C/1-2h to restore to as-packed condition. Maximum 420° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Mo	V	F	OES (mg/m³)
20	2	<0.5	3	<0.2	<0.1	<0.1	18	1.7

12Cr

SOLID WIRE FOR WELDING 410

PRODUCT DESCRIPTION

Solid wire for TIG & MIG.

SPECIFICATIONS

AWS A5.9M	ER410
BS EN ISO 14343-A	13
BS EN ISO 14343-B	SS410

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 6

CHEMICAL COMPOSITION (WIRE WT %)

	C *	Mn	Si	S	P	Cr	Ni	Mo	Cu
Min.	0.06	--	0.25	--	--	12.0	--	--	--
Max.	0.12	0.6	0.50	0.02	0.03	13.5	0.3	0.3	0.3
Typical	0.1	0.4	0.3	0.01	0.02	12.5	0.2	0.03	0.2

* BS 2901: Pt2 requires 0.09-0.15%C.

ALL-WELD MECHANICAL PROPERTIES

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

TYPICAL OPERATING PARAMETERS

	Shielding	Current	Diameter (mm)	Parameters
TIG	ArgonM	DC-	2.4	100A, 12V
MIG	Ar / 1-3%O_2 or Ar / 3-20%CO_2 **	DC+	1.2	280A, 28V

* Also required as a purge for root runs.

** Most economic gas is Ar-20%CO_2. This gas provides the highest resistance to weld metal porosity and carbon content typically not exceeding 0.12%.

PACKAGING DATA

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

FUME DATA

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

Fe	Mn	Cr^3	Ni	Cu	OES (mg/m3)
55	4	8	<0.1	<0.5	5

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410NiMo MARTENSITIC STAINLESS

ALLOY TYPE

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

MATERIALS TO BE WELDED

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

APPLICATIONS

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

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

PWHT

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

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

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	13.4.Mo.L.R	AWS E410NiMo-26
	13.4.Mo.L.B	AWS E410NiMo-25
TIG/MIG	ER410NiMo	AWS ER410NiMo
FCW	Supercore 410NiMo	AWS E410NiMoT1-1/4

13.4.Mo.L.R

RUTILE MMA ELECTRODE FOR 410NiMo

PRODUCT DESCRIPTION

Rutile metal powder type made on pure low carbon core wire.

Moisture resistant coating giving very low weld metal hydrogen levels.

Diameters above 3.2mm are not recommended for positional welding.

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

SPECIFICATIONS

AWS A5.4M	E410NiMo-26
BS EN ISO 3581	E 13 4 R 5 2

ASME IX QUALIFICATION

QW432	F-No 1
QW442	A-No 6

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

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

ALL-WELD MECHANICAL PROPERTIES

Typical properties		Min.	PWHT (1)	As-welded (2)
Tensile strength (MPa)		760	940	1000
0.2% proof strength (MPa)		500	695	780
Elongation (%)	4d	15	17	4.5
	5d	15	16	3
Reduction of area %		--	45	10
Impact ISO-V(J)	+ 20°C	--	45	27
	- 40°C	--	35	13
	- 60°C	--	30	8
Hardness (HV)		--	270-300	350

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

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

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

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	70	80	100	140
max. A	110	140	180	240

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	350	350	450	450
kg/carton	12.6	15.0	18.0	16.8
Pieces/carton	570	363	240	171

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed**:**

Redry 300 – 350ºC/1-2h to restore to as-packed condition. Maximum 420ºC, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Mo	V	F	OES (mg/m³)
18	2	0.5	3	<0.2	<0.2	<0.2	18	1.7

13.4.Mo.L.B

BASIC MMA ELECTRODE FOR WELDING 410NiMo

PRODUCT DESCRIPTION

Basic metal powder type made on pure low carbon core wire.
Moisture resistant coating giving very low weld metal hydrogen levels.
Diameters above 3.2mm are not recommended for positional welding.
Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E410NiMo-25*	* 2005 Edition
BS EN ISO 3581	E 13 4 B 6 2	

ASME IX QUALIFICATION

QW432	F-No 1
QW442	A-No 6

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
Min.	--	--	--	--	--	11.0	4.0	0.40	--
Max.	0.06	1.0	0.90	0.025	0.03	12.5	5.0	0.70	0.50
Typical	0.03	0.7	0.25	0.01	0.01	12	4.5	0.6	0.05

ALL-WELD MECHANICAL PROPERTIES

Typical properties	Min.	PWHT (1)
Tensile strength (MPa)	760	900
0.2% proof strength (MPa)	500	650
Elongation (%) 4d	15	17
5d	15	16
Reduction of area (%)	--	45
Impact ISO-V(J) +20°C	--	50

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

OPERATING PARAMETERS, DC +VE

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	70	80	100	140
max. A	110	140	180	240

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	350	350	450	450
kg/carton	12.6	14.1	18.0	17.1
Pieces/carton	570	330	261	156

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.
For electrodes that have been exposed:
Redry 300 – 350°C/1-2h to restore to as-packed condition. Maximum 420°C, 3 cycles, 10h total.
Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

FUME DATA

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Mo	V	F	OES (mg/m³)
18	2	0.5	3	<0.2	<0.2	<0.2	18	1.7

ER410NiMo

SOLID WIRE FOR WELDING 410NiMo

PRODUCT DESCRIPTION

Solid wire for TIG and MIG.

SPECIFICATIONS

AWS A5.9M	(ER410NiMo)	Does not always strictly conform, see composition.
BS EN ISO 14343-A	13 4	
BS EN ISO 14343-B	(SS410NiMo)	

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 6

CHEMICAL COMPOSITION (WIRE WT %)

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

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

ALL-WELD MECHANICAL PROPERTIES

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

TYPICAL OPERATING PARAMETERS

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

* Also required as a purge for root runs.

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

PACKAGING DATA

Diameter (mm)	1.2	1.6	2.0	2.4
TIG	--	2.5 kg tube	To order	2.5 kg tube
MIG	15kg spool	--	--	--

FUME DATA

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

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m³)
54	5	8	3.2	<0.5	<0.5	5

SUPERCORE 410NiMo

ALL –POSITIONAL FLUX CORED WIRE FOR WELDING 410NiMo

PRODUCT DESCRIPTION

All-positional rutile flux cored wire made on a high purity stainless steel strip
Metal recovery about 90% with respect to wire.

SPECIFICATIONS

AWS A5.22M	E410NiMoT1-1/4
BS EN ISO 17633-A	T 13 4 P C/M 2
BS EN ISO 17633-B	TS410NiMo-FB1

ASME IX QUALIFICATION

QW432	F-No 1
QW442	A-No 6

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Co
Min.	--	--	--	--	--	11.0	4.0	0.4	--	--
Max.	0.06	1.0	1.0	0.025	0.030	12.5	5.0	0.7	0.3	0.05
Typical	0.03	0.7	0.4	0.005	0.017	11.8	4.5	0.5	0.03	0.03

ALL-WELD MECHANICAL PROPERTIES

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

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

OPERATING PARAMETERS

Shielding gas Ar-20%CO_2 or 100% CO_2 at 20-25l/min.

Current DC+ve parameters as below (for 100%CO_2 increase voltage by 1-3V):

Diameter (mm)	range	typical	stickout
1.2	150-280A, 25-32V	180A, 29V	15-25mm
1.6	200-350A, 26-34V	260A, 30V	15-25mm

PACKAGING DATA

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

FUME DATA

Fume composition, wt %

Fe	Mn	Cr^{VI}	Ni	Mo	Cu	OES (mg/m³)
18	3	2.5	1	0.2	<0.5	2

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MARTENSITIC PRECIPITATION HARDENING STAINLESS STEELS

ALLOY TYPE

High strength martensitic precipitation hardening stainless steels.

MATERIALS TO BE WELDED

FV520 Types:

ASTM

A564, A693, A705; Grade XM-25

UNS

S45000

BS

3146 Grade ANC 20. 'S' grades; 2S.143; 3S.144; 3S.145

Proprietary

FV520B (Firth Vickers), Custom 450 (Carpenter)

630 / 17.4.PH Types:

ASTM

A564; Grade 630, A747; CB7Cu-1 (cast)

UNS

S17400

BS EN

10088-2; X5CrNiCuNb 16-4 (1.4542)

DIN

1.4548, 1.4549

Proprietary

17-4PH (Armco Steel), Custom 630 (Carpenter)

APPLICATIONS

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

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

PWHT

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

ADDITIONAL INFORMATION

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

PRODUCTS AVAILABLE

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

FV520-1

MMA ELECTRODE FOR FV520 BASE MATERIAL

PRODUCT DESCRIPTION

Rutile metal powder coating on pure low carbon steel core wire.
Moisture resistant coating gives very low weld metal hydrogen levels.
Diameters above 3.2mm are not recommended for positional welding.
Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

There are no national specifications for this electrode.

ASME IX QUALIFICATION

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

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

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

ALL-WELD MECHANICAL PROPERTIES

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

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

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

Diameter (mm)	2.5	3.2	4.0
min. A	70	80	100
max. A	110	140	180

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	350	350	350
kg/carton	13.5	14.4	13.5
Pieces/carton	630	345	240

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.
For electrodes that have been exposed:
Redry 300 – 350°C/1-2h to restore to as-packed condition. Maximum 420° C, 3 cycles, 10h total.
Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

FUME DATA

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Mo	V	F	OES (mg/m3)
15	3	0.5	4	0.8	0.2	<0.1	18	1.2

17.4.Cu.R

MMA ELECTRODE FOR 17-4PH BASE MATERIAL

PRODUCT DESCRIPTION

Rutile metal powder coating on pure low carbon steel core wire.
Moisture resistant coating gives very low weld metal hydrogen levels.
Diameters above 3.2mm are not recommended for positional welding.
Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

There are no national specifications for this electrode, but is is similar to AWS A5.4 E630-16

ASME IX QUALIFICATION

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

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
Min.	--	--	--	--	--	14.0	3.5	--	1.5
Max.	0.10	1.0	0.8	0.030	0.030	16.5	4.5	0.5	2.5
Typical	0.02	0.7	0.25	0.01	0.01	15	4	0.2	2

ALL-WELD MECHANICAL PROPERTIES

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

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

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

Diameter (mm)	**2.5**	**3.2**	**4.0**
min. A	70	80	100
max. A	110	140	180

PACKAGING DATA

Diameter (mm)	**2.5**	**3.2**	**4.0**
Length (mm)	350	350	450
kg/carton	12.3	15.0	18.6
Pieces/carton	528	345	246

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.
For electrodes that have been exposed:
Redry 300 – 350°C/1-2h to restore to as-packed condition. Maximum 420° C, 3 cycles, 10h total.
Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

FUME DATA

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Mo	V	F	OES (mg/m3)
15	3	0.5	4	0.8	0.2	<0.1	18	1.2

FV520B

SOLID TIG WIRE FOR WELDING FV520 STAINLESS STEEL

PRODUCT DESCRIPTION

Solid wire for TIG welding.

SPECIFICATIONS

There are no national specifications for this electrode.

ASME IX QUALIFICATION

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

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Nb
Min.	--	0.5	0.2	--	--	13.2	5.0	1.2	1.2	0.15
Max.	0.07	1.0	0.5	0.03	0.03	14.7	6.0	2.0	2.0	0.5
Typical	0.05	0.7	0.3	0.01	0.02	14	5.5	1.6	1.7	0.3

ALL-WELD MECHANICAL PROPERTIES

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

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

TYPICAL OPERATING PARAMETERS

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

* Also required as a purge for root runs.

PACKAGING DATA

Diameter (mm)	1.6	2.4	3.2
TIG	5 kg tube	5 kg tube	5 kg tube

FUME DATA

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

Fe	Mn	Cr³	Ni	Mo	Cu	OES (mg/m³)
52	4	11	4	<0.5	2.7	4.5

17-4PH

SOLID TIG WIRE FOR WELDING 17-4PH STAINLESS STEEL

PRODUCT DESCRIPTION

Solid wire for TIG welding.

SPECIFICATIONS

AWS A5.9 ER630

ASME IX QUALIFICATION

QW432 F-No 6

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Nb
Min.	--	0.25	--	--	--	16.00	4.5	--	3.25	0.15
Max.	0.05	0.75	0.75	0.03	0.03	16.75	5.0	0.75	4.00	0.30
Typical	0.03	0.6	0.4	0.005	0.02	16.3	4.8	0.2	3.5	0.2

ALL-WELD MECHANICAL PROPERTIES

Typical PWHT	Over-aged *
Tensile strength (MPa)	930
0.2% proof strength (MPa)	740
Elongation (%)	10

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

TYPICAL OPERATING PARAMETERS

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

* Also required as a purge for root runs.

PACKAGING DATA

Diameter (mm)	1.6	2.4
TIG	2.5 kg tube	2.5 kg tube

FUME DATA

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

Fe	Mn	Cr3	Ni	Mo	Cu	OES (mg/m3)
50	4	13	3.5	<0.5	5.5	3.6

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308L STAINLESS STEELS

ALLOY TYPE

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

MATERIALS TO BE WELDED

ASTM	*BS EN & DIN*
304L	1.4306
304	1.4301
304LN	1.4311
CF3	1.4308
CF8	1.4541
321	1.4543/1.4561/1.4550
347	

BS	*UNS*
304S11	S30403
304S15/16/31	S30400
304S61	S30453
304C12	S32100
304C15	S34700
321S31	
347S31	

APPLICATIONS

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

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

ADDITIONAL INFORMATION

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

RELATED ALLOY GROUPS

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

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Supermet 308L**	AWS E308L-17
	Ultramet 308L	AWS E308L-16
	Ultramet B308L	AWS E308L-15
	Ultramet 308LP	AWS E308L-16
TIG	**308S92**	AWS ER308L
MIG	**Supermig 308LSi**	AWS ER308LSi
SAW	**308S92**	AWS ER308L
	SS300	BS EN SA AF2
	SSB	BS EN SA AF2
FCW	**Supercore 308L**	AWS E308LT0-1/4
	Supercore 308LP	AWS E308LT1-1/4
	Superoot 308L	AWS R308LT1-5

SUPERMET 308L

GENERAL PURPOSE RUTILE 308L MMA ELECTRODE

PRODUCT DESCRIPTION

MMA electrode – rutile aluminosilicate flux on high purity 304L core wire giving very low typical carbon level.
'Low hydrogen' manufacturing technology ensures high resistance to weld metal porosity. 'Supermet Technology' gives acid rutile operability combined with controlled silicon content for maximum cracking/corrosion resistance.
Designed for ease of use, exceptional weld bead appearance and high weld metal integrity, primarily in the downhand and HV positions; smaller sizes offer all-positional operability.
Recovery is about 115% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E308L-17
BS EN ISO 3581	E 19 9 L R 3 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	18.0	9.0	--	--	3
Max.	0.04	2.0	0.90	0.025	0.030	21.0	11.0	0.5	0.5	10
Typical	0.02	0.8	0.6	0.01	0.02	19.5	10	0.10	0.05	6

ALL-WELD MECHANICAL PROPERTIES

As-welded	Min.	typical
Tensile strength (MPa)	520	590
0.2% proof strength (MPa)	320	450
Elongation (%) 4d	35	45
5d	30	40
Reduction of area %	--	45
Impact ISO-V(J) +20°C	--	80

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

Diameter (mm)	2.0	2.5	3.2	4.0	5.0
min. A	50	60	75	100	130
max. A	70	90	120	155	210

PACKAGING DATA

Diameter (mm)	2.0	2.5	3.2	4.0	5.0
Length (mm)	300	300	350	450	450
kg/carton	10.5	11.4	12.0	16.5	16.5
Pieces/carton	846	609	333	243	156

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m3)
8	5	5	0.8	-	< 0.2	16	1

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

ULTRAMET 308L

ALL-POSITIONAL RUTILE MMA ELECTRODE FOR 304L

PRODUCT DESCRIPTION

MMA electrode – rutile flux coated 308L electrode on high purity 304L core wire. Ultramet has all the benefits of an advanced rutile flux design – this includes optimum versatility for downhand welding with high cosmetic finish and weld metal integrity; and all-positional welding with the 2.5/3.2mm electrodes including fixed pipework.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E308L-16
BS EN ISO 3581	E 19 9 L R 3 2
Approvals	TÜV

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	18.0	9.0	--	--	3
Max.	0.04	2.0	0.90	0.025	0.030	21.0	11.0	0.50	0.5	10
Typical	<0.03	1	0.6	0.01	0.02	19	9.5	0.1	0.1	6

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	typical	1050°C + WQ
Tensile strength (MPa)		520	590	540
0.2% proof strength (MPa)		320	450	290
Elongation (%)	4d	35	45	50
	5d	30	42	48
Reduction of area %		--	50	64
Impact ISO-V(J)	-100°C	--	35	--
	-196°C	-- *	--	> 60

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

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	12.0	13.5	13.5	17.1
Pieces/carton	726	414	261	171

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m3)
8	5	5	0.8	-	< 0.2	16	1

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

ULTRAMET B308L

BASIC COATED MMA PIPE-WELDING ELECTRODE FOR 304L

PRODUCT DESCRIPTION

MMA electrode – designed and manufactured to give high moisture resistance using a basic flux system and high purity 304L core wire. Ultramet B308L is particularly suited to the most demanding vertical and overhead welding applications including fixed pipework in the ASME 5G/6G position. Under site conditions it is tolerant to adverse wind and drafts.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

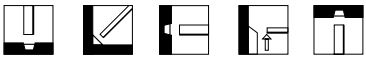
SPECIFICATIONS

AWS A5.4M	E308L-15
BS EN ISO 3581	E 19 9 L B 4 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)



CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	18.0	9.0	--	--	3
Max.	0.04	2.0	0.90	0.025	0.030	21.0	11.0	0.50	0.5	10
Typical	0.03	1.2	0.3	0.01	0.015	19	10	0.1	<0.1	6

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		520	600
0.2% proof strength (MPa)		320	440
Elongation (%)	4d	35	44
	5d	30	40
Reduction of area %		--	60
Impact ISO-V(J)	+20°C	--	80-120
	-196°C	--	35-50

TYPICAL OPERATING PARAMETERS, DC +VE ONLY

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	12.0	13.5	13.5
Pieces/carton	700	405	266

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m3)
8	5	5	0.8	-	< 0.2	16	1

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

ULTRAMET 308LP

ALL-POSITIONAL PIPE WELDING AND ROOT WELDING ELECTRODE

PRODUCT DESCRIPTION

MMA electrode – rutile flux on high purity 304L core wire giving very low typical carbon level. Ultramet 308LP is a fully all-positional electrode capable of the most demanding fixed pipework applications including ASME 5G/6G.
The Ultramet 308LP electrode has also been designed to deposit single-side root runs without the need for a gas purge.
The electrode is also suitable for vertical-down welding on thin sheet material.
Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.

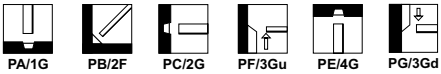
SPECIFICATIONS

AWS A5.4M	E308L-16
BS EN ISO 3581	E 19 9 L R 11

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)



CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	18.0	9.0	--	--	3
Max.	0.04	2.0	0.90	0.025	0.030	21.0	11.0	0.1	0.5	10
Typical	0.02	0.8	0.8	0.01	0.02	19	10	0.01	0.1	6

ALL-WELD MECHANICAL PROPERTIES

As welded	Min.	Typical
Tensile strength (MPa)	520	620
0.2% proof strength (MPa)	320	450
Elongation (%) 4d	35	45
5d	30	43
Reduction of area %	--	50
Impact ISO-V(J) -105°C	--	35

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

Diameter (mm)	2.0	2.5	3.2
min. A	50	60	75
max. A	70	90	120

PACKAGING DATA

Diameter (mm)	2.0	2.5	3.2
Length (mm)	300	300	350
kg/carton	11.7	12.0	14.1
Pieces/carton	1086	702	447

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m3)
8	5	5	0.8	-	< 0.2	16	1

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

308S92 and SUPERMIG 308LSi

SOLID WIRES FOR TIG, MIG AND SAW

PRODUCT DESCRIPTION

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

SPECIFICATIONS

	308S92 (TIG & Sub-arc)	Supermig 308LSi (MIG)
AWS A5.9M	ER308L	ER308L Si
BS EN ISO 14343-A	19 9 L	G 19 9 L Si
BS EN ISO 14343-B	SS308L	SS308L Si
APPROVALS	TÜV (TIG)	

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 3

CHEMICAL COMPOSITION (WIRE WT %)

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

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

ALL-WELD MECHANICAL PROPERTIES

As welded		Typical		
		TIG	MIG	SAW + SS300
Tensile strength (MPa)		605	570	570
0.2% proof strength (MPa)		465	435	450
Elongation (%)	4d	35	42	41
	5d	33	40	37
Impact ISO-V(J)	-130°C	110	70	50
	-196°C *	80	30-60	30
Hardness cap/mid	HV	200/220	200/220	195/215

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

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon	DC-	2.4	100A, 12V
MIG	Ar+2%O_2*	DC+	1.2	260A, 26V
SAW	SS300**	DC+	2.4	350A,28V

* Also proprietary Ar and Ar-He gas mixtures with < 3%CO2.

** SSB, L2N and LA491 also suitable.

PACKAGING DATA

Diameter (mm)	0.8	1.0	1.2	1.6	2.0	2.4	3.2	4.0
TIG (308S92)	--	5 kg tube	5 kg tube	5 kg tube	5 kg tube	5 kg tube	5 kg tube	--
MIG (Supermig 308LSi)	15kg reel	15kg reel	15kg reel	--	--	--	--	--
SAW (308S92)	--	--	--	--	--	25kg spool	25kg spool	25kg spool

FUME DATA

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

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

SUPERCORE 308L, 308LP

RUTILE FLUX CORED WIRES

PRODUCT DESCRIPTION

Flux cored wires – the wires are made with an austenitic stainless steel sheath and rutile flux system. **Supercore 308L** combines easy operability, high deposit quality and exceptional weld bead appearance for downhand and HV welding.

Supercore 308LP is designed for all-positional welding including fixed pipework.

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

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

SPECIFICATIONS

	Supercore 308L	Supercore 308LP
AWS A5.22M	E308LT0-1/4	E308LT1-1/4
BS EN ISO 17633-A	T 19 9 L R C/M 3	T 19 9 L P C/M 2
BS EN ISO 17633-B	TS308L-FB0	TS308L-FB1
Approvals	TÜV, DNV, LRS	TÜV

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	0.2	--	--	18.5	9.0	--	--	3
Max.	0.04	2.0	1.0	0.025	0.030	20.5	11.0	0.3	0.3	12
Typical	0.03	1.3	0.7	0.02	0.02	19.5	10	0.1	0.1	8

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		520	560
0.2% proof strength (MPa)		320	400
Elongation (%)	4d	35	43
	5d	30	42
Reduction of area (%)		--	60
Impact ISO-V(J)	+20°C	--	80
	-110°C	--	40
Hardness	HV	--	200

OPERATING PARAMETERS

Shielding gas: 80%Ar-20%CO_2 or 100% CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.

Current: DC+ve ranges as below for Ar-20%CO_2. Welding with 100%CO_2 requires approx 3V higher:

Diameter (mm)	amp-volt range	typical	stickout
1.2	120 – 280A, 22 – 34V	180A, 29V	15 – 20mm
1.2P	120 – 250A, 22 – 32V	150A, 25V	15 – 20mm
1.6	200 – 350A, 26 – 36V	250A, 30V	15 – 25mm

PACKAGING DATA

Spools vacuum-sealed in barrier foil with cardboard carton: 15kg.

The as-packed shelf life is virtually indefinite.

Resistance to moisture absorption is high, but to maintain the high integrity of the wire surface and prevent any possibility of porosity, it is advised that part-used spools are returned to polythene wrappers.

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

FUME DATA

Fume composition (wt %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m³)
12	6	1	7	1	<1	12	1

SUPEROOT 308L

FLUX CORED TIG WIRE FOR ROOT WELDS WITHOUT BACK PURGE

PRODUCT DESCRIPTION

Flux cored TIG wire **Superoot 308L** is made with a seamless austenitic stainless steel sheath, which results in a robust moisture resistant wire and rutile flux system.
Superoot 308L is designed specifically for situations where it is impractical to apply back-purge for the TIG root run, or where there is an economic benefit in eliminating back-purge.
Metal recovery is 90% with respect to the whole wire.

SPECIFICATIONS

AWS A5.22M	R308LT1-5
BS EN ISO 17633-B	TS308L-RI1

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 6

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
Min.	--	0.5	--	--	--	18.0	9.0	--	--
Max.	0.03	2.5	1.2	0.03	0.04	21.0	11.0	0.5	0.5
Typical	0.02	1.7	0.8	0.005	0.020	19.6	10.3	0.1	0.05

Typically 8FN.

ALL-WELD MECHANICAL PROPERTIES

As welded	Typical
Tensile strength (MPa)	640
0.2% proof strength (MPa)	450
Elongation (%) 4d	47

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

TYPICAL OPERATING PARAMETERS

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

* No back-purge is required.
Satisfactory application of Superoot 308L requires the use of a keyhole welding technique. Further details are available on request.

PACKAGING DATA

Diameter (mm)	2.2
TIG	1 kg tube

FUME DATA

Fume composition (wt%)

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

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347 STAINLESS STEELS

ALLOY TYPE

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

MATERIALS TO BE WELDED

ASTM-ASME
- 321
- 347
- CF8C (cast)

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

BS
- 321S31
- 347S31
- 347C17 (cast)

UNS
- S32100
- S34700

APPLICATIONS

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

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

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

ADDITIONAL INFORMATION

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

RELATED ALLOY GROUPS

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

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Ultramet 347**	AWS E347-16
	Ultramet B347	AWS E347-15
TIG/MIG	**347S96**	AWS ER347
MIG	**Supermig 347Si**	AWS ER347Si
SAW	**347S96**	AWS ER347
	SS300	BS EN SA AF2
	SSB	BS EN SA AF2
FCW	**Supercore 347**	AWS E347T0-1/4

ULTRAMET 347

ALL-POSITIONAL RUTILE MMA ELECTRODE FOR 321/347

PRODUCT DESCRIPTION

MMA rutile flux coated 347 electrode on high purity 304L core wire.
Ultramet 347 has all the benefits of an advanced rutile flux design, including all-positional fixed pipework welding with the 2.5/3.2mm diameter electrodes.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

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

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

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

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	Typical	
Tensile strength (MPa)		560	650	
0.2% proof strength (MPa)		350	500	
Elongation (%)	4d	30	40	
	5d	25	37	
Reduction of area %		--	52	
Impact ISO-V(J)	+20°C	--	70	
	-196°C	--	20	
	-196°C	--	53	(1050°C + WQ)

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	11.4	13.5	13.5	16.5
Pieces/carton	660	399	261	159

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Ni	Cr	Cu	F *	OES (mg/m³)
8	5	0.8	5	<0.2	16	1

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

ULTRAMET B347

BASIC PIPE-WELDING ELECTRODE FOR 321/347

PRODUCT DESCRIPTION

MMA electrode with basic carbonate-fluoride flux on high purity 304L core wire. Designed to give good moisture resistance and hence freedom from weld porosity. The electrode is particularly suited to positional welding of fixed pipework qualified in the ASME 5G/6G position and is tolerant to adverse wind and draughts under site conditions. Compared with rutile types, the basic flux gives a more convex fillet bead profile and although the slag does not self-lift, it is easily removed and gives welds of exceptional appearance and quality.

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

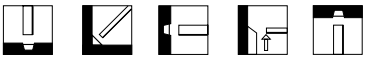
SPECIFICATIONS

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

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)



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

CHEMICAL COMPOSITION (WELD METAL WT %)

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

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	typical
Tensile strength (MPa)		560	650
0.2% proof strength (MPa)		350	500
Elongation (%)	4d	30	40
	5d	25	37
Reduction of area %		--	52
Impact ISO-V(J)	-50°C	--	90

TYPICAL OPERATING PARAMETERS, DC +VE

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350/450	450
kg/carton	12.0	13.5	13.5/17.4	17.4
Pieces/carton	669	396	258/267	162

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

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Ni	Cr	Cu	F *	OES (mg/m³)
8	5	0.8	5	<0.2	16	1

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

347S96 and SUPERMIG 347Si

SOLID WIRES FOR TIG, MIG & SAW OF 321/347

PRODUCT DESCRIPTION

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

SPECIFICATIONS

	347S96 (TIG, MIG & sub-arc)	Supermig 347Si (MIG)
AWS A5.9M	ER347	ER347Si
BS EN ISO 14343-A	19 9 Nb	G 19 9 Nb Si
BS EN ISO 14343-B	SS347	SS347 Si

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

W=TIG, G=MIG, S=SAW

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	FN
Min.	--	1.0	0.30	--	--	19.0	9.0	--	10xC	--	4
Max.	0.08	2.5	0.65	0.020	0.030	21.0	11.0	0.3	1.0	0.3	12
Typical	< 0.04	1.5	0.4	0.005	0.02	19.5	9.7	0.2	0.6	0.1	8

ALL-WELD MECHANICAL PROPERTIES

Typical values as welded		TIG	MIG/Supermig 347Si
Tensile strength (MPa)		660	650
0.2% proof strength (MPa)		450	475
Elongation (%)	4d	42	47
	5d	40	42
Impact ISO-V(J)	20°C	230	100
	- 50°C	150	
	- 196°C	35	
Hardness cap/mid	HV	220/240	

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon*	DC-	2.4	100A, 12V
MIG	Ar+2%O_2**	DC+	1.2	260A, 26V
SAW	SS300 or SSB	DC+	2.4	350A,28V

* Also required as a purge for root runs.

** Also proprietary Ar and Ar-He mixtures with <3%CO_2.

PACKAGING DATA

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

FUME DATA

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

Fe	Mn	Cr3	Ni	Mo	Cu	OES (mg/m³)
32	12	16	8	<0.5	<0.5	3.1

SUPERCORE 347

DOWNHAND RUTILE FLUX CORED WIRE FOR 321/347

PRODUCT DESCRIPTION

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

SPECIFICATIONS

AWS A5.22M	E347T0-1/4
BS EN ISO 17633-A	T19 9 Nb R C/M 3
BS EN ISO 17633-B	TS347-FB0

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	FN
Min.	--	0.5	--	--	--	18.0	9.0	--	8xC	--	4
Max.	0.08	2.0	1.0	0.025	0.030	21.0	11.0	0.3	1.0	0.3	12
Typical	0.03	1.2	0.4	0.01	0.02	19	10.5	0.1	0.5	0.1	8

ALL-WELD MECHANICAL PROPERTIES

As welded	Min.	Typical
Tensile strength (MPa)	550	600
0.2% proof strength (MPa)	350	435
Elongation (%) 4d	30	47
5d	25	42
Reduction of area %	--	50
Impact ISO-V(J) +20°C	--	90

OPERATING PARAMETERS

Shielding gas: 80%Ar-20%CO2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85% argon.
The wire is suitable for use on CO2 but with some loss of cosmetic appearance and increased spatter.

Current: DC+ve ranges as below (for 100%CO2 increase voltage by 2-3V):

Diameter (mm)	amp-volt range	typical	stickout
1.2	120 – 280A, 22 – 34V	180A, 29V	15 – 20mm

PACKAGING DATA

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

FUME DATA

Fume composition, wt %

Fe	Mn	Ni	Cr3	Cr6	Cu	F	OES (mg/m³)
17	11	2	4	5	<1	5	1

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316L STAINLESS STEELS

ALLOY TYPE

316L Mo bearing austenitic stainless.

MATERIALS TO BE WELDED

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

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

APPLICATIONS

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

ADDITIONAL INFORMATION

There are Technical Profiles available on Superoot 316L and sub-arc welding with 316S92. There is also additional information available covering the Supercore flux cored wires.

RELATED ALLOY GROUPS

316L stainless steel consumables for LNG, and other cryogenic applications, are in data sheet B-38. Stainless steel consumables for high temperature applications on 316H can be found in data sheets C-12 or C-13.

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Supermet 316L**	AWS E316L-17
	Ultramet 316L	AWS E316L-16
	Ultramet B316L	AWS E316L-15
	Ultramet 316LP	AWS E316L-16
TIG	**316S92**	AWS ER316L
MIG	**Supermig 316LSi**	AWS ER316LSi
SAW	**316S92**	AWS ER316L
	SS300	BS EN SA AF2
	SSB	BS EN SA AF2
FCW	**Supercore 316L**	AWS E316LT0-1/4
	Supercore 316LP	AWS E316LT1-1/4
	Superoot 316L	AWS R316LT1-5

SUPERMET 316L

GENERAL PURPOSE RUTILE 316L MMA ELECTRODE

PRODUCT DESCRIPTION

MMA electrode – rutile aluminosilicate flux on high purity 304L core wire giving very low typical carbon level. 'Low hydrogen' manufacturing technology ensures high resistance to weld metal porosity. 'Supermet Technology' gives acid rutile operability combined with controlled silicon content for maximum cracking/corrosion resistance. Designed for ease of use, exceptional weld bead appearance and high weld metal integrity, primarily in the downhand and HV positions; smaller sizes offer all-positional operability. Recovery is about 115% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E316L-17
BS EN ISO 3581	E 19 12 3 L R 3 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

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

* DIN & BS EN require Mo 2.5 – 3.0%.

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	typical	1050°C + WQ
Tensile strength (MPa)		520	600	550
0.2% proof strength (MPa)		320	480	320
Elongation (%)	4d	30	42	52
	5d	25	39	49
Reduction of area %		--	60	52
Impact ISO*-V(J)	+20°C	--	70	--
	-196°C	--	--	35

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

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

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

PACKAGING DATA

Diameter (mm)	1.6	2.0	2.5	3.2	4.0	5.0
Length (mm)	250	300	300	350	450	450
kg/carton	8.7	10.5	11.4	12.6	17.4	16.8
Pieces/carton	1344	846	603	339	249	159

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m3)
8	7	5	1	0.5	< 0.2	16	1

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

ULTRAMET 316L

ALL-POSITIONAL RUTILE MMA ELECTRODE FOR 316L

PRODUCT DESCRIPTION

MMA electrode – rutile flux coated 316L electrode on high purity 304L core wire. Ultramet has all the benefits of an advanced rutile flux design – this includes optimum versatility for downhand welding with high cosmetic finish and weld metal integrity; and all-positional welding with the 2.5/3.2mm electrodes including fixed pipework.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E316L-16
BS EN ISO 3581	E 19 12 3 L R 3 2
Approvals	TÜV, LRS

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

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

* DIN & BS EN require Mo 2.5 – 3.0%.

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	typical	1050°C + WQ
Tensile strength (MPa)		520	580	540
0.2% proof strength (MPa)		320	480	305
Elongation (%)	4d	30	43	52
	5d	25	41	50
Reduction of area %		--	65	58
Impact ISO-V(J)	+20°C	--	70	--
	-100°C	--	40	--
	-196°C	--	--	40
Hardness	HV	--	230	185

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

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	11.4	12.9	13.5	16.5
Pieces/carton	618	393	261	159

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F	OES (mg/m3)
8	7	5	1	0.5	< 0.2	16	1

ULTRAMET B316L

BASIC COATED MMA PIPE-WELDING ELECTRODE FOR 316L

PRODUCT DESCRIPTION

MMA electrode – designed and manufactured to give high moisture resistance using a basic flux system and high purity 304L core wire. **Ultramet B316L** is particularly suited to the most demanding vertical and overhead welding applications including fixed pipework in the ASME 5G/6G position. Under site conditions it is tolerant to adverse wind and drafts.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E316L-15
BS EN ISO 3581	E 19 12 3 L B 4 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

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

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		520	600
0.2% proof strength (MPa)		320	470
Elongation (%)	4d	30	37
	5d	25	33
Reduction of area %		--	50
Impact ISO-V(J)	+20°C	--	80
	-196°C	--	45
Lateral expansion * (mm)	-196°C	0.38	0.5

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

TYPICAL OPERATING PARAMETERS, DC +VE ONLY

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	12.0	13.5	13.5	16.5
Pieces/carton	681	396	261	159

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F	OES (mg/m³)
8	7	5	1	0.5	< 0.2	28	1

ULTRAMET 316LP

ALL-POSITIONAL PIPE WELDING AND ROOT WELDING ELECTRODE

PRODUCT DESCRIPTION

MMA electrode – rutile flux on high purity 304L core wire giving very low typical carbon level. **Ultramet 316LP** is a fully all-positional electrode capable of the most demanding fixed pipework applications including ASME 5G/6G. The Ultramet 316LP electrode has also been designed to deposit single-side root runs without the need for a gas purge. The electrode is also suitable for vertical-down welding on thin sheet material.

Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.

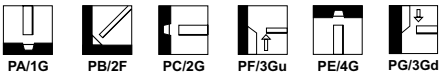
SPECIFICATIONS

AWS A5.4M	E316L-16
BS EN ISO 3581	E 19 12 3 L R 1 1

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)



CHEMICAL COMPOSITION (WELD METAL WT %)

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

ALL-WELD MECHANICAL PROPERTIES

As welded	Min.	Typical
Tensile strength (MPa)	520	620
0.2% proof strength (MPa)	320	500
Elongation (%) 4d	30	38
5d	25	35
Reduction of area %	--	45
Impact ISO-V(J) -105°C	--	40

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

Diameter (mm)	2.0	2.5	3.2
min. A	50	60	75
max. A	70	90	120

PACKAGING DATA

Diameter (mm)	2.0	2.5	3.2
Length (mm)	300	300	350
kg/carton	11.7	12.3	14.4
Pieces/carton	1089	747	459

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m³)
8	7	5	1	0.5	< 0.2	16	1

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

316S92 and SUPERMIG 316LSi

SOLID WIRES FOR TIG, MIG AND SAW

PRODUCT DESCRIPTION

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

SPECIFICATIONS

	316S92 (TIG & sub-arc)	Supermig 316LSi (MIG)
AWS A5.9M	ER316L	ER316LSi
BS EN ISO 14343-A	19 12 3 L	G 19 12 3 LSi
BS EN ISO 14343-B	SS316L	SS316LSi
Approvals	TÜV, LRS	TÜV, LRS

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

W=TIG, G=MIG, S=SAW

CHEMICAL COMPOSITION (WIRE WT %)

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

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

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical		
			TIG	MIG	SAW + SS300
Tensile strength (MPa)		510	605	570	570
0.2% proof strength (MPa)		320	465	435	450
Elongation (%)	4d	30	35	42	41
	5d	30	33	40	37
Impact ISO-V(J)	-130°C	--	> 100	> 70	> 45
	-196°C	--	> 60	30-60	30
Hardness cap/mid	HV	--	200/220	200/220	195/215

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

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon	DC-	2.4	100A, 12V
MIG	Ar+2%O_2*	DC+	1.2	260A, 26V
SAW	SS300**	DC+	2.4	350A,28V

* Also proprietary Ar and Ar-He gas mixtures with < 3%CO_2.

** SSB also suitable.

PACKAGING DATA

Diameter (mm)	0.8	0.9	1.0	1.2	1.6	2.0	2.4	3.2
TIG (316S92)	To order	--	5 kg tube	5 kg tube	5 kg tube	5 kg tube	5 kg tube	5 kg tube
MIG (Supermig 316LSi)	15kg reel	15kg reel	15kg reel	15kg reel	--	--	--	--
SAW (316S92)	--	--	--	--	--	--	25kg spool	25kg spool

FUME DATA

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

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

SUPERCORE 316L, 316LP

RUTILE FLUX CORED WIRES

PRODUCT DESCRIPTION

Flux cored wires – the wires are made with an austenitic stainless steel sheath and rutile flux system. **Supercore 316L** combines easy operability, high deposit quality and exceptional weld bead appearance for downhand and HV welding. **Supercore 316LP** is designed for all-positional welding including fixed pipework. Metal recovery is about 90% with respect to the wire.
The Supercore 316L wire is not suitable for applications requiring PWHT or solution annealing – for these applications, it is recommended that Supercore 316LP is used.

SPECIFICATIONS

	Supercore 316L	Supercore 316LP
AWS A5.22M	E316LT0-1/4	E316LT1-1/4
BS EN ISO 17633-A	T 19 12 3 L R C/M 3	T 19 12 3 L P C/M 2
BS EN ISO 17633-B	TS316L-FB0	TS316L-FB1
Approvals (1.2 & 1.6mm)	TÜV, LRS	TÜV, LRS, ABS, DNV

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	0.2	--	--	17.0	11.0	2.5	--	3
Max.	0.04	2.0	1.0	0.025	0.030	20.0	13.0	3.0	0.3	12
Typical	0.03	1.3	0.5	0.02	0.02	18	12.5	2.7	0.1	6

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

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		510	580
0.2% proof strength (MPa)		320	440
Elongation (%)	4d	30	40
	5d	25	38
Reduction of area (%)		--	50
Impact ISO-V(J)	+20°C	--	70
	-110°C	--	40
Hardness cap/mid	HV	--	200/210

OPERATING PARAMETERS

Shielding gas: Either 80%Ar-20%CO2 or 100% CO2 shielding gas at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.

Current: DC+ve ranges as below for Ar-20%CO2. Welding with 100%CO2 requires approx 3V higher:

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

PACKAGING DATA

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

FUME DATA

Fume composition (wt %)

Fe	Mn	Ni	Cr^{3}	Cr^{6}	Cu	F	OES (mg/m³)
13.5	1.5	1.5	7.5	1	< 1	11	1.2

SUPEROOT 316L

FLUX CORED TIG WIRE FOR ROOT WELDS WITHOUT BACK PURGE

PRODUCT DESCRIPTION

Flux cored TIG wire Superoot 316L is made with a seamless austenitic stainless steel sheath, which results in a robust moisture resistant wire and rutile flux system. Superoot 316L is designed specifically for situations where it is impractical to apply back-purge for the TIG root run, or to gain the economic benefit of eliminating back-purge. For most applications, the use of a 316L root bead is considered compatible with subsequent filling with 308L, 347 or 316L as appropriate.
Metal recovery is 90% with respect to the whole wire.

SPECIFICATIONS

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

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

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

Typically 5FN.

ALL-WELD MECHANICAL PROPERTIES

As welded	Typical
Tensile strength (MPa)	605
0.2% proof strength (MPa)	450
Elongation (%) 4d	38

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

TYPICAL OPERATING PARAMETERS

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

* No back-purge is required.
Satisfactory application of Superoot 316L requires the use of a keyhole welding technique. Further details are available on request.

PACKAGING DATA

Diameter (mm)	**2.2**
TIG	1 kg tube

FUME DATA

Fume composition (wt%)

Fe	Mn	Ni	Cr[3]	Cu	F	OES (mg/m3)	OES (mg/m³)
30	12	11	15	< 0.5	--	3.3	3.1

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NON-MAGNETIC 316L CONSUMABLES

ALLOY TYPE

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

MATERIALS TO BE WELDED

For type 316L and similar parent materials where ferrite-free and non-magnetic weld metal is required; also suitable for 304/304L and 316/316L for cryogenic service.
May be suitable for welding 200 series stainless steels, eg. UNS S20910 (XM-19), Nitronic 50 (Armco) and other. nitrogen strengthened stainless steels.

APPLICATIONS

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

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

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

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

MICROSTRUCTURE

Fully austenitic.

WELDING GUIDELINES

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

ADDITIONAL INFORMATION

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

RELATED ALLOY GROUPS

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

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Ultramet 316NF**	BS EN **E 18 15 3 L R 3 2**
	Ultramet B316NF	BS EN **E 18 15 3 L B 4 2**
TIG/MIG	**ER316MnNF**	BS EN **20 16 3 Mn N L**
FCW	**Supercore 316NF**	(BS EN T 18 16 5 N L R C/M 3)

ULTRAMET 316NF

ALL-POSITIONAL RUTILE MMA ELECTRODE

PRODUCT DESCRIPTION

Rutile (low silica) flux on high purity 304L core wire.
Special control of residuals coupled with a high manganese content ensures freedom from microfissuring.
Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	(E316LMn-16)	Nearest classification
BS EN ISO 3581	E 18 15 3 L R 3 2	

ASME IX QUALIFICATION

QW432 F-No 5

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

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N
Min.	--	2.5	--	--	--	16.5	14.0	2.5	--	0.1
Max.	0.04	4.0	0.9	0.025	0.030	19.5	17.0	3.5	0.5	0.2
Typical	< 0.03	3.0	0.4	0.01	0.02	18	16	2.8	< 0.1	0.15

Maximum magnetic permeability 1.01

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	Typical
Tensile strength (MPa)		560	610
0.2% proof strength (MPa)		300	430
Elongation (%)	4d	--	38
	5d	30	35
Reduction of area %		--	54
Impact ISO-V(J)	-196°C *	--	60
Lateral expansion(mm, mils)	-196°C *	--	0.7mm / (28mils)

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

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	350
kg/carton	13.5	15.0	15.0	16.5
Pieces/carton	684	402	267	189

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Ni	Cr	Cu	F *	OES (mg/m3)	OES (mg/m³)
8	10	1.5	5	<0.2	16	1	1

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

ULTRAMET B316NF

BASIC ALL-POSITIONAL MMA PIPE WELDING ELECTRODE

PRODUCT DESCRIPTION

Basic carbonate-fluoride flux on high purity 304L core wire. Special control of residuals coupled with a high manganese to ensure freedom from microfissuring.
Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	(E316LMn-15)	Nearest classification
BS EN ISO 3581	E 18 15 3 L B 4 2	

ASME IX QUALIFICATION

QW432 F-No 5

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

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N
Min.	--	2.5	--	--	--	16.5	14.0	2.5	--	0.1
Max.	0.04	4.0	0.9	0.025	0.030	19.5	17.0	3.5	0.5	0.2
Typical	< 0.03	3.5	0.4	0.01	0.02	18	16	2.8	< 0.1	0.15

Maximum magnetic permeability 1.01.

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	Typical
Tensile strength (MPa)		560	610
0.2% proof strength (MPa)		300	440
Elongation (%)	4d	--	38
	5d	30	35
Reduction of area %		--	50
Impact ISO-V(J)	-196°C *	--	50
Lateral expansion(mm, mils)	-196°C *	--	0.6 / (24mils)

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

TYPICAL OPERATING PARAMETERS, DC +VE

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	350
kg/carton	12.0	13.5	13.5	16.5
Pieces/carton	678	393	252	153

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Ni	Cr	Cu	F *	OES (mg/m3)	OES (mg/m³)
8	10	1.5	5	<0.2	16	1	1

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

ER316MnNF

NON-MAGNETIC SOLID WIRES FOR TIG AND MIG

PRODUCT DESCRIPTION

Solid wire for TIG and MIG welding.

SPECIFICATIONS

AWS A5.9M	ER316LMn
BS EN ISO 14343-A	20 16 3 Mn N L

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No --

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N
Min.	--	6.0	0.30	--	--	19.0	15.0	2.5	--	0.12
Max.	0.025	8.0	0.65	0.02	0.030	21.0	18.0	3.5	0.3	0.20
Typical	0.02	7	0.5	0.01	0.02	20	16	3	0.15	0.15

Maximum magnetic permeability 1.01.

ALL-WELD MECHANICAL PROPERTIES

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

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

TYPICAL OPERATING PARAMETERS

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

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

PACKAGING DATA

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

FUME DATA

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

Fe	Mn	Cr3	Ni	Mo	Cu	OES (mg/m³)
26	22	15	13	1.5	< 0.5	3.3

SUPERCORE 316NF

RUTILE FLUX CORED WIRE

PRODUCT DESCRIPTION

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

SPECIFICATIONS

AWS A5.22M	(E316LT0-1/4)	Nearest classification
BS EN ISO 17633-A	(T 18 16 5 N L R C/M 3)	Nearest classification
Approval	TÜV	

ASME IX QUALIFICATION

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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	N
Min.	--	2.0	0.2	--	--	17.0	14.0	2.5	0.08
Max.	0.04	3.0	1.0	0.025	0.03	19.0	16.0	3.5	0.20
Typical	0.03	2.5	0.4	0.01	0.025	18	15	3	0.12

Maximum magnetic permeability 1.01.

ALL-WELD MECHANICAL PROPERTIES

As welded	Min.	Typical
Tensile strength (MPa)	560	605
0.2% proof strength (MPa)	300	410
Elongation (%) 4d	30	37
5d	25	34
Impact ISO-V(J) - 196°C *	--	50
Lateral expansion (mm) - 196°C *	0.38 (15mils)	0.6
Hardness HV	--	185

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

OPERATING PARAMETERS

Shielding gas: 80%Ar-20%CO2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 80%.
The wire is suitable for use on 100%CO2 with some loss of cosmetic appearance and increased spatter.

Current: DC+ve parameters as below (for 100%CO2 increase voltage by ~3V):

Diameter (mm)	amp-volt range	typical	stickout
1.2	130A-25V to 280A-34V	180A-29V	12-20mm

PACKAGING DATA

Spools vacuum-sealed in barrier foil with cardboard carton: 12.5kg
The as-packed shelf life is virtually indefinite.
Resistance to moisture absorption is high, but to maintain the high integrity of the wire surface and prevent any possibility of porosity, it is advised that part-used spools are returned to polythene wrappers.
Where possible, preferred storage conditions are 60% RH max, 18°C min.

FUME DATA

Fume composition (wt %)

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

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318 STAINLESS STEELS

ALLOY TYPE

Nb stabilised, Mo-bearing stainless steel.

MATERIALS TO BE WELDED

	wrought	*cast*
ASTM/ASME	316Ti, 316Cb	CF10MC
DIN & BS EN	1.4571 / 1.4573 1.4580 / 1.4583	1.4579 / 1.4581
BS	320S31 / 33	318C17
UNS	S31635, 31640	

APPLICATIONS

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

No preheat, maximum interpass temperature 250°C.

ADDITIONAL INFORMATION

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

RELATED ALLOY GROUPS

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

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	Supermet 318	AWS E318-17
TIG/MIG	318S96	AWS ER318
SAW	318S96	AWS ER318
	SS300	BS EN SA AF2
	SSB	BS EN SA AF2

SUPERMET 318

NB STABILISED MO-BEARING STAINLESS STEEL MMA ELECTRODE

PRODUCT DESCRIPTION

Rutile-aluminosilicate flux on high purity 304L core wire giving very low (<0..025%) typical carbon levels.
Designed for ease of use, exceptional weld bead appearance, and high weld metal integrity, primarily in the downhand and H-V welding positions. Smaller sizes up to 3.2mm offer excellent all-positional operability.
Low hydrogen manufacturing technology ensures high resistance to weld metal porosity.
Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E318-17
BS EN ISO 3581	E 19 12 3 Nb R 3 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

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

ALL-WELD MECHANICAL PROPERTIES

As welded	Min.	Typical
Tensile strength (MPa)	560	630
0.2% proof strength (MPa)	350	500
Elongation (%) 4d	25	36
5d	25	35
Reduction of area %	--	55
Impact ISO-V(J) +20°C	--	65

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	11.4	14.1	13.2	18.0
Pieces/carton	564	387	237	165

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Ni	Cr	Mo	Cu	F	OES (mg/m³)
8	7	1	5	0.5	<0.2	16	1

318S96

SOLID WIRES FOR TIG, MIG AND SAW

PRODUCT DESCRIPTION

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

SPECIFICATIONS

AWS A5.9M	ER318
BS EN ISO 14343-A	19 12 3 Nb
BS EN ISO 14343-B	SS318

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WIRE WT %)

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

ALL-WELD MECHANICAL PROPERTIES

Typical values as welded		TIG
Tensile strength (MPa)		655
0.2% proof strength (MPa)		440
Elongation (%)	4d	42
	5d	35
Impact ISO-V(J)	+20°C	90
Hardness cap/mid	HV	200/215

TYPICAL OPERATING PARAMETERS

	Shielding	Current	Diameter (mm)	Parameters
TIG	Argon*	DC-	2.4	100A, 12V
MIG	Ar+2%O2 **	DC+	1.2	260A, 26V
SAW	SS300 ***	DC+	2.4	350A, 28V

* Also required as a back purge for root runs.

** Also proprietary Ar and Ar-He mixtures with <3%CO_2.

*** SSB also suitable.

PACKAGING DATA

Diameter (mm)	1.2	1.6	2.0	2.4
TIG	--	5 kg tube	5 kg tube	5 kg tube
MIG	15kg spool	--	--	--
SAW	--	--	--	25kg spool

FUME DATA

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

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

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317L STAINLESS STEELS

ALLOY TYPE

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

MATERIALS TO BE WELDED

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

APPLICATIONS

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

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

ADDITIONAL INFORMATION

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

RELATED ALLOY GROUPS

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

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Ultramet 317L**	AWS E317L-16
TIG/MIG	**ER317L**	AWS ER317L
FCW	**Supercore 317LP**	AWS E317LT1-1/4

ULTRAMET 317L

ALL-POSITIONAL MMA ELECTRODE FOR 317L STAINLESS STEEL

PRODUCT DESCRIPTION

Rutile flux on high purity 304L core wire giving very low (<0.025%) typical carbon levels. A controlled addition of nitrogen, in conjunction with ~3.8%Mo, provides improved pitting corrosion resistance compared to 316L. Ultramet 317L gives both welder and weld metal all the benefits of advanced rutile electrode design. These features include optimum versatility for downhand and positional welding, combined with high cosmetic finish and full volumetric weld metal integrity. The smaller electrode sizes are particularly suited to vertical and overhead welding applications including fixed pipework. Low hydrogen manufacturing technology ensures high resistance to weld metal porosity.

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

SPECIFICATIONS

AWS A5.4M	E317L-16
BS EN ISO 3581	E 19 13 4 N L R 3 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

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

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		550	620
0.2% proof strength (MPa)		350	470
Elongation (%)	4d	30	38
	5d	25	36
Reduction of area %		--	45
Impact ISO-V(J)	+20°C	--	55
	-50°C	--	30

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	12.0	13.5	13.5	18.6
Pieces/carton	669	381	225	171

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Ni	Cr	Cu	Mo	F	OES (mg/m³)
8	6	1	6	<0.2	0.6	16	0.8

ER317L

SOLID WIRES FOR TIG AND MIG

PRODUCT DESCRIPTION

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

SPECIFICATIONS

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

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WIRE WT %)

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

ALL-WELD MECHANICAL PROPERTIES

Typical values as welded	TIG
Tensile strength (MPa)	630
0.2% proof strength (MPa)	450
Elongation (%) 4d	35
Impact ISO-V(J) +20°C	75

TYPICAL OPERATING PARAMETERS

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

* Also required as a purge for root runs.

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

PACKAGING DATA

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

FUME DATA

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

Fe	Mn	Ni	Cr[3]	Mo	Cu	OES (mg/m³)
28	12	12	15	2	<0.5	1

SUPERCORE 317LP

ALL-POSITIONAL RUTILE FLUX CORED WIRE

PRODUCT DESCRIPTION

Flux cored wire made with an austenitic stainless steel sheath and rutile flux system. **Supercore 317LP** is designed for all-positional welding including fixed pipework but provides excellent operability in the flat and HV positions as well. Metal recovery is about 90% with respect to the wire.

SPECIFICATIONS

AWS A5.22M	E317LT1-1/4	
BS EN ISO 17633-A	(T 19 13 4 N L P C/M 2)	Nearest classification
BS EN ISO 17633-B	TS317L-FB1	

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	FN
min.	--	0.5	0.2	--	--	18.0	12.0	3.0	--	--	3
max.	0.04	2.5	1.0	0.025	0.030	20.0	14.0	4.0	0.5	0.20	10
Typical	0.03	1	0.6	0.02	0.02	19	13	3.5	0.1	0.07	6

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		550	570
0.2% proof strength (MPa)		350	440
Elongation (%)	4d	20	27
	5d	20	25
Reduction of area %		--	30
Impact ISO-V(J)	+20°C	--	55
	-50°C	--	45
Hardness	HV	--	220

OPERATING PARAMETERS

Shielding gas: 80%Ar-20%CO_2 or 100% CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.

Current: DC+ve ranges as below for Ar-20%CO_2. Welding with 100%CO_2 requires approx 3V higher:

Diameter (mm)	amp-volt range	typical	stickout
1.2	120 – 280A, 22 – 34V	180A, 29V	15 – 20mm

PACKAGING DATA

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

FUME DATA

Fume composition (wt %)

Fe	Mn	Ni	Cr3	Cr6	Cu	F	OES (mg/m³)
17	10	1.5	3	5	<1	5	1

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CRYOGENIC 308LCF CONSUMABLES

ALLOY TYPE

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

MATERIALS TO BE WELDED

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

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

APPLICATIONS

Used to weld 18/8 stainless steels with service temperatures down to –196°C. The controlled ferrite SMAW electrodes and flux cored wires are specifically designed for cryogenic service; they are not batch selected consumables.

Applications include **pipework** and **vessels** subject **to cryogenic service (-196°C)** eg **LNG**.

Standard 308L consumables for general purpose fabrication can be found in data sheet B-30. The 308L consumables covered here are not suitable for 304/304H in elevated temperature structural applications, see data sheets C-10 and C-12.

MICROSTRUCTURE

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

WELDING GUIDELINES

No preheat, maximum interpass temperature 250°C (300°C may be acceptable on thicker section material); no PWHT required.

For optimum impact properties use heat inputs at the higher end of the allowable ranges.

ADDITIONAL INFORMATION

There is a Technical Profile covering the use of the controlled ferrite consumables for LNG applications.

G B Holloway et al 'Stainless steel arc welding consumables for cryogenic applications.' Stainless Steel World America 2004 Conference, Houston, 2004.

RELATED ALLOY GROUPS

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

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Ultramet 308LCF**	AWS E308L-16
	Ultramet B308LCF	AWS E308L-15
TIG	**ER308LCF**	AWS ER308L
SAW	**ER308LCF**	AWS ER308L
	SS300	BS EN SA AF2
FCW	**Supercore 308LCF**	AWS E308LT1-1/4J

ULTRAMET 308LCF

RUTILE MMA ELECTRODE FOR CRYOGENIC 304L APPLICATIONS

PRODUCT DESCRIPTION

MMA electrode – special rutile flux coated 308L electrode on high purity 304L core wire. Versatile downhand and positional capability, **Ultramet 308LCF** has a controlled composition and ferrite content designed for cryogenic service requiring >0.38mm lateral expansion at minus 130-196°C. Also suitable for unusual occasions when 304L is specified for service up to 550°C and corrosion conditions preclude the use of 308H.

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

SPECIFICATIONS

AWS A5.4M	E308L-16
BS EN ISO 3581	E 19 9 L R 3 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	18.0	9.0	--	--	2
Max.	0.04	2.0	0.90	0.025	0.030	21.0	11.0	0.50	0.5	5
Typical	<0.025	1	0.6	0.01	0.02	18.5	10	0.1	<0.1	3

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	typical
Tensile strength (MPa)		520	600
0.2% proof strength (MPa)		320	445
Elongation (%)	4d	35	50
	5d	30	46
Reduction of area (%)		--	43
Impact ISO*-V(J)	-100°C	--	45
	-196°C	--	35
Lateral expansion* (mm)	-196°C	0.38	0.50

* Batch tested for Charpy lateral expansion >0.38mm at –196°C

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	11.4	13.5	13.5	16.2
Pieces/carton	627	414	261	159

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m³)
8	5	5	0.8	-	< 0.2	16	1

* F=28% for basic coated Ultramet B308LCF but this does not affect the OES

ULTRAMET B308LCF

BASIC MMA PIPE-WELDING ELECTRODE FOR CRYOGENIC 304L APPLICATIONS

PRODUCT DESCRIPTION

MMA electrode – designed and manufactured to give high moisture resistance using a basic flux system and high purity 304L core wire. **Ultramet B308LCF** is particularly suited to the most demanding vertical and overhead welding applications including fixed pipework in the ASME 5G/6G position. Under site conditions it is tolerant to adverse wind and drafts.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E308L-15
BS EN ISO 3581	E 19 9 L B 4 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	18.0	9.0	--	--	2
Max.	0.04	2.0	0.90	0.025	0.030	21.0	11.0	0.50	0.5	5
Typical	0.03	1.2	0.3	0.01	0.015	18.5	10	0.05	<0.1	3

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	typical
Tensile strength (MPa)		520	600
0.2% proof strength (MPa)		320	440
Elongation (%)	4d	35	44
	5d	30	40
Reduction of area %		--	60
Impact ISO-V(J)	+20°C	--	80-120
	-196°C	--	35-50
Lateral expansion * (mm)	-196°C	0.38	0.55

* Batch tested for Charpy lateral expansion >0.38mm at –196°C.

TYPICAL OPERATING PARAMETERS, DC +VE ONLY

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	12.0	13.5	13.5
Pieces/carton	700	405	266

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m³)
8	5	5	0.8	-	< 0.2	16	1

* F=28% for basic coated Ultramet B308LCF but this does not affect the OES

ER308LCF

SOLID WIRES FOR CRYOGENIC 304L APPLICATIONS

PRODUCT DESCRIPTION

Batch selected solid wire for TIG and sub-arc welding.

SPECIFICATIONS

AWS A5.9M	ER308L
BS EN ISO 14343-A	19 9 L
BS EN ISO 14343-B	SS308L

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	1.0	0.30	--	--	19.5	9.0	--	--	3
Max.	0.025	2.0	0.65	0.020	0.030	21.0	11.0	0.3	0.3	8
Typical	0.01	1.7	0.4	0.01	0.015	20	10	0.1	0.15	7

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical	
			TIG	SAW + SS300
Tensile strength (MPa)		510	605	550
0.2% proof strength (MPa)		320	465	390
Elongation (%)	4d	30	35	41
	5d	30	33	37
Impact ISO-V(J)	-130°C	--	110	50
	-196°C	--	80	45
Lateral expansion * (mm)	-196°C	0.38	1.0	0.5

* ER308LCF SAW wire batch tested, with SS300 flux, for Charpy lateral expansion >0.38mm at −196°C.C.

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon	DC-	2.4	100A, 12V
SAW	SS300	DC+	2.4	350A,30V

PACKAGING DATA

Diameter (mm)	1.6	2.0	2.4	3.2
TIG	2.5 kg tube	2.5 kg tube	2.5 kg tube	2.5 kg tube
SAW	--	--	25kg spool	25kg spool

FUME DATA

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

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

SUPERCORE 308LCF

RUTILE ALL-POSITIONAL FLUX CORED WIRE FOR CRYOGENIC 304L APPLICATIONS

PRODUCT DESCRIPTION

Supercore 308LCF has a controlled composition and ferrite content designed for cryogenic service requiring >0.38mm lateral expansion at minus 130-196°C.

Supercore 308LCF is designed for all-positional welding including fixed pipework. Metal recovery is about 90% with respect to the wire.

SPECIFICATIONS

AWS A5.22M	E308LT1-1/4J
BS EN ISO 17633-A	T 19 9 L P C/M 2
BS EN ISO 17633-B	TS308L-FB1

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	0.2	--	--	18.0	9.0	--	--	2
Max.	0.04	2.0	1.0	0.025	0.030	21.0	11.0	0.3	0.3	5
Typical	0.03	1.4	0.6	0.01	0.02	18.6	10.5	0.1	0.1	3

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		520	540
0.2% proof strength (MPa)		320	400
Elongation (%)	4d	30	50
	5d	30	46
Reduction of area %		--	50
Impact ISO-V(J)	+20°C	--	74
	-130°C	--	40
	-196°C	--	36
Lateral expansion * (mm)	-196°C	0.38	0.70

* Batch tested for Charpy lateral expansion >0.38mm at –196°C.

OPERATING PARAMETERS

Shielding gas: 80%Ar-20%CO_2 or 100% CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.

CCurrent: DC+ve ranges as below for Ar-20%CO_2. Welding with 100%CO_2 requires approx 3V higher:

Diameter (mm)	amp-volt range	typical	stickout
1.2	120 – 280A, 22 – 34V 150A, 25V (positional)	180A, 29V (downhand) 15 – 20mm	15 – 25mm

PACKAGING DATA

Spools vacuum-sealed in barrier foil with cardboard carton: 15kg (33 lbs)
The as-packed shelf life is virtually indefinite.
Resistance to moisture absorption is high, but to maintain the high integrity of the wire surface and prevent any possibility of porosity, it is advised that part-used spools are returned to polythene wrappers.
Where possible, preferred storage conditions are 60% RH max, 18°C min.

FUME DATA

Fume composition (wt %)

Fe	Mn	Ni	Cr^{3}	Cr^{6}	Cu	F	OES (mg/m³)
17	10	1.5	3	5	<1	5	1

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CRYOGENIC 316LCF CONSUMABLES

ALLOY TYPE

Controlled ferrite 316L austenitic stainless steels for joining 316L base materials used in cryogenic applications.

MATERIALS TO BE WELDED

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

BS	*UNS*
316S11 / 13	S 31603
316S16 / 31 / 33	S 31600
316S61	S 31653
316C12	
316C16 / 71	

APPLICATIONS

These consumables are used for Mo bearing austenitic stainless steels with 1.5 – 3% Mo. Type 316/316L steels are widely used for their good resistance to pitting, many acids and general corrosion. . The controlled ferrite SMAW electrodes and flux cored wires are specifically designed for cryogenic service; they are not batch selected consumables.

Applications include **pipework** and **vessels** subject to **cryogenic service (-196°C)** eg **LNG**.

Standard 316L consumables for general purpose fabrication can be found in data sheet B-32. The 316L consumables covered here are not suitable for 316/316H in elevated temperature structural applications, see data sheets C-12 and C-13.

MICROSTRUCTURE

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

WELDING GUIDELINES

No preheat, maximum interpass temperature 250°C (300°C may be acceptable on thicker section material); no PWHT required.
For optimum impact properties use heat inputs at the higher end of the allowable ranges.

ADDITIONAL INFORMATION

There is a Technical Profile covering the use of the controlled ferrite consumables for LNG applications.

G B Holloway et al 'Stainless steel arc welding consumables for cryogenic applications.' Stainless Steel World America 2004 Conference, Houston, 2004.

RELATED ALLOY GROUPS

General purpose 316L stainless steel consumables are in data sheet B-32. Stainless steel consumables for high temperature applications on 316H can be found in data sheets C-12 or C-13.

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Ultramet 316LCF**	AWS E316L-16
	Ultramet B316LCF	AWS E316L-15
TIG	**ER316LCF**	AWS ER316L
SAW	**ER316LCF**	AWS ER316L
	SS300	BS EN SA AF2
FCW	**Supercore 316LCF**	AWS E316LT1-1/4J

ULTRAMET 316LCF

RUTILE MMA ELECTRODE FOR CRYOGENIC 316L APPLICATIONS

PRODUCT DESCRIPTION

MMA electrode – special rutile flux coated 316L electrode on high purity 304L core wire. Versatile downhand and positional capability, **Ultramet 316LCF** has a controlled composition and ferrite content designed for cryogenic service requiring >0.38mm lateral expansion at minus 130-196°C. Also suitable for unusual occasions when 316L is specified for service up to 550°C and corrosion conditions preclude the use of 316H.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E316L-16	
BS EN ISO 3581	(E 19 12 3 L R 3 2)	Nearest classification

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo*	Cu	FN
Min.	--	0.5	--	--	--	17.0	11.0	2.0	--	2
Max.	0.04	2.0	0.90	0.025	0.030	20.0	13.0	3.0	0.5	5
Typical	<0.03	1	0.6	0.01	0.02	18	12	2.2	<0.1	3

* Does not conform to DIN & BS EN which requires Mo 2.5 – 3.0%.

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	typical
Tensile strength (MPa)		520	595
0.2% proof strength (MPa)		320	440
Elongation (%)	4d	30	43
	5d	25	39
Reduction of area %		--	48
Impact ISO*-V(J)	+20°C	--	70
	-100°C	--	50
	-196°C	--	30
Lateral expansion * (mm)	-196°C	0.38	0.40
Hardness	HV	--	230

* Batch tested for Charpy lateral expansion >0.38mm at –196°C.

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	11.4	13.5	13.5	16.5
Pieces/carton	618	396	261	165

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m³)
8	7	5	1	0.5	< 0.2	16	1

* F=28% for basic coated Ultramet B316LCF but this does not affect the OES.

ULTRAMET B316LCF

BASIC MMA PIPE-WELDING ELECTRODE FOR CRYOGENIC 316L APPLICATIONS

PRODUCT DESCRIPTION

MMA electrode – designed and manufactured to give high moisture resistance using a basic flux system and high purity 304L core wire. **Ultramet B316L** is particularly suited to the most demanding vertical and overhead welding applications including fixed pipework in the ASME 5G/6G position. Under site conditions it is tolerant to adverse wind and drafts.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E316L-15
BS EN ISO 3581	**(E 19 12 3 L B 4 2)** Nearest classification

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo *	Cu	FN
Min.	--	0.5	--	--	--	17.0	11.0	2.0	--	2
Max.	0.04	2.0	0.90	0.025	0.030	20.0	13.0	3.0	0.5	5
Typical	<0.03	1.2	0.3	0.01	0.02	19	12	2.2	<0.1	3

* Does not conform to DIN & BS EN which requires Mo 2.5 – 3.0%.

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	typical
Tensile strength (MPa)		520	600
0.2% proof strength (MPa)		320	470
Elongation (%)	4d	30	37
	5d	25	33
Reduction of area %		--	50
Impact ISO-V(J)	+20°C	--	80
	-196°C	--	35
Lateral expansion * (mm)	-196°C	0.38	0.45

* Batch tested for Charpy lateral expansion >0.38mm at –196°C.

OPERATING PARAMETERS, DC +VE ONLY

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	450
kg/carton	12.0	13.5	17.4
Pieces/carton	669	396	255

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m³)
8	7	5	1	0.5	< 0.2	16	1

* F=28% for basic coated Ultramet B316LCF but this does not affect the OES.

ER316LCF

SOLID WIRES FOR CRYOGENIC 316L APPLICATIONS

PRODUCT DESCRIPTION

Solid wires for TIG and sub-arc welding.

SPECIFICATIONS

AWS A5.9M	ER316L
BS EN ISO 14343-A	19 12 3 L
BS EN ISO 14343-B	SS316L

W=TIG, S=SAW

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	1.0	0.30	--	--	18.0	11.0	2.5	--	3
Max.	0.025	2.0	0.65	0.020	0.030	20.0	14.0	3.0	0.3	8
Typical	0.01	1.4	0.5	0.01	0.015	18.5	12.8	2.6	0.15	6

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical	
			TIG	SAW + SS300
Tensile strength (MPa)		510	605	560
0.2% proof strength (MPa)		320	465	400
Elongation (%)	4d	30	50	41
	5d	25	45	37
Impact ISO-V(J)	-130°C	--	> 100	> 45
	-196°C	--	> 60	40
Lateral expansion * (mm)	-196°C	0.38	1.0	0.5

* ER316LCF SAW wire batch tested, with SS300 flux for Charpy lateral expansion >0.38mm at –196°C.

TYPICAL OPERATING PARAMETERS

	Shielding	Current	Diameter (mm)	Voltage
TIG	Argon	DC-	2.4	100A, 12V
SAW	SS300	DC+	2.4	350A, 28V

PACKAGING DATA

Diameter (mm)	1.6	2.0	2.4	3.2
TIG	2.5kg tube	2.5kg tube	2.5kg tube	2.5kg tube
SAW	--	--	25kg spool	--

FUME DATA

Fume composition (wt%), (TIG and SAW fume negligible)

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

SUPERCORE 316LCF

RUTILE ALL-POSITIONAL FLUX CORED WIRE FOR CRYOGENIC 316L APPLICATIONS

PRODUCT DESCRIPTION

Supercore 316LCF has a controlled composition and ferrite content designed for cryogenic service requiring >0.38mm lateral expansion at minus 130-196°C.

Supercore 316LCF is designed for all-positional welding including fixed pipework. Metal recovery is about 90% with respect to the wire.

SPECIFICATIONS

AWS A5.22M	E316LT1-1/4J
BS EN ISO 17633-A	(T 19 12 3 L P C/M 2) Nearest classification
BS EN ISO 17633-B	TS316L-FB1

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo *	Cu	FN
Min.	--	0.5	0.2	--	--	17.0	11.0	2.0	--	2
Max.	0.04	2.0	1.0	0.025	0.030	20.0	13.0	3.0	0.5	5
Typical	0.03	1.4	0.6	0.01	0.02	18.0	12.4	2.2	0.1	3

* Does not conform to BS EN ISO 17633-A which requires Mo 2.5 – 3.0%.

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		510	550
0.2% proof strength (MPa)		320	410
Elongation (%)	4d	30	40
	5d	25	38
Reduction of area %		--	45
Impact ISO-V(J)	+20°C	--	75
	-130°C	--	45
	-196°C	--	34
Lateral expansion * (mm)	-130°C	--	0.70
	-196°C	0.38	0.55

* Batch tested for Charpy lateral expansion >0.38mm at –196°C.

OPERATING PARAMETERS

Shielding gas: 80%Ar-20%CO_2 or 100% CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.

Current: DC+ve ranges as below for Ar-20%CO_2. Welding with 100%CO_2 requires approx 3V higher:

Diameter (mm)	amp-volt range	typical	stickout
1.2	120 – 280A, 22 – 34V 150A, 25V (positional)	180A, 29V (downhand) 160A, 26V	15 – 20mm

PACKAGING DATA

Spools vacuum-sealed in barrier foil with cardboard carton: 15kg (33 lbs)

The as-packed shelf life is virtually indefinite.

Resistance to moisture absorption is high, but to maintain the high integrity of the wire surface and prevent any possibility of porosity, it is advised that part-used spools are returned to polythene wrappers.

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

FUME DATA

Fume composition (wt %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m³)
14	12	2.5	4	4	< 1	5	1.2

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904L STAINLESS STEELS

ALLOY TYPE

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

MATERIALS TO BE WELDED

ASTM - ASME
N08904

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

DIN
1.4505
1.4506
1.4536
1.4539
1.4585
1.4500 (cast)

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

Suitable for copper-free variants of the above alloys and also to overmatch leaner alloys such as 317L, 317LN, 317LM, 317LMN, 1.4439, 1.4440 and S31726.

APPLICATIONS

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

They are not normally chosen for resistance to corrosion in concentrated nitric acid. For service in severe chloride pitting media, overmatching nickel-base weld metal is recommended, see alloy 625 (data sheet D-20).

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

PRODUCTS AVAILABLE

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

ULTRAMET 904L

RUTILE MMA ELECTRODE FOR ALLOY 904L

PRODUCT DESCRIPTION

MMA electrode (formerly 21.26.5.CuNb.R) with a special rutile flux on low carbon, high purity austenitic stainless steel core wire. Careful control of carbon, silicon, manganese and molybdenum contents to give resistance to microfissuring. Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E385-16
BS EN ISO 3581	E 20 25 5 Cu N L R 5 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 9

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Nb	N
Min.	--	1.0	--	--	--	19.5	24.0	4.2	1.2	--	--
Max.	0.03	2.5	0.90	0.02	0.030	21.5	26.0	5.2	2.0	0.5	0.25
Typical	0.02	1.2	0.55	0.015	0.02	20.5	25	4.6	1.5	0.02	0.09

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	typical
Tensile strength (MPa)		560	620
0.2% proof strength (MPa)		320	420
Elongation (%)	4d	30	38
	5d	25	35
Reduction of area %		--	50
Impact ISO*-V(J)	-196°C	--	50
Hardness cap/mid	HV	--	185/200

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	12.0	13.5	14.1
Pieces/carton	504	360	213

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 150 – 250°C/1-2h to restore to as-packed condition. Maximum 250° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Ni	Cr	Mo	Cu	F *	OES (mg/m³)
8	8	2	7	1.5	0.5	18	0.7

* F=28% for basic coated Ultramet B904L but this does not affect the OES.

ULTRAMET B904L

BASIC ALL-POSITIONAL MMA PIPE-WELDING ELECTRODE FOR ALLOY 904L

PRODUCT DESCRIPTION

Special basic flux on low carbon, high purity austenitic stainless steel core wire. Careful control of carbon, silicon, manganese and molybdenum contents to give resistance to microfissuring.
Recovery is about 130% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E385-15
BS EN ISO 3581	E 20 25 5 Cu N L B 6 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 9

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Nb	N
Min.	--	1.0	--	--	--	19.5	24.0	4.2	1.2	--	--
Max.	0.03	2.5	0.90	0.02	0.030	21.5	26.0	5.2	2.0	0.5	0.25
Typical	0.025	2	0.4	0.005	0.02	21	25	4.8	1.8	0.05	0.08

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	typical
Tensile strength (MPa)		560	620
0.2% proof strength (MPa)		320	440
Elongation (%)	4d	30	41
	5d	25	38
Reduction of area %		--	60
Impact ISO-V(J)	+20°C	--	50
Hardness cap/mid	HV	--	190/215

OPERATING PARAMETERS, DC +VE

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	11.4	13.5	14.1
Pieces/carton	471	359	273

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Ni	Cr	Mo	Cu	F *	OES (mg/m³)
8	8	2	7	1.5	0.5	18	0.7

* F=28% for basic coated Ultramet B904L but this does not affect the OES.

20.25.4.Cu

SOLID WIRES FOR TIG AND MIG FOR ALLOY 904L

PRODUCT DESCRIPTION

Solid wire for TIG and MIG welding.

SPECIFICATIONS

AWS A5.9M	ER385
BS EN ISO 14343-A	20 25 5 Cu L
BS EN ISO 14343-B	SS385

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 9

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
Min.	--	1.0	0.25	--	--	19.5	24.0	4.2	1.2
Max.	0.025	2.5	0.50	0.015	0.020	21.5	26.0	5.2	2.0
Typical	0.01	1.7	0.3	0.001	0.015	20	25	4.5	1.5

ALL-WELD MECHANICAL PROPERTIES

Typical values as welded		TIG
Tensile strength (MPa)		650
0.2% proof strength (MPa)		490
Elongation (%)	4d	35
	5d	32
Impact ISO-V(J)	+20°C	210
Hardness cap/mid	HV	175/195

TYPICAL OPERATING PARAMETERS

	Shielding	Current	Diameter (mm)	Voltage
TIG	Argon*	DC-	2.4	100A, 12V
MIG	Ar+2%O2 **	DC+	1.2	230A, 30V

* Also required as a purge for root runs.

** Ar-He-CO2 proprietary mixtures also suitable.

PACKAGING DATA

Diameter (mm)	0.8	1.2	1.6	2.0	2.4
TIG		--	2.5kg tube	2.5kg tube	2.5kg tube
MIG	15kg spool	15kg spool	--	--	--

FUME DATA

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

Fe	Mn	C[a]	Ni	Mo	Cu	OES (mg/m³)
28	13	16	20	3	2.5	2.5

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CONSUMABLES FOR ALLOY 20

ALLOY TYPE

20%Cr-34%Ni-3.5%Cu-2.5%Mo (alloy 20) austenitic corrosion resistant alloy.

MATERIALS TO BE WELDED

ASTM

A351, A744 Grade CN-7M

BS

1504 Grade 332C11

Proprietary

Alloy 20, 20Cb, 20Cb-3 (Carpenter)
Paramount P20 (Lake & Elliot)
Langalloy 20V (Meighs)

APPLICATIONS

This electrode is usually made to order. It gives a fully austenitic, niobium stabilised weld metal with molybdenum and copper and a high resistance to corrosion in sulphuric acid, other mineral acids, organic acids and their mixtures. Most parent material specifications are for castings.

Applications include tanks, process piping, heat exchangers, agitators and rotors, cast pumps and valves; for use in the chemical processing, metal cleaning and pickling industries.

MICROSTRUCTURE

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

WELDING GUIDELINES

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

Repair of alloy 20 castings may present particular problems with HAZ regions being sensitive to fissuring and weld metal increasing in crack sensitivity if silicon pick-up takes place. Troublesome castings may require buttering at very low heat input with small diameter electrodes and minimum dilution.

PWHT

Welds are normally left in the as-welded condition but castings to ASTM specifications may require solution treatment at 1125°C following major repairs.

RELATED ALLOY GROUPS

The 825 consumables (data sheet B-42) are similar high alloy corrosion resistant products and can be offered as a technically compatible alternative in some applications.

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**E320LR-15**	AWS E320LR-15

E320LR-15

MMA ELECTRODE FOR ALLOY 20

PRODUCT DESCRIPTION

MMA electrode with a specially balanced basic-fluoride-rutile flux on an over-matching high purity core wire. The E320LR-15 electrode is manufactured with strict controls on the maximum carbon, silicon, sulphur and phosphorus (to optimise as-welded corrosion resistance); and also restricted ranges for manganese and niobium. This low residual (LR) electrode is intended to reduce sensitivity to microfissuring whilst maintaining excellent corrosion resistance, but interpass temperature and heat input still need to be controlled.

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

SPECIFICATIONS

AWS A5.4M E320LR-15

ASME IX QUALIFICATION

QW432 F-No 5

QW442 A-No 9

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu
min.	--	1.5	--	--	--	19.0	32.0	2.0	8xC	3.0
max.	0.03	2.5	0.30	0.015	0.020	21.0	36.0	3.0	0.40	4.0
Typical	0.02	2	0.2	0.005	0.01	20	34	2.5	0.3	3.5

ALL-WELD MECHANICAL PROPERTIES

As welded		Min. (1)	Typical
Tensile strength (MPa)		520	535
0.2% proof strength (MPa)		--	345
Elongation (%)	4d	30	36
	5d	25	30
Reduction of area (%)		--	37
Impact ISO-V(J)	- 20°C	--	117
	- 40°C	--	98
Hardness cap/mid	HV	--	156/182

(1) ASTM N08020 parent material requires TS >550MPa, PS >240MPa

OPERATING PARAMETERS, DC +VE

Diameter (mm)	2.5	3.2	4.0
min. A	60	70	90
max. A	80	110	150

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	275	350	325
kg/carton	12.0	13.8	13.5
Pieces/carton	714	411	261

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 250°C/1-2h to restore to as-packed condition. Maximum 300° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition (wt %) typical

Fe	Mn	Ni	Cr	Mo	Cu	F	OES (mg/m³)
5	5	2	6	1	1	20	0.8

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CONSUMABLES FOR ALLOY 825

ALLOY TYPE

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

MATERIALS TO BE WELDED

Matching 825 materials:

ASTM/ UNS

N08825

DIN

2.4858

BS

1501 & 3072 Grade NA16

Proprietary

Incoloy 825 (Special Metals)
Incoloy 825CP, cast (Special Metals)
Nicrofer 4221 (Krupp VDM)

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

ASTM/ UNS

N08028

DIN

1.4563

Proprietary

Nicrofer 3127LC (Krupp VDM)
Sanicro 28 (Sandvik)

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

APPLICATIONS

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

ADDITIONAL INFORMATION

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

RELATED ALLOY GROUPS

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

PRODUCTS AVAILABLE

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

E825L-15

MMA ELECTRODE FOR AUSTENITIC ALLOY 825

PRODUCT DESCRIPTION

MMA electrode for welding 825, alloy 28 and alloy 20 type materials. Specially balanced basic-fluoride-rutile flux on high purity 825 core wire. The electrodes are designed for fixed pipework welds including the demanding ASME 5G/6G positions. Careful control of carbon, manganese, silicon and nitrogen to maximise corrosion resistance in the as-welded condition and to ensure high resistance to solidification cracking and microfissuring in multipass welds. The composition is controlled to give a Pitting Resistance Equivalent (PRE) of about 40, where PRE = %Cr + 3.3%Mo.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M (E383-15)
Does not strictly conform; Ni & Cu are higher in E825L-15 compared to the E383-15 classification

DIN EL-NiCr28Mo

ASME IX QUALIFICATION

QW432 F-No 5
(This is nearest because the electrode does not strictly conform to AWS.

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Nb	Fe
min.	--	1.0	--	--	--	27.0	35.0	3.2	1.5	--	--
max.	0.03	3.0	0.5	0.015	0.030	31.0	40.0	4.5	3.0	1.0	30
Typical	0.02	2	0.3	0.01	0.01	28	38	3.5	2	0.3	27

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		550	640
0.2% proof strength (MPa)		240	410
Elongation (%)	4d	30	40
	5d	25	39
Reduction of area (%)		--	43
Impact ISO-V(J)	+20°C	--	120
	- 196°C	--	65
Hardness (HV)		--	220

OPERATING PARAMETERS, DC +VE

Diameter (mm)	2.5	3.2	4.0
min. A	60	70	90
max. A	80	110	150

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	275	325	325
kg/carton	10.8	13.8	14.1
Pieces/carton	612	387	261

STORAGE

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

FUME DATA

Fume composition (wt %) typical

Fe	Mn	Ni	Cr	Mo	Cu	F	OES (mg/m³)
4	5	3	7	1	1	20	0.7

82-50

SOLID TIG AND MIG WIRE FOR AUSTENITIC ALLOY 825

PRODUCT DESCRIPTION

Solid wire for TIG and MIG welding of 825 and alloy 20 type materials. The 82-50 wire only has a nominal 21%Cr and so is not suitable for alloy 28. Note MIG wire is to order only.

SPECIFICATIONS

AWS A5.14M	ERNiFeCr-1
BS EN ISO 18274	SNi8065

Also known generically as filler metal 65 (FM65)

ASME IX QUALIFICATION

QW432 F-No 45

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Al	Ti	Fe
min.	--	--	--	--	--	19.5	38.0	2.5	1.5	--	0.60	22.0
max.	0.05	1.0	0.50	0.015	0.020	23.5	46.0	3.5	3.0	0.20	1.2	bal
Typical	0.02	0.5	0.3	0.005	0.015	22	40	3	2	0.1	0.8	30

ALL-WELD MECHANICAL PROPERTIES

Typical values as welded		TIG (Ar)	TIG (Ar+2%H_2)
Tensile strength (MPa)		475	580
0.2% proof strength (MPa)		350	350
Elongation (%)	4d	18	39
	5d	16	35
Reduction of area (%)		35	35
Hardness cap/mid	HV	165/180	190/205

TYPICAL OPERATING PARAMETERS

	Shielding	Current	Diameter (mm)	Voltage
TIG	Argon*	DC-	2.4	100A, 12V
MIG	Argon	DC+ **	1.2	220A, 30V

* Also required as a purge for root runs. Ar+1-5%H_2 can prove beneficial see mechanical properties.

** Pulsed current may provide better arc transfer characteristics.

PACKAGING DATA

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

FUME DATA

Fume composition (wt%), (TIG fume negligible)

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m³)
23	2	19	29	2	3	1.7

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310L STAINLESS STEELS

ALLOY TYPE

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

MATERIALS TO BE WELDED

BS EN / DIN

X1CrNi25 21 (1.4335)

AFNOR

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

Proprietary

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

APPLICATIONS

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

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

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

MICROSTRUCTURE

Fully austenitic.

WELDING GUIDELINES

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

RELATED ALLOY GROUPS

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

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

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**25.20.L.R**	None

25.20.L.R

MMA ELECTRODE FOR 310L STAINLESS STEEL

PRODUCT DESCRIPTION

Special low silica basic rutile flux on low carbon stainless steel core wire.
Detrimental residual elements including silicon are kept to low levels for optimum corrosion performance.
Coupled with raised manganese, these features also ensure excellent resistance to microfissuring hot cracking.
Suitable for all-positional welding up to 3.2mm diameter.
Recovery is about 140% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

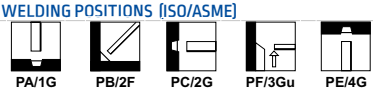
There are no national specifications for this electrode.

Approvals: Approved for welding equivalent parent material Uranus 65 by independent tests.

ASME IX QUALIFICATION

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

WELDING POSITIONS (ISO/ASME)



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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu
min.	--	4.0	--	--	--	24.0	19.0	--	--	--
max.	0.040	7.0	0.4	0.020	0.025	26.0	22.0	0.2	0.3	0.3
Typical	0.03	5	0.3	0.008	0.01	25	21	0.1	<0.1	0.08

ALL-WELD MECHANICAL PROPERTIES

As welded		Typical
Tensile strength (MPa)		520
0.2% proof strength (MPa)		350
Elongation (%)	4d	37
	5d	30
Reduction of area (%)		55
Impact ISO-V(J)	- 196°C	90
Hardness (HV)		170

ALL-WELD CORROSION PROPERTIES

The weld metal has been subjected to the Huey test (ASTM A262 practice C: 5 x 48hr periods in boiling 65% nitric acid).
The corrosion rates were as follows:

Condition	Corrosion rate	Selective attack
As-welded	0.40 µm/48hr (= 0.07mm or 3 mils/year)	< 0.01mm
PWHT 815°C/2hrs	0.73 µm/48hr (= 0.13mm or 5 mils/year)	< 0.13mm

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

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

PACKAGING DATA

Diameter (mm)	3.2	4.0
Length (mm)	350	350
kg/carton	13.5	13.2
Pieces/carton	318	192

STORAGE

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

FUME DATA

Fume composition (wt %) typical

Fe	Mn	Ni	Cr	Cu	F	OES (mg/m³)
9	10	2	7.5	<0.2	18	0.6

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310MoLN STAINLESS STEELS

ALLOY TYPE

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

MATERIALS TO BE WELDED

AISI
310MoLN

AFNOR
Z1 CND 25.22.Az

UNS
S31050

DIN / EN
1.4465 (X2CrNiMoN 25-25-2)
1.4466 (X1CrNiMoN 25-22-2)

Proprietary
Uranus 25 22 2 (Usinor Industeel)
2RE69, 3R60U.G (Sandvik)
Cronifer 25.25.LCN (VDM)
HR3ELM (Sumitomo)

APPLICATIONS

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

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

ADDITIONAL INFORMATION

The alloy has excellent resistance to the ASTM A262 practice C corrosion test (Huey test). Typically required to meet <0.16g/m²/h (0.18mm/year), and selective attack <0.07mm.

PRODUCTS AVAILABLE

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

ULTRAMET B310MoLN

MMA ELECTRODE FOR ALLOY 310MOLN

PRODUCT DESCRIPTION

MMA electrode with a specially balanced basic carbonate-fluoride flux on high purity stainless steel core wire. Low silicon and high manganese levels ensure freedom from microfissuring.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

BS EN ISO 3581 E 25 22 2 N L B 4 2

ASME IX QUALIFICATION

QW432 F-No 5
(This is nearest because the electrode does not strictly conform to AWS)

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	N	Cu
min.	--	3.0	--	--	--	24.0	20.0	2.0	0.10	--
max.	0.04	5.0	1.0	0.025	0.030	27.0	23.0	3.0	0.20	0.50
Typical	0.03	4	0.4	0.005	0.02	25	22	2.2	0.15	0.05

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		510	640
0.2% proof strength (MPa)		320	430
Elongation (%)	4d	--	37
	5d	25	36
Reduction of area (%)		--	50
Impact ISO-V(J)	- 50°C	--	75
Hardness cap/mid	HV	--	185/205

OPERATING PARAMETERS, DC +VE

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	11.4	13.8	13.8
Pieces/carton	465	375	21.0

STORAGE

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

FUME DATA

Fume composition (wt %) typical

Fe	Mn	Ni	Cr	Cu	F	OES (mg/m³)
9	10	2	7.5	<0.2	18	0.6

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20.18.6.CU.R

PRODUCT DESCRIPTION

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

SPECIFICATIONS

There are no national specifications for this electrode.

MATERIALS TO BE WELDED

ASTM

A351 CK3MCuN (cast).

A182 F44.

S31254

BS EN

1.4547

Proprietary

254SMO (Outokumpu)

APPLICATIONS

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

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

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

MICROSTRUCTURE

Fully austenitic.

HEAT TREATMENT

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

A minimum temperature of 1200°C is required to dissolve these intermetallic phases and some authorities require >1230°C. This is followed by water quenching to prevent further intermetallic formation on cooling.

WELDING GUIDELINES

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

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE
Min.	--	0.2	0.2	--	--	19.5	17.5	6.0	0.5	0.15	40
Max.	0.03	1.0	0.8	0.02	0.03	21.0	20.0	7.0	1.0	0.28	--
Typical	0.02	0.8	0.3	0.01	0.02	20.5	18.5	6.5	0.7	0.2	44

PRE = Cr + 3.3Mo + 16N

ALL-WELD MECHANICAL PROPERTIES

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

* Minimum properties for CK3MCuN castings.

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

Diameter (mm)	3.2	4.0
min. A	80	130
max. A	110	160

PACKAGING DATA

Diameter (mm)	3.2	4.0
Length (mm)	350	350
kg/carton	15.0	14.1
Pieces/carton	378	201

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200–300°C/1-2h to restore to as-packed condition. Maximum 250° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Mo	Cu	F	OES (mg/m³)
8	8	7	2	1.5	1	18	0.7

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309L STAINLESS STEELS

ALLOY TYPE

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

MATERIALS TO BE WELDED

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

APPLICATIONS

There are 3 main areas of application:

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

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

ADDITIONAL INFORMATION

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

RELATED ALLOY GROUPS

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

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Supermet 309L**	AWS E309L-17
	Ultramet 309L	AWS E309L-16
	Ultramet B309L	AWS E309L-15
	Ultramet 309LP	AWS E309L-16
TIG	**309S92**	AWS ER309L
MIG	**Supermig 309LSi**	AWS ER309LSi
SAW	**309S92**	AWS ER309L
	SS300	BS EN SA AF2
	SSB	BS EN SA AF2
FCW	**Supercore 309L**	AWS E309LT0-1/4
	Supercore 309LP	AWS E309LT1-1/4

SUPERMET 309L

GENERAL PURPOSE RUTILE 309L MMA ELECTRODE

PRODUCT DESCRIPTION

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

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

SPECIFICATIONS

AWS A5.4M	E309L-17
BS EN ISO 3581	E 23 12 L R 3 2
APPROVALS	TÜV, ABS

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	22.0	12.0	--	--	8
Max.	0.04	2.5	0.90	0.025	0.030	25.0	14.0	0.5	0.5	20
Typical	0.02	0.8	0.6	0.01	0.02	24	13	0.05	0.1	15

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	Typical
Tensile strength (MPa)		560	620
0.2% proof strength (MPa)		320	500
Elongation (%)	4d	30	40
	5d	30	36
Reduction of area %		--	50
Impact ISO*-V(J)	+20°C	--	55
Hardness (HV)		--	220

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	450	450
kg/carton	11.4	13.5	18.3	18.0
Pieces/carton	579	354	258	171

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F*	OES (mg/m³)
9	6	7	1	0.1	< 0.2	17	0.7

* F=28% for basic coated Ultramet B309L but this does not affect the OES.

ULTRAMET 309L

ALL-POSITIONAL RUTILE 309L MMA ELECTRODE

PRODUCT DESCRIPTION

MMA electrode – rutile flux coated 309L electrode on high purity 304L core wire. Ultramet has all the benefits of an advanced rutile flux design – this includes optimum versatility for downhand welding with high cosmetic finish and weld metal integrity; and all-positional welding with the 2.5/3.2mm electrodes including fixed pipework. The 2.5mm electrodes are also designed for open butt root welding.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E309L-16
BS EN ISO 3581	E 23 12 L R 3 2
APPROVALS	TÜV

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	22.0	12.0	--	--	8
Max.	0.04	2.5	0.90	0.025	0.030	25.0	14.0	0.50	0.5	20
Typical	0.03	0.8	0.6	0.01	0.02	23.5	13	0.1	0.1	15

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		560	595
0.2% proof strength (MPa)		320	495
Elongation (%)	4d	30	41
	5d	30	38
Reduction of area %		--	59
Impact ISO-V(J)	- 20°C	--	45
Hardness (HV)		--	230

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	11.4	13.5	13.5	18.0
Pieces/carton	660	393	252	165

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F*	OES (mg/m³)
9	6	7	1	0.1	< 0.2	17	0.7

* F=28% for basic coated Ultramet B309L but this does not affect the OES.

ULTRAMET B309L

BASIC COATED 309L MMA ELECTRODE FOR PIPE-WELDING

PRODUCT DESCRIPTION

MMA electrode – designed and manufactured to give high moisture resistance using a basic flux system and high purity 304L core wire. Ultramet B309L is particularly suited to the most demanding vertical and overhead welding applications including fixed pipework in the ASME 5G/6G position. Under site conditions it is tolerant to adverse wind and drafts.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E309L-15
BS EN ISO 3581	E 23 12 L B 4 2
BS 2926	23.12.L B
DIN 8556	E 23 12 L B 20+

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	22.0	12.0	--	--	8
Max.	0.04	2.5	0.90	0.025	0.030	25.0	14.0	0.50	0.5	20
Typical	0.03	1.2	0.3	0.01	0.02	23.5	13	0.1	0.1	15

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		560	630
0.2% proof strength (MPa)		320	490
Elongation (%)	4d	30	36
	5d	30	34
Reduction of area %		--	45
Impact ISO-V(J)	+20°C	--	75
	-50°C	--	50

TYPICAL OPERATING PARAMETERS, DC +VE ONLY

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0 *	5.0 **
Length (mm)	300	350	350/450	450
kg/carton	12.0	13.8	14.1/17.4	17.1
Pieces/carton	675	402	267/267	159

* 350mm is the standard length for 4.0mm diameter; 450mm is available to order.
** 5.0mm diameter made to order.

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F*	OES (mg/m³)
9	6	7	1	0.1	< 0.2	17	0.7

* F=28% for basic coated Ultramet B309L but this does not affect the OES.

ULTRAMET 309LP

ALL-POSITIONAL PIPE WELDING AND ROOT WELDING ELECTRODE

PRODUCT DESCRIPTION

MMA electrode – rutile flux on high purity 309L core wire giving very low typical carbon level. Ultramet 309LP is a fully all-positional electrode capable of the most demanding fixed pipework applications including ASME 5G/6G. The Ultramet 309LP electrode has also been designed to deposit single-side root runs without the need for a gas purge. The electrode is also suitable for vertical-down welding on thin sheet material.

Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.

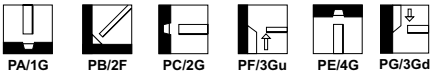
SPECIFICATIONS

AWS A5.4M	E309L-16
BS EN ISO 3581	E 23 12 L R 1 1

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)



CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	22.0	12.0	--	--	8
Max.	0.04	2.5	0.90	0.025	0.030	25.0	14.0	0.50	0.5	20
Typical	0.03	0.8	0.6	0.01	0.02	23.5	13	0.1	0.1	15

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		560	635
0.2% proof strength (MPa)		320	525
Elongation (%)	4d	30	40
	5d	30	38
Reduction of area %		--	45
Impact ISO-V(J)	+20°C	--	47
	-20°C	--	42
Hardness (HV)		--	230

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

Diameter (mm)	2.0	3.2
min. A	50	75
max. A	80	120

PACKAGING DATA

Diameter (mm)	2.0	3.2
Length (mm)	300	350
kg/carton	11.7	12.0
Pieces/carton	1090	453

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F*	OES (mg/m³)
9	6	7	1	0.1	< 0.2	17	0.7

* F=28% for basic coated Ultramet B309L but this does not affect the OES.

309S92, SUPERMIG 309LSi

309L SOLID WIRES FOR TIG, MIG AND SAW

PRODUCT DESCRIPTION

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

SPECIFICATIONS

	309S92 (TIG & sub-arc)	Supermig 309LSi (MIG)
AWS A5.9M	ER309L	ER309L Si
BS EN ISO 14343-A	23 12 L	G 23 12 L Si
BS EN ISO 14343-B	SS309L	SS309L Si
APPROVALS	TÜV	

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si *	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	1.0	0.30	--	--	23.0	12.0	--	--	8
Max.	0.03	2.5	0.65	0.020	0.030	25.0	14.0	0.3	0.3	20
Typical	0.015	1.7	0.5	0.005	0.015	23.5	13	0.1	0.15	12

* Supermig 309LSi: Si range is 0.65 – 1.0%, typically 0.8%.

ALL-WELD MECHANICAL PROPERTIES

As welded		Typical	
		TIG	MIG
Tensile strength (MPa)		590	560
0.2% proof strength (MPa)		450	430
Elongation (%)	4d	43	42
	5d	41	39
Reduction of area (%)		55	56
Impact ISO-V(J)	+ 20°C	>200	100
	- 20°C	--	80
	- 75°C	>150	--
Hardness cap/mid	HV	205/225	175/215

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon*	DC-	2.4	100A, 12V
MIG	Ar+2%O_2**	DC+	1.2	260A, 26V
SAW	SS300***	DC+	2.4	350A,28V

* Also required as a purge for root runs.

** Also proprietary Ar and Ar-He gas mixtures with < 3%CO2.

*** SSB also suitable.

PACKAGING DATA

Diameter (mm)	0.8	1.0	1.2	1.6	2.0	2.4	3.2
TIG (309S92)	--	--	--	5 kg tube	5 kg tube	5 kg tube	5 kg tube
MIG (Supermig 309LSi)	15kg spool	15kg spool	15kg spool	--	--	--	--
SAW (309S92)	--	--	--	25kg spool	--	25kg spool	25kg spool

FUME DATA

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

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m3)
32	12	20	11	< 0.5	< 0.5	2.5

SUPERCORE 309L, 309LP

RUTILE FLUX CORED WIRES

PRODUCT DESCRIPTION

Flux cored wires – the wires are made with an austenitic stainless steel sheath and rutile flux system. **Supercore 309L** combines easy operability, high deposit quality and exceptional weld bead appearance for downhand and HV welding. **Supercore 309LP** is designed for all-positional welding including fixed pipework. Metal recovery is about 90% with respect to the wire.

SPECIFICATIONS

	Supercore 309L	Supercore 309LP
AWS A5.22M	E309LT0-1/4	E309LT1-1/4
BS EN ISO 17633-A	T 23 12 L R C/M 3	T 23 12 L P C/M 2
BS EN ISO 17633-B	TS309L-FB0	TS309L-FB1
Approvals	TÜV, LRS	TÜV, ABS, DNV

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	22.0	12.0	--	--	12
Max.	0.04	2.0	1.0	0.025	0.030	25.0	14.0	0.3	0.3	22
Typical	0.03	1.3	0.6	0.02	0.02	24	12.5	0.1	0.1	15

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		520	560
0.2% proof strength (MPa)		320	445
Elongation (%)	4d	30	40
	5d	25	36
Reduction of area (%)		--	52
Impact ISO-V(J)	+20°C	--	65 *
	-110°C	--	55 *
Hardness (HV)		--	205

* These values are for Supercore 309LP. Values for Supercore 309L are 45J at +20°C, 40J at -20°C.

OPERATING PARAMETERS

Shielding gas: Either 80%Ar-20%CO2 or 100% CO2 shielding gas at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.

Current: DC+ve ranges as below for Ar-20%CO2. Welding with 100%CO2 requires approx 3V higher:

Diameter (mm)	amp-volt range	typical	stickout
1.2	120 – 280A, 22 – 34V	180A, 29V	15 – 20mm
1.2P	120 – 250A, 22 – 32V	150A, 25V	15 – 20mm

PACKAGING DATA

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

FUME DATA

Fume composition (wt %)

Fe	Mn	Ni	Cr^{3}	Cr^{6}	Cu	F	OES (mg/m^3)
9	4	1	6	1	<1	15	1.2

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309Mo STAINLESS STEELS

ALLOY TYPE

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

MATERIALS TO BE WELDED

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

APPLICATIONS

There are 3 main areas of application:

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

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

ADDITIONAL INFORMATION

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

RELATED ALLOY GROUPS

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

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Supermet 309Mo**	AWS E309LMo-17
	Vertamet 309Mo	AWS E309LMo-17
TIG/MIG	**ER309Mo**	EN ISO 23 12 2 L
SAW	**ER309Mo**	EN ISO 23 12 2 L
	SS300	EN ISO SA AF2 64
	SSB	EN ISO SA AF2
FCW	**Supercore 309Mo**	AWS E309LMoT0-1/4
	Supercore 309MoP	AWS E309LMoT1-1/4

SUPERMET 309Mo

GENERAL PURPOSE RUTILE 309MO MMA ELECTRODE

PRODUCT DESCRIPTION

Acid rutile electrode made on nearly matching austenitic steel core wire.
Moisture resistant coating gives sound porosity-free deposits.
Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E309LMo-17
BS EN ISO 3581	E 23 12 2 L R 3 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	22.0	12.0	2.0	--	10
Max.	0.04	2.5	0.9	0.025	0.030	25.0	14.0	3.0	0.5	30
Typical	0.02	0.8	0.6	0.01	0.02	23.5	12.5	2.5	0.05	25

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	Typical
Tensile strength (MPa)		560	680
0.2% proof strength (MPa)		350	510
Elongation (%)	4d	30	37
	5d	30	35
Reduction of area %		--	40
Impact ISO*-V(J)	+20°C	--	50
Hardness (HV)		--	220

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	450	450
kg/carton	12.0	13.2	17.7	18.0
Pieces/carton	609	336	246	162

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Ni	Cr	Cu	F *	OES (mg/m³)
9	6	1	7	< 0.5	17	0.7

* F=28% for basic coated Ultramet B309Mo but this does not affect the OES.

VERTAMET 309Mo

RUTILE VERTICAL-DOWN 309MO MMA ELECTRODE

PRODUCT DESCRIPTION

Rutile-aluminosilicate flux on high purity 309L core wire giving very low typical carbon levels. 'Low hydrogen' manufacturing technology ensures high resistance to weld metal porosity. The electrode is designed for all-positional use where the emphasis is on fast welding speeds achieved by the vertical-down welding technique (BS EN 287-1 PG position). For fillet and lap joints in thinner sheet material, an added advantage is reduced distortion resulting from the lower heat input of vertical-down welding. Although designed primarily for vertical-down it can be successfully used in all other positions.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E309LMo-17
BS EN ISO 3581	E 23 12 2 L R 1 1

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	22.0	12.0	2.0	--	10
Max.	0.04	2.5	0.90	0.025	0.030	25.0	14.0	3.0	0.5	30
Typical	0.02	0.8	0.8	0.01	0.02	23	12	2.4	0.1	15

ALL-WELD MECHANICAL PROPERTIES

As welded	**Min.**	**Typical**
Tensile strength (MPa)	560	580
0.2% proof strength (MPa)	350	380
Elongation (%) 4d	30	42
5d	30	38
Reduction of area %	--	50

TYPICAL OPERATING PARAMETERS, DC +VE OR AC (OCV: 45V MIN)

Diameter (mm)	**2.5**	**3.2**
min. A	60	75
max. A	90	120
Typical vertical-up	≈65	≈80
Typical vertical-down	≈85	≈110

PACKAGING DATA

Diameter (mm)	**2.5**	**3.2**
Length (mm)	300	300
kg/carton	12.9	12.9
Pieces/carton	837	467

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Ni	Cr	Cu	F *	OES (mg/m³)
9	6	1	7	< 0.5	17	0.7

* F=28% for basic coated Ultramet B309Mo but this does not affect the OES.

ER309Mo

SOLID 309Mo WIRES FOR TIG, MIG AND SAW

PRODUCT DESCRIPTION

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

SPECIFICATIONS

AWS A5.9M	(ER309LMo)	Nearest classification
EN ISO 14343-A	23 12 2 L	
EN ISO 14343-B	(SS309LMo)	Nearest classification

ASME IX QUALIFICATION

QW432 F-No 6
QW442 A-No 8
Most relevant F & A No because wire does not conform to AWSA5.9

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	1.0	0.30	--	--	21.0	11.0	2.0	--	5
Max.	0.03	2.5	0.65	0.02	0.030	25.0	15.5	3.5	0.3	20
Typical	0.015	1.7	0.5	0.005	0.015	22	14.5	2.7	0.2	10

ALL-WELD MECHANICAL PROPERTIES

As welded		TIG
Tensile strength (MPa)		610
0.2% proof strength (MPa)		440
Elongation (%)	4d	35
	5d	31
Reduction of area %		54
Impact ISO-V(J)	+20°C	> 90
Hardness cap/mid (HV)		205/220

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon	DC-	2.4	100A, 12V
MIG	Ar+2%O_2*	DC+	1.2	260A, 26V
SAW	SS300**	DC+	2.4	350A,28V

* Proprietary Ar and Ar-He gas mixtures with <3%CO2 also suitable.
** SSB also suitable.

PACKAGING DATA

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

FUME DATA

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

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
32	12	20	11	1.5	<0.5	2.5

SUPERCORE 309Mo, 309MoP

RUTILE FLUX CORED WIRES

PRODUCT DESCRIPTION

Flux cored wires made using an austenitic stainless steel sheath and rutile flux system. Supercore 309Mo combines easy operability, high deposit quality and exceptional weld bead appearance for downhand and HV welding. Supercore 309MoP is designed for all-positional welding.
Metal recovery is about 90% with respect to wire.

SPECIFICATIONS

	Supercore 309Mo	Supercore 309MoP
AWS A5.22M	E309LMoT0-1/4	E309LMoT1-1/4
EN ISO 17633-A	T 23 12 2 L R C/M 3	T 23 12 2 L P C/M 2
EN ISO 17633-B	TS309LMo-FB0	TS309LMo-FB1
Approvals	DNV	DNV, LRS

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN
Min.	--	0.5	--	--	--	22.0	12.0	2.0	--	15
Max.	0.04	2.0	1.0	0.025	0.030	25.0	14.0	3.0	0.3	25
Typical	0.03	1.3	0.7	0.01	0.02	23	12.8	2.3	0.1	20

ALL-WELD MECHANICAL PROPERTIES

As welded	Min.	Typical
Tensile strength (MPa)	550	700
0.2% proof strength (MPa)	350	550
Elongation (%) 4d	25	32
5d	25	30
Reduction of area %	--	40
Impact ISO-V(J) +20°C	--	50
Hardness (HV)	--	245

OPERATING PARAMETERS

Shielding gas: 80%Ar-20%CO2 or 100% CO2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.
Current: DC+ve ranges as below for Ar-20%CO2. Welding with 100%CO2 requires approx 3V higher:

Diameter (mm)	amp-volt range	typical	stickout
1.2	120A-22V to 280A-34V	180A-29V	15-20mm
1.2P	120A-22V to 250A-32V	160A-26V	15-20mm

PACKAGING DATA

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

FUME DATA

Fume composition (wt %)

Fe	Mn	Ni	Cr^{3}	Cr^{6}	Cu	F	OES (mg/m³)
11	6	2	8.5	1	<1	11	0.8

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ULTRAMET 309Nb

PRODUCT DESCRIPTION

MMA electrode with rutile flux system made on high purity 304L stainless steel core wire. Deposits a low carbon 309 type weld metal with a minimum niobium level of 0.7%. Recovery is about 115% with respect to core wire and 65% with respect to the whole electrode.

SPECIFICATIONS

AWS A5.4M	E309Nb-16 (previously E309Cb-16)
BS EN ISO 3581	E 23 12 Nb R 32

ASME IX QUALIFICATION

QW432 F-No 5 QW442 A-No 8

MATERIALS TO BE WELDED

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

APPLICATIONS

Ultramet 309Nb is designed specifically for use where niobium stabilised weld metal is required in overlays, or inlays, on CMn or low alloy steels. A minimum niobium content of 0.7% in undiluted weld metal ensures a fully stabilised deposit of approximately 347 composition is produced in the first layer on mild and medium carbon steels.
It may also be useful for the first run when welding 321 or 347 clad steels, prior to completion with 347 type weld metal. It is not recommended as an alternative to 309L types for dissimilar welded joints.

MICROSTRUCTURE

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

WELDING GUIDELINES

Preheat is dependent on the base material hardenability, eg none on mild steel, up to 200°C on hardenable (0.4%C) steels.
With a typical dilution of 25-30% on a medium carbon steel, Ultramet 309Nb could produce a fully austenitic weld deposit. It is well known that weld metals containing niobium are especially sensitive to hot cracking when little or no ferrite is present. Therefore it is desirable to minimise dilution in the first layer of overlays by controlling parameters and bead overlap (aim for 50% overlap).

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

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu
Min.	--	0.5	--	--	--	22.0	12.0	--	0.70	--
Max.	0.04	2.5	0.9	0.025	0.030	25.0	14.0	0.50	1.00	0.50
Typical	0.03	1.5	0.5	0.01	0.02	23	12.5	0.05	0.8	0.1

ALL-WELD MECHANICAL PROPERTIES

As welded		Typical
Tensile strength (MPa)		660
0.2% proof strength (MPa)		470
Elongation (%)	4d	34
	5d	31
Reduction of area %		52

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	13.8	15.6	15.9	18.0
Pieces/carton	717	441	288	168

STORAGE

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

FUME DATA

Fume composition, wt % typical

Fe	Mn	Ni	Cr	Mo	Cu	F	OES (mg/m³)
9	6	1	7	<0.5	<0.2	17	0.7

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LEAN DUPLEX STAINLESS STEELS

ALLOY TYPE

Ferritic-austenitic lean duplex stainless steels.

MATERIALS TO BE WELDED

BS EN & DIN

X2CrNiN23L

1.4362

ASTM/UNS

S32304

S32101

S32001

Proprietary alloys include:

Sandvik	SAF 2304
Usinor Industeel	Uranus 35N
Avesta Polarit	LDX 2101
AK Steel	Nitronic 19D

APPLICATIONS

Lean duplex stainless steels (LDSS) provide cost savings compared to 22%Cr duplex stainless steels because of the reductions in Ni and Mo. The LDSS also provide a strength advantage compared to austenitic stainless steels and generally have comparable corrosion resistance to austenitic stainless steels.

The LDSS are finding more widespread use in today's economic climate, particularly in structural applications. Uses include: bridges and structural work generally replacing austenitic stainless steels and carbon steels rather than replacing standard duplex alloys.

MICROSTRUCTURE

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

WELDING GUIDELINES

Preheat not generally required. Interpass temperature 150°C max, although for many applications this could be relaxed to 250°C. Heat input in the range 1.0–2.5 kJ/mm (depending on material thickness) should be acceptable. Welds are left in the as-welded condition.

RELATED ALLOY GROUPS

The 22%Cr duplex consumables (data sheet B-60) are related and can also be used for welding the lean duplex stainless steels.

There is no matching solid wire available. The ER329N (AWS ER2209) wire should be used for MIG/TIG/SAW applications, data sheet B-60.

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Ultramet 2304**	--
FCW	**Supercore 2304P**	--

ULTRAMET 2304

RUTILE MMA ELECTRODE FOR LEAN DUPLEX STEELS

PRODUCT DESCRIPTION

MMA electrode made on high quality stainless steel core wire with rutile flux system optimised for all welding positions except vertical down.
Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M Proposed E2101-16

ASME IX QUALIFICATION

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

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
min.	--	0.5	--	--	--	22.5	8.0	0.1	--	0.10	24
max.	0.04	1.5	0.9	0.02	0.03	25.5	9.5	0.8	0.5	0.20	31
Typical	0.03	0.7	0.7	0.015	0.025	24.5	9.1	0.2	0.3	0.13	27

PRE_N = Cr + 3.3Mo + 16N

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		690	790
0.2% proof strength (MPa)		480	640
Elongation (%)	4d	20	31
Reduction of area (%)		--	42
Impact ISO-V(J)	+20°C	--	55
	- 20°C	--	50
	- 50°C	--	37

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

Diameter (mm)	2.5	3.2	4.0
min. A	50	65	100
max. A	90	120	160

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	450
kg/carton	12	13.5	17.4
Pieces/carton	229	130	86

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life.
Direct use from tin is satisfactory for longer than a working shift of 8h.
Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.
For electrodes that have been exposed:
Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 380° C, 3 cycles, 10h total.
Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended.
Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

FUME DATA

Fume composition (wt %) typical

Fe	Mn	Cr	Ni	Mo	Cu	F	OES (mg/m³)
7	6	6	1	0.2	<0.2	16	0.8

SUPERCORE 2304P

ALL-POSITIONAL RUTILE FLUX CORED WIRE FOR LEAN DUPLEX STEELS

PRODUCT DESCRIPTION

High performance rutile all positional flux cored wire produced in the most versatile size of 1.2mm.
Made with an austenitic stainless steel sheath and rutile flux system.
Weld metal carbon content is typically <0.04% when using either 80%Ar-20%CO2 or 100% CO2 shielding gas.
Metal recovery about 90% with respect to the wire.

SPECIFICATIONS

NONE

ASME IX QUALIFICATION

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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
min.	--	0.5	--	--	--	22.5	8.0	0.1	--	0.08	24
max.	0.04	2.0	1.00	0.02	0.03	25.5	10.0	0.8	0.75	0.20	31
Typical	0.03	1.0	0.6	0.01	0.02	24.5	9.2	0.2	0.2	0.14	27

PREN (pitting resistance equivalent) = Cr + 3.3Mo + 16N

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		690	760
0.2% proof strength (MPa)		480	610
Elongation (%)	4d	20	35
	5d	20	32
Reduction of area (%)		--	50
Impact ISO-V(J)	- 20°C	--	70
	- 50°C	--	55
Hardness (HV)		--	240

OPERATING PARAMETERS

Shielding gas: Either 80%Ar-20%CO2 or 100% CO2 shielding gas at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.

Current: DC+ve ranges as below for Ar-20%CO2. Welding with 100%CO2 requires approx 3V higher:

Diameter (mm)	amp-volt range	typical	stickout
1.2 P	120A-22V to 250A-34V	150A-25V	15-20mm

PACKAGING DATA

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

FUME DATA

Fume composition (wt %) typical

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
10	12	2	4	5.5	<0.5	9	0.9

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22%Cr DUPLEX STAINLESS STEELS

ALLOY TYPE

22%Cr standard ferritic-austenitic duplex stainless steels.

MATERIALS TO BE WELDED

ASTM	*UNS*
A182 Gr F51	S31803
A890 Gr 4A (cast)	S32205
BS	S32101
318S13	S32304
	S32001
BS EN & DIN	J92205 (cast)
1.4462	
X2CrNiMoN22-5-3	

Proprietary alloys include:

Sandvik	SAF2205
Avesta Polarit	2205
Creusot Ind	UR 45N
Böhler	A903
VDM	Cronifer 2205LCN
S+C	Maresist F51 (cast)
Sumitomo	SM22Cr

Lean and Mo-free duplex including:

(UNS S32304 / DIN 1.4362 / X2CrNiN23L)

Sandvik	SAF 2304
Creusot Ind	UR35N
LDX 2101	Avesta Polarit

APPLICATIONS

Duplex stainless steel pipe, plate, fittings and forgings have an approximate 50:50 microstructure of austenite with a ferrite matrix.

This, coupled with general alloying level, confers:

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

PWHT

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

ADDITIONAL INFORMATION

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

RELATED ALLOY GROUPS

Lean duplex (data sheet B-59), superduplex (data sheets B-61, B-62 and B-63) and duplex matching consumables for casting repairs.

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Supermet 2205**	-
	Ultramet 2205	AWS E2209-16
	Supermet 2205AR	AWS E2209-17
	2205XKS	AWS E2209-15
TIG/SAW	**ER329N**	AWS ER2209
MIG	**ER329N**	AWS ER2209
MCW	**Supercore M2205**	AWS EC2209
SAW flux	**SSB**	BS EN SA AF2 DC
FCW	**Supercore 2205**	AWS E2209T0-1/4
	Supercore 2205P	AWS E2209T1-1/4

SUPERMET 2205

OVERALLOYED RUTILE ELECTRODE FOR 22%Cr DUPLEX STEELS

PRODUCT DESCRIPTION

MMA electrode with enhanced Cr, Mo and N levels, giving higher weld pitting resistance than the nearest AWS specification A5.4 E2209-16. See **Ultramet 2205** for rutile type conforming to AWS.

Supermet 2205 is made on high quality stainless steel core wire with a rutile flux system designed to give minimum carbon content coupled with optimum operating characteristics.

Supermet 2205 is designed for welding wrought, forged or cast «standard» duplex stainless steels for service in the as-welded condition. Good properties are also obtained when solution treated, as frequently required for casting repairs. The electrode has a rutile flux system and is used primarily for downhand and H-V welding applications. Smaller sizes offer excellent all-positional operability.

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

SPECIFICATIONS

AWS A5.4M E2209-16 nearest classification

ASME IX QUALIFICATION

QW432 F-No --
QW442 A-No 8

WELDING POSITIONS (ISO/ASME)

PA/1G PB/2F PC/2G

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
Min.	--	0.5	0.3	--	--	24.0	8.5	3.0	--	0.14	36
Max.	0.03	2.0	1.0	0.02	0.03	26.0	10.0	4.0	0.5	0.25	43
Typical	0.02	1	0.7	0.01	0.02	25	9.5	3.4	0.1	0.17	38

PRE_N = Cr + 3.3Mo + 16N

ALL-WELD MECHANICAL PROPERTIES

As welded	Min.	Typical	Pipe butt weld	1120°C/ 3h + WQ
Tensile strength (MPa)	690	850	867	800
0.2% proof strength (MPa)	480	650	752	480
Elongation (%) 4d	20	30	25	32
Reduction of area %	--	40	35	--
Impact ISO*-V(J) +20°C	--	60-73	--	--
- 20°C	--	45-55	45-50	--
- 30°C	--	40-52	42-46	> 90
- 40°C	--	35-47	38-43	> 70
- 50°C	--	30-40	35-40	> 35

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

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	50	65	100	130
max. A	90	120	160	190

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	12.0	13.2	13.8	18.6
Pieces/carton	630	354	255	165

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 380° C, 3 cycles, 10h total.

Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended.

Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m³)
7	6	6	1	0.2	<0.2	16	0.8

* F = 28% for basic coated 2205XKS but this does not affect OES.

ULTRAMET 2205

RUTILE ALL-POSITIONAL MMA ELECTRODE FOR 22%Cr DUPLEX STEELS

PRODUCT DESCRIPTION

MMA electrode made on duplex stainless steel core wire with a rutile flux system designed to give minimum carbon content coupled with optimum operating characteristics. The electrode has a rutile flux system optimised for all welding positions except vertical down and provides excellent operability.
Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E2209-16
BS EN ISO 3581	E 22 9 3 N L R 3 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
Min.	--	0.5	0.3	--	--	22.0	8.5	2.8	--	0.14	34
Max.	0.03	2.0	0.90	0.02	0.03	23.5	10.0	3.5	0.5	0.2	38
Typical	0.02	1	0.7	0.01	0.02	23.2	9	3.2	0.1	0.17	36

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	typical
Tensile strength (MPa)		690	850
0.2% proof strength (MPa)		480	675
Elongation (%)	4d	20	27
	5d	20	25
Reduction of area %		--	40
Impact ISO-V(J)	+20°C	--	> 54 (> 0.8)
	-20°C	--	43-48 (> 0.5)
	-50°C	--	32-41 (>0.38)
Hardness (HRC)	HV10	--	< 305 (< 28)

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

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	60	75	100	130
max. A	90	120	155	190

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	350
kg/carton	12.0	13.5	13.5	13.5
Pieces/carton	654	378	249	174

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.
For electrodes that have been exposed:
Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 380° C, 3 cycles, 10h total.
Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m³)
7	6	6	1	0.2	<0.2	16	0.8

* F = 28% for basic coated 2205XKS but this does not affect OES.

SUPERMET 2205AR

RUTILE DOWNHAND MMA ELECTRODE FOR 22%Cr DUPLEX STEELS

PRODUCT DESCRIPTION

MMA electrode made on high quality stainless steel core wire with a rutile flux system designed to give minimum carbon content coupled with optimum operating characteristics.
The electrode has a rutile flux system optimised for operability.
Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E2209-17
BS EN ISO 3581	E 22 9 3 N L R 3 3

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

PA/1G PB/2F PC/2G

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
Min.	--	0.5	--	--	--	21.5	8.5	2.5	--	0.14	35
Max.	0.04	2.0	1.00	0.025	0.030	23.5	10.5	3.5	0.5	0.2	38
Typical	0.03	0.8	0.7	0.01	0.02	23	9	3.2	0.1	0.17	36

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		690	830
0.2% proof strength (MPa)		450	680
Elongation (%)	4d	20	28
	5d	20	26
Impact ISO-V(J)	+ 20°C	--	45
	- 20°C	--	40
	- 50°C	--	35
Hardness (HRC)	HV10	--	< 310 (< 28)

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

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	60	75	100	130
max. A	90	120	155	190

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	450	450
kg/carton	11.4	13.5	18.0	18.6
Pieces/carton	594	363	249	165

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.
For electrodes that have been exposed:
Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 380° C, 3 cycles, 10h total.
Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m³)
7	6	6	1	0.2	<0.2	16	0.8

* F = 28% for basic coated 2205XKS but this does not affect OES.

2205XKS

BASIC PIPE-WELDING MMA ELECTRODE FOR 22%Cr DUPLEX STEELS

PRODUCT DESCRIPTION

MMA electrode made on duplex stainless core wire with a special basic flux to give optimum all-positional operability.
Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.
The electrode has a basic flux system and is recommended where the highest sub-zero toughness is required, and for the most demanding positional welding applications such as fixed pipework in the ASME 6G position.

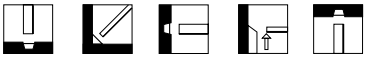
SPECIFICATIONS

AWS A5.4M	E2209-15
BS EN ISO 3581	E 22 9 3 N L B 4 2
Approvals	ABS, DNV, TÜV

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)



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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
Min.	--	0.5	--	--	--	22.0	8.5	3.0	--	0.15	35
Max.	0.04	2.0	0.90	0.02	0.03	23.5	10.0	3.5	0.75	0.20	38
Typical	0.03	1	0.6	0.01	0.02	23	9	3.2	0.1	0.17	36

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical	1120 – 1135°C +WQ
Tensile strength (MPa)		690	750-870	790
0.2% proof strength (MPa)		450	630-700	480
Elongation (%)	4d	20	28	41
	5d	20	26	37
Reduction of area %		--	45	64
Impact ISO-V(J)	+ 20°C	--	> 85	--
	- 50°C	47	> 60	> 75
	- 75°C	--	> 30	--
Hardness (HV)		--	260-290	240

TYPICAL OPERATING PARAMETERS, DC +VE ONLY

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	50	70	100	130
max. A	75	95	155	190

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	350
kg/carton	12.0	12.9	13.5	13.5
Pieces/carton	720	402	273	171

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.
For electrodes that have been exposed:
Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 380° C, 3 cycles, 10h total.
Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended.
Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

FUME DATA

Fume composition, wt % typical

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m³)
7	6	6	1	0.2	<0.2	16	0.8

* F = 28% for basic coated 2205XKS but this does not affect OES.

ER329N

SOLID WIRES FOR TIG, MIG AND SAW

PRODUCT DESCRIPTION

Solid TIG, MIG and sub-arc wires for welding 2205 type duplex stainless steels.

SPECIFICATIONS

AWS A5.9M	ER2209	
BS EN ISO 14343-A	22 9 3 N L	
BS EN ISO 14343-B	SS2209	
Approvals	DNV, TÜV	For TIG wires

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N
Min.	--	1.0	0.25	--	--	22.5	8.0	3.0	--	0.14
Max.	0.03	2.0	0.65	0.020	0.030	23.5	9.5	3.5	0.3	0.20
Typical	0.015	1.6	0.5	0.001	0.015	23	8.2	3.2	0.1	0.17*

Duplex weld metal microstructure with austenite + 30-50% ferrite.

Pitting resistance equivalent PREN = Cr + 3.3Mo + 16N is > 35.

* ER329N MIG spooled wire is selected for suitability for both MIG and auto-TIG, with typically 0.15%N to control porosity.

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical		
			TIG	MIG	SAW + SSB
Tensile strength (MPa)		690	790	800-835	790
0.2% proof strength (MPa)		450	620	560-620	630
Elongation (%)	4d	20	36	28-35	30
	5d	20	33	30	27
Impact ISO-V(J)	-30°C	--	180 (> 140)	> 70	75 (>55)
	-50°C	--	180 (> 120)	> 60	55 (>35)
	-75°C	--	125 (>70)	--	--
Hardness	HV	--	270 (< 310)	270 (< 310)	275 (< 320)
	HRC	--	23 (< 28)	23 (< 28)	23 (< 28)

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon	DC-	1.6 / 2.4	100A, 12V
MIG	Ar / He / CO_2	pulsed	1.2	180A, 28V
SAW	SSB flux *	DC+	2.4	350A,30V

PACKAGING DATA

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

FUME DATA

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

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
28	10	20	8	1.5	< 0.5	2.5

SUPERCORE M2205

METAL CORED WIRE FOR 22%CR DUPLEX STEELS

PRODUCT DESCRIPTION

The wire is made with an austenite stainless steel sheath and high purity metal powders.
Metal recovery is about 96% with respect to the wire.

SPECIFICATIONS

AWS A5.22M	EC2209
BS EN ISO 17633-A	T 22 9 3 N L M M12 3
BS EN ISO 17633-B	TS2209-FB0

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE*
Min.	--	0.5	--	--	--	21.5	7.5	2.5	--	0.08	34
Max.	0.03	2.0	0.90	0.025	0.030	23.5	9.5	3.5	0.5	0.20	38
Typical	0.02	1.4	0.8	0.010	0.018	22.5	8.5	3.0	0.15	0.15	35

* PRE (pitting resistance equivalent) = Cr + 3.3Mo + 16N

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical Ar-38%He-2%CO_2
Tensile strength (MPa)		690	820
0.2% proof strength (MPa)		480	680
Elongation (%)	4d	20	30
	5d	20	27
Impact ISO-V(J)	- 20°C	--	50
	- 50°C	--	38
Hardness	HV	--	280

OPERATING PARAMETERS

Shielding gas: Stainshield heavy, Ar-38%-He-2%CO2 shielding gas at 15-20l/min.
Current: DC+ve

Diameter (mm)	amp-volt range	typical	stickout
1.2	180A-27V to 250A-32V	200A-29V	10-20mm

PACKAGING DATA

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

FUME DATA

fume composition (wt %)

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
28	10	20	8	1.5	< 0.5	2.5

SUPERCORE 2205, 2205P

FLAT AND ALL-POSITIONAL FLUX CORED WIRES FOR 22%CR DUPLEX STEELS

PRODUCT DESCRIPTION

High performance rutile flux cored wires produced in the most versatile size of 1.2mm.
Supercore 2205 is suited to welding in the flat and horizontal-vertical positions (material > 6mm).
Supercore 2205P is optimised for positional welding, both vertical up and for fixed pipework qualified in the ASME 5G or 6G welding positions (pipe typically > 150mm diameter, > 15mm wall).
Made with an austenitic stainless steel sheath and rutile flux system.
Weld metal carbon content is typically <0.03% when using either 80%Ar-20%CO2 or 100% CO2 shielding gas.
Metal recovery about 90% with respect to the wire.

SPECIFICATIONS

	Supercore 2205	Supercore 2205P
AWS A5.22M	E2209T0-1/4	E2209T1-1/4
BS EN ISO 17633-A	T 22 9 3 N L R C/M 3	T 22 9 3 N L P C/M 2
BS EN ISO 17633-B	TS2209-FB0	TS2209-FB1
Approvals		LRS

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE*
Min.	--	0.5	--	--	--	21.5	8.5	2.8	--	0.08	34
Max.	0.04	2.0	1.00	0.02	0.030	24.0	10.0	4.0	0.3	0.20	38
Typical	0.03	1.2	0.7	<0.01	0.02	23	9.2	3.1	0.1	0.12	35

* PRE (pitting resistance equivalent) = Cr + 3.3Mo + 16N

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Supercore 2205P typical	Supercore 2205 typical
Tensile strength (MPa)		690	800	800
0.2% proof strength (MPa)		480	630	610
Elongation (%)	4d	20	32	30
	5d	20	29	26
Reduction of area (%)		--	45	36
Impact ISO-V(J)	- 20°C	--	65	50
	- 50°C	--	45	40
	- 75°C	--	30	-
Hardness (HV)		--	270	270

OPERATING PARAMETERS

Shielding gas: Either 80%Ar-20%CO2 or 100% CO2 shielding gas at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%. Gas mixtures without oxygen additions can be helpful for optimum weld metal toughness.
Fillet weld penetration and profile will be related to the skill level of the operator.

Current: DC+ve ranges as below for Ar-20%CO2. Welding with 100%CO2 requires approx 3V higher:

Diameter (mm)	amp-volt range	typical	stickout
1.2	150A-25V to 280A-34V	200A-30V	15-20mm
1.6	200A-28V to 330A-34V	230A-30V	15-25mm
1.2 P	120A-22V to 250A-34V	150A-25V	15-20mm

PACKAGING DATA

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

FUME DATA

Fume composition, wt %

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m³)
11	6	1	9	1.5	0.1	12	0.9

SSB FLUX

SUB-ARC FLUX

PRODUCT DESCRIPTION

Agglomerated basic non-alloying flux for submerged arc welding.

SPECIFICATIONS

DIN 32522	BFB6 63353 DC8M
BS EN ISO 14174	SA AF2 DC

ASME IX QUALIFICATION

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

COMPOSITION (TYPICAL)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N
ER329N wire	0.015	1.6	0.5	0.001	0.015	23	8.5	3.2	0.1	0.17
deposit	0.02	1.3	0.5	--	--	22.5	8.5	3.1	0.1	0.15

ALL-WELD MECHANICAL PROPERTIES

As welded		
Tensile strength (MPa)		790
0.2% proof strength (MPa)		630
Elongation (%)	4d	30
Impact ISO-V(J)	- 30°C	75 (>55)
	- 50°C	55 (>35)
Hardness	HV	275 (< 320)
	HRC	23 (< 28)

OPERATING PARAMETERS

Current: DC +ve ranges as below:

Diameter (mm)	amp-volt range	typical	stickout
1.6	200-350A, 27-31V	300A, 28V	20-25mm
2.4	250-450A, 28-32V	350A, 29V	20-25mm

PACKAGING DATA

Metrode SSB Flux is supplied in sealed moisture resistant 20kg metal drums.
Preferred storage conditions for opened drums: < 60%RH, > 18°C.
If the flux has become damp or has been stored for a long period, it should be redried in the range 250-400°C/1-3h.

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25%Cr SUPERDUPLEX STEELS - ZERON® 100

ALLOY TYPE

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

MATERIALS TO BE WELDED

MATCHING

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

OTHER SUPERDUPLEX, INCLUDING

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

APPLICATIONS

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

PWHT

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

ADDITIONAL INFORMATION

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

RELATED ALLOY GROUPS

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

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Zeron® 100XKS**	BS EN E25 9 4 N L B
TIG/MIG/ SAW	**Zeron® 100X**	BS EN 25 9 4 N L
SAW flux	**SSB**	BS EN SA AF 2
FCW	**Supercore Z100XP**	AWS E2594T1-4

ZERON® 100XKS

BASIC PIPE-WELDING MMA ELECTRODE FOR SUPERDUPLEX STEELS

PRODUCT DESCRIPTION

Basic coated all-positional MMA electrode for welding Zeron® 100 and other superduplex alloys for service in the as-welded condition. This electrode is overmatching with respect to nickel content to achieve correct austenite-ferrite microstructural phase balance. It is designed for the most demanding vertical and overhead welding positions such as fixed pipework qualified in the ASME 6G position.

Fully alloyed matching Zeron® 100 core wire including W and Cu. Moisture resistant flux technology.

Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E2595-15
BS EN ISO 3581	E 25 9 4 N L B 4 2
Weir Materials	MDS 12809/08
Approvals	ABS, DNV

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Cu	N	PRE_N	PRE_W
min.	--	--	--	--	--	24.0	9.0	3.5	0.5	0.5	0.2	40	40
max.	0.03	1.0	1.0	0.01	0.03	26.0	10.0	4.0	1.0	1.0	0.3	--	--
Typical	0.025	0.9	0.5	0.005	0.02	25	9.3	3.6	0.7	0.7	0.23	41	42

Pitting resistance equivalent PREN = Cr + 3.3Mo + 16N

Pitting resistance equivalent PREW = Cr + 3.3Mo + 1.65W + 16N

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		760	800-950
0.2% proof strength (MPa)		550	650-750
Elongation (%)	4d	15	30
	5d	20	22-27
Reduction of area %		--	40-45
Impact ISO-V(J)	- 20°C	--	> 55
	- 50°C	--	> 40
Hardness (HV)		--	270-320

OPERATING PARAMETERS, DC +VE

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	50	70	100	130
max. A	75	95	155	210

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	350
kg/carton	12.0	14.1	13.5	13.5
Pieces/carton	696	360	270	168

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Mo	V	F	OES (mg/m³)
7	6	1	7	0.5	0.2	<0.1	28	0.7

ZERON® 100X

SOLID WELDING WIRE FOR SUPERDUPLEX STEELS

PRODUCT DESCRIPTION

Solid wire for TIG, MIG and sub-arc welding.
For applications where Zeron® 100X wire is to be used for welding supermartensitic stainless steels it is possible for wire to be supplied with a total hydrogen content of 3ppm maximum.

SPECIFICATIONS

AWS A5.9M	ER2594
BS EN ISO 14343-A	25 9 4 N L (prefix W=TIG, G=MIG, S=SAW)
Weir Materials	MDS 12809/07
Approvals	ABS, TÜV, DNV (TIG and SAW in conjunction with SSB flux)

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Cu	N	PRE_N	PRE_W
Min.	--	--	--	--	--	24.0	9.0	3.5	0.5	0.5	0.2	40	40
Max.	0.03	1.0	1.0	0.01	0.03	26.0	10.0	4.0	1.0	1.0	0.3	--	--
Typical	0.015	0.7	0.4	0.002	0.02	25	9.3	3.7	0.6	0.7	0.23	41	42

ALL-WELD MECHANICAL PROPERTIES

Typical values as welded		Min.	TIG	MIG	SAW	TIG at 160°C
Tensile strength (MPa)		760	870	860	885	769
0.2% proof strength (MPa)		550	695	645	700	523
Elongation (%)	4d	15	36	25	26	39
	5d	20	32	23	24	34
Reduction of area (%)		--	68	28	48	72
Impact ISO-V(J)	-50°C	--	130	60	40	--
	-75°C	--	>100	--	--	--
Hardness cap/mid (HV)		--	290	290	290	--

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon	DC-	1.6 / 2.4	100A, 12V
MIG	Ar / He / CO_2	pulsed	1.2	180A, 28V
SAW	SSB flux	DC+	1.6	350A,30V

PACKAGING DATA

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

FUME DATA

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Mo	V	F	OES (mg/m³)
7	6	1	7	0.5	0.2	<0.1	28	0.7

SSB FLUX

SUB-ARC FLUX

PRODUCT DESCRIPTION

Agglomerated basic non-alloying flux for submerged arc welding.

SPECIFICATIONS

BS EN ISO 14174 SA AF2 DC

ASME IX QUALIFICATION

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

COMPOSITION (TYPICAL)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	W	N
Zeron® 100X wire	0.015	0.7	0.4	0.002	0.023	25	9.3	3.7	0.7	0.7	0.23
Deposit	0.02	0.6	0.4	0.002	0.02	24.5	9.3	3.6	0.7	0.7	0.21

ALL-WELD MECHANICAL PROPERTIES WITHZERON® 100X WIRE

Typical values as welded		min	SAW
Tensile strength (MPa)		750	890
0.2% proof strength (MPa)		550	700
Elongation (%)	4d	--	25
	5d	20	24
Reduction of area (%)		--	>40
Impact ISO-V(J)	- 50°C	--	40
Hardness (HV)		--	290

OPERATING PARAMETERS

Current: DC +ve ranges as below:

Diameter (mm)	amp-volt range	typical	stickout
1.6	200-350A, 27-31V	300A, 28V	20-25mm
2.4	250-450A, 28-32V	350A, 29V	20-25mm

PACKAGING DATA

Metrode SSB Flux is supplied in sealed moisture resistant 20kg metal drums.
Preferred storage conditions for opened drums: < 60%RH, > 18°C.
If the flux has become damp or has been stored for a long period, it should be redried in the range 250-400°C/1-3h.

SUPERCORE Z100XP

RUTILE ALL-POSITIONAL FLUX CORED WIRE FOR SUPERDUPLEX STEELS

PRODUCT DESCRIPTION

Flux cored wire made with an alloyed stainless steel sheath and rutile flux system.
Supercore Z100XP combines easy operability, high deposit quality for both positional pipework and downhand welding.
Metal recovery is about 90% with respect to the wire.

SPECIFICATIONS

AWS A5.22M	E2594T1-4
BS EN ISO 17633-B	TS 2594-F M21 1

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	W	N	PRE_N	PRE_W
Min.	--	0.5	--	--	--	24.0	8.5	3.5	0.5	0.5	0.2	40	40
Max.	0.04	1.5	1.0	0.02	0.03	26.0	10.0	4.0	1.0	1.0	0.3	--	--
Typical	0.03	1.0	0.5	0.005	0.02	24.5	9.1	3.7	0.6	0.6	0.22	41	42

Pitting resistance equivalent PREN = Cr + 3.3Mo + 16N
Pitting resistance equivalent PREW = Cr + 3.3Mo + 1.65W + 16N

ALL-WELD MECHANICAL PROPERTIES

Typical values		Min.	T ypical
Tensile strength (MPa)		760	880
0.2% proof strength (MPa)		550	690
Elongation (%)	4d	15	27
	5d	18	25
Reduction of area (%)		--	33
Impact ISO-V(J)	-20°C	--	40
	-50°C	--	32
Hardness	HV	--	280
	HRC	--	26

TYPICAL OPERATING PARAMETERS

Shielding gas: 80%Ar-20%CO2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.
Current: DC+ve ranges as below for Ar-20%CO_2:

Diameter (mm)	range	typical	stickout
1.2	120 – 250A, 22 – 34V	180A, 29V	15 – 20mm

PACKAGING DATA

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

FUME DATA

Fume composition, wt %

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
14	4	1	11	3	<1	10	1.0

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25%Cr SUPERDUPLEX STEELS - 2507

ALLOY TYPE

25%Cr ferritic-austenitic superduplex stainless steels.

MATERIALS TO BE WELDED

25%Cr superduplex:

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

Castings:

UNS J93404
ASTM A890 Gr5A, 6A *
ACI CE3MN

* Zeron® 100 (see DS: B-61)

APPLICATIONS

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

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

PWHT

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

ADDITIONAL INFORMATION

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

RELATED ALLOY GROUPS

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

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**2507XKS**	AWS 2594-15
	Ultramet 2507	AWS 2594-16
TIG	**2507**	AWS ER2594
FCW	**Supercore 2507**	AWS E2594T0-4
	Supercore 2507P	AWS E2594T1-4

2507XKS

BASIC PIPE-WELDING MMA ELECTRODE FOR SUPERDUPLEX STEELS

PRODUCT DESCRIPTION

Basic coated all-positional MMA electrode for welding superduplex alloys for service in the as-welded condition. This electrode is overmatching with respect to nickel content to achieve correct austenite-ferrite microstructural phase balance. It is designed for the most demanding vertical and overhead welding positions such as fixed pipework qualified in the ASME 5G/6G position, and for applications requiring the highest toughness.

Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E2594-15
BS EN ISO 3581	E 25 9 4 N L B 4 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No--

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
min.	--	0.5	--	--	--	24.0	8.5	3.5	--	0.20	40
max.	0.04	2.0	1.0	0.02	0.03	26.0	10.5	4.5	0.5	0.30	46
Typical	0.03	1	0.5	0.01	0.02	25	9.5	3.8	0.1	0.22	41

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	typical	>1120°C/>3h + WQ transverse *
Tensile strength (MPa)		800	870	>760
0.2% proof strength (MPa)		550	700	--
Elongation (%)	4d	22	28	--
	5d	18	25	--
Reduction of area %		--	45	--
Impact ISO-V(J)	+20°C	--	85	--
	-50°C	--	60	>80
	-75°C	--	35	--
Hardness (HV)		--	280-330	<300

* Representative properties for solution treated welds in castings of ASTM A890 grade 5A. Ferrite >30%.

OPERATING PARAMETERS, DC +VE

Diameter (mm)	2.5	3.2	4.0	5.0
min. A	50	70	100	130
max. A	75	95	155	190

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	350
kg/carton	12.0	13.5	13.5	13.5
Pieces/carton	669	420	267	165

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life.

Direct use from tin is satisfactory for longer than a working shift of 8h.

Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended.

Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

FUME DATA

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Mo	V	F *	OES (mg/m³)
7	6	1	7	0.5	0.2	<0.1	16	0.7

* F = 28% for basic coated 2507XKS electrode but this does not affect the OES.

ULTRAMET 2507

RUTILE ALL-POSITIONAL MMA ELECTRODE FOR SUPERDUPLEX STEELS

PRODUCT DESCRIPTION

Rutile coated MMA electrode for welding superduplex alloys for service in the as-welded condition. This electrode is overmatching with respect to nickel content to achieve the correct austenite-ferrite microstructural phase balance. Recovery is about 105% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E2594-16
BS EN ISO 3581	E 25 9 4 N L R 3 2

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No --

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
Min.	--	0.5	--	--	--	24.0	8.5	3.5	--	0.20	40
Max.	0.04	1.5	1.0	0.02	0.03	26.0	10.5	4.5	0.5	0.30	46
Typical	0.03	1	0.8	0.01	0.02	25	9.5	4	0.1	0.23	42

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		750	890
0.2% proof strength (MPa)		550	750
Elongation (%)	4d	22	26
	5d	20	24
Reduction of area (%)		--	35
Impact ISO-V(J)	-20°C	--	28
	-50°C	--	>21
Hardness	HV	--	275-315
	HRC	--	28

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	11.4	13.5	13.8
Pieces/carton	609	393	249

STORAGE

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

FUME DATA

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Mo	V	F *	OES (mg/m³)
7	6	1	7	0.5	0.2	<0.1	16	0.7

* F = 28% for basic coated 2507XKS electrode but this does not affect the OES.

2507

SOLID WELDING WIRE FOR SUPERDUPLEX STEELS

PRODUCT DESCRIPTION

Solid wire for TIG

SPECIFICATIONS

AWS A5.9M	ER2594
BS EN ISO 14343-A	W 25 9 4 N L

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No --

COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Cu	N	PRE_N
Min.	--	--	--	--	--	24.0	8.0	3.0	--	--	0.20	40
Max.	0.03	2.5	1.0	0.02	0.03	27.0	10.5	4.5	0.5	0.5	0.30	--
Typical	0.02	0.8	0.4	0.005	0.02	25	9.3	3.9	0.05	0.05	0.25	42

ALL-WELD MECHANICAL PROPERTIES WITHZERON® 100X WIRE

Typical values as welded		Min.	TIG
Tensile strength (MPa)		760	870
0.2% proof strength (MPa)		550	695
Elongation (%)	4d	15	36
	5d	20	32
Reduction of area (%)		--	68
Impact ISO-V(J)	- 50°C	--	130
Hardness cap/mid	HV	--	300

TYPICAL OPERATING PARAMETERS

	Shielding gas	Current	Diameter (mm)	Parameters
TIG	Argon	DC-	1.6 / 2.4	100A, 12V

PACKAGING DATA

Diameter (mm)	1.6	2.0	2.4
TIG	2.5 kg tube	2.5 kg tube	2.5 kg tube

FUME DATA

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

Fe	Mn	Cr^3	Ni	Mo	Cu	OES (mg/m^3)
28	10	22	8	2	1.3	2.3

SUPERCORE 2507, 2507P

RUTILE FLUX CORED WIRES FOR SUPERDUPLEX STEELS

PRODUCT DESCRIPTION

Flux cored wire made with an alloyed stainless steel sheath and rutile flux system. The **Supercore 2507** combines easy operability, high deposit quality and exceptional bead appearance for downhand and HV welding. **Supercore 2507P** combines easy operability, high deposit quality for both positional pipework and downhand welding. Metal recovery is about 90% with respect to the wire.

SPECIFICATIONS

	Supercore 2507	Supercore 2507P
AWS A5.22M	E2594T0-4	E2594T1-4
BS EN ISO 17633-A	T 25 9 4 N L R M21 3	T 25 9 4 N L P M21 2

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No --

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	W	N	PRE_N
Min.	--	0.5	--	--	--	24.0	8.5	3.5	--	--	0.20	40
Max.	0.04	2.0	1.0	0.02	0.03	26.0	10.5	4.5	0.5	0.5	0.30	--
Typical	0.03	1.0	0.5	0.010	0.02	24.5	9.3	3.8	0.05	0.05	0.23	41

Pitting resistance equivalent PREN = Cr + 3.3Mo + 16N

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		760	870
0.2% proof strength (MPa)		550	660
Elongation (%)	4d	15	30
	5d	18	29
Reduction of area (%)		--	38
Impact ISO-V(J)	+20°C	--	60
	-20°C	--	45
	-50°C	--	35
Hardness (HV)		--	300

TYPICAL OPERATING PARAMETERS

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.
Current: DC+ve ranges as below for Ar-20%CO_2:

Diameter (mm)	range	typical	stickout
1.2	120 – 280A, 22 – 34V	180A, 29V	15 – 20mm
1.2P	120 – 250A, 22 – 32V	150A, 25V	15 – 20mm

PACKAGING DATA

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

FUME DATA

Fume composition, wt %

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m^3)
11	6	1	9	2	< 1	12	1.0

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25%Cr SUPERDUPLEX STEELS WITH 2%Cu

ALLOY TYPE

25%Cr ferritic-austenitic superduplex stainless steels with nominally 25%Cr-8%Ni-3.5%Mo-1.5%Cu-0.2%N.

MATERIALS TO BE WELDED

ASTM

A240 UNS S32550 (wrought).
A351 & A744 grade CD4MCu.
A890 grade 1A/UNS J93370.
A890 grade 1B/UNS J93372.

DIN

1.4515 (G-X3CrNiMoCuN 26 6 3).
1.4517 (G-X3CrNiMoCuN 26 6 3 3).

BS

3100 grade 332C13.
3146 grade ANC21.

Proprietary

Ferralium 255 and SD40 (Meighs).
Uranus 50M, 55, 52N, 52N+ (CLI).
Ferrinox 255 (Advanced Metals).

APPLICATIONS

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

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

MICROSTRUCTURE

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

WELDING GUIDELINES

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

PWHT

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

RELATED ALLOY GROUPS

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

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Supermet 2506Cu**	AWS E2553-16
FCW	**Supercore 2507Cu**	(AWS E2553T0-4)
	Supercore 2507CuP	(AWS E2553T1-4)

SUPERMET 2506Cu

RUTILE MMA ELECTRODE FOR COPPER BEARING SUPERDUPLEX STEELS

PRODUCT DESCRIPTION

MMA electrode made on a low carbon stainless steel core wire with a rutile flux containing additional elements for alloying and deoxidation. Nitrogen and nickel are controlled to give a balanced duplex structure to minimise the risk of cracking, particularly in highly restrained welds.

Recovery is about 140% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E2553-16
BS EN ISO 3581	E 25 9 3 Cu N L R 5 2

ASME IX QUALIFICATION

QW432	F-No5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE *
min.	--	0.5	--	--	--	24.0	7.5	2.9	1.5	0.18	40
max.	0.04	1.5	1.0	0.025	0.030	27.0	8.5	3.9	2.5	0.25	--
Typical	0.03	1	0.4	0.01	0.02	25.5	8	3.5	1.7	0.22	41

* PRE (Pitting Resistance Equivalent) = %Cr + 3.3%Mo + 16%N

ALL-WELD MECHANICAL PROPERTIES

Typical as-welded and PWHT		1120°C/2h + WQ		As-welded	
		Min. *	Typical	Min.	Typical
Tensile strength (MPa)		690	775	760	925
0.2% proof strength (MPa)		485	575	550	780
Elongation (%)	4d	16	32	15	17
	5d	--	--	15	16
Reduction of area (%)		--	40	--	25
Impact ISO-V(J)	+20°C	--	70	--	35
	-30°C	--	60	--	22
Hardness	HV	--	260	--	340
	HRC	--	--	--	30

* These properties are appropriate for ASTM CD4MCu castings solution treated for optimum corrosion resistance; rapid cooling is important for best impact properties.

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	12.0	15.0	14.1	16.5
Pieces/carton	513	321	219	111

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 250°C/1-2h to restore to as-packed condition. Maximum 300° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition, wt % typical:

Fe	Mn	Ni	Cr	Cu	Mo	V	F	OES (mg/m³)
9	5	1	7.5	1	0.6	<0.1	16	0.6

SUPERCORE 2507Cu, 2507CuP

RUTILE FLUX CORED WIRES FOR CU CONTAINING SUPERDUPLEX STEELS

PRODUCT DESCRIPTION

Flux cored wire made with an alloyed stainless steel sheath and rutile flux system. Supercore 2507Cu combines easy operability, high deposit quality and exceptional bead appearance for downhand and HV welding (material >6mm). Supercore 2507CuP is optimised for positional welding, both vertical up and for fixed pipework qualified in the ASME 5G or 6G welding positions (pipe typically >150mm diameter, >15mm wall).

Made with an austenitic stainless steel sheath and rutile flux system. Weld metal carbon content is typically <0.03% when using either 80%Ar-20%CO2 or 100% CO2 shielding gas.

Metal recovery about 90% with respect to the wire.

SPECIFICATIONS

	Supercore 2507Cu	Supercore 2507CuP	
AWS A5.22M	E2553T0-4	E2553T1-4	Nearest classification
BS EN ISO 17633-A	T 25 9 4 Cu N L R C/M 3	T 25 9 4 Cu N L P C/M 2	
BS EN ISO 17633-B	TS2553-FB0	TS2553-FB1	Nearest classification

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	N	PRE_N
min.	--	--	--	--	--	24.0	8.5	3.2	1.0	0.2	40
max.	0.04	1.5	1.0	0.02	0.03	26.0	10.5	4.2	2.0	0.3	--
Typical	0.03	0.8	0.5	0.005	0.02	24.5	9.3	3.7	1.4	0.25	41

Pitting resistance equivalent PRE_N = Cr + 3.3Mo + 16N

ALL-WELD MECHANICAL PROPERTIES

Typical as welded and PWHT	1120°C/2h + WQ typical	As-welded	
		Min.	Typical
Tensile strength (MPa)	760	750	780
0.2% proof strength (MPa)	450	550	590
Elongation (%) 4d	40	--	35
5d	39	20	33
Reduction of area (%)	--	--	32
Impact ISO-V(J) - 20°C	65	--	40
- 50°C	45	--	>27
Hardness (HV)	250	--	300

OPERATING PARAMETERS

Shielding gas: 80%Ar-20%CO_2 at 20-25l/min. Proprietary gases may be used but argon should not exceed 85%.

Current: DC+ve ranges as below for Ar-20%CO_2:

Diameter (mm)	amp-volt range	typical	stickout
1.2	140 – 280A, 22 – 35V	180A, 28V	15 – 20mm
1.2P	120 – 250A, 20 – 32V	180A, 26V	15 – 20mm

PACKAGING DATA

Spools vacuum-sealed in barrier foil with cardboard carton: 15kg

The as-packed shelf life is virtually indefinite.

Resistance to moisture absorption is high, but to maintain the high integrity of the wire surface and prevent any possibility of porosity, it is advised that part-used spools are returned to polythene wrappers.

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

FUME DATA

Fume composition (wt %)

Fe	Mn	Ni	Cr^3	Cr^6	Cu	F	OES (mg/m3)
14	10	1.5	5	5	1	5	1.0

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NUCLEAR 308L CONSUMABLES

ALLOY TYPE

308L austenitic stainless steels conforming to RCC-M for joining 304L base materials used in nuclear applications.

MATERIALS TO BE WELDED

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

UNS

S 30403
S 30400
S 30453

APPLICATIONS

Used to weld 304L (18/8) stainless steels for applications in the nuclear industry requiring conformance to the RCC-M code.

Standard 308L consumables for general purpose fabrication can be found in data sheet B-30. 308H consumables for elevated temperature service can be found in data sheets C-10 and C-12. Controlled ferrite 308L consumables for cryogenic applications can be found in data sheet B-37.

MICROSTRUCTURE

Austenite with a controlled level of ferrite, 5-15FN.

WELDING GUIDELINES

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

ADDITIONAL INFORMATION

Requirements are taken from the relevant consumable data sheets in the French RCC-M code.

For consumable qualification data sheets (B-93 and B-94) in accordance with RCC-M S 5142 please contact Metrode Technical Department.

RELATED ALLOY GROUPS

See data sheet B-81 and B-83 for related 316L and 309L consumables conforming to the RCC-M requirements.

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Ultramet 308L(N)**	AWS E308L-16 RCC-M S 2920
	Ultramet B308L(N)	AWS E308L-15 RCC-M S 2920
TIG	**308S92(N)**	AWS ER308L RCC-M S 2910

ULTRAMET 308L(N)

RUTILE MMA ELECTRODE

PRODUCT DESCRIPTION

MMA electrode – special rutile flux coated 308L electrode on high purity 304L core wire.

Versatile downhand and positional capability, **Ultramet 308L(N)** has a controlled composition and ferrite content designed to meet the requirements of the RCC-M data sheet S 2920.

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

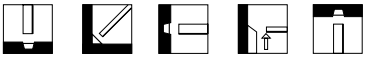
SPECIFICATIONS

AWS A5.4M	E308L-16
BS EN ISO 3581	E 19 9 L R 3 2
RCC-M	S 2920

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)



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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Co	N	FN *
Min.	--	0.5	--	--	--	18.00	9.00	--	--	--	--	5
Max.	0.035	2.0	0.90	0.025	0.025	21.00	11.00	0.50	0.5	0.20	--	15
Typical	<0.025	0.7	0.6	0.01	0.02	19.5	9.5	0.1	<0.1	0.04	0.08	8

* Ferrite calculated in accordance with DeLong diagram.

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	Typical	Min +350°C	Typical +350°C
Tensile strength (MPa)		520	600	--	410
0.2% proof strength (MPa)		320	465	125	305
Elongation (%)	4d	35	47	--	30
	5d	30	45	--	--
Reduction of area (%)		--	55	--	60
Impact ISO-V(J) +20°C		60 (42) *	65	--	--

* Minimum average (minimum individual value).

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	11.4	13.5	13.5	16.5
Pieces/carton	627	411	261	159

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition (wt %)

Fe	Mn	Cr	Ni	Mo	Cu	F	OES (mg/m³)
8	5	5	0.8	-	< 0.2	16	1

ULTRAMET B308L(N)

BASIC MMA ELECTRODE

PRODUCT DESCRIPTION

MMA electrode – special basic flux coated 308L electrode on high purity 304L core wire. Versatile downhand and positional capability, **Ultramet B308L(N)** has a controlled composition and ferrite content designed to meet the requirements of the RCC-M data sheet S 2920.

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

SPECIFICATIONS

AWS A5.4M	E308L-15
BS EN ISO 3581	E 19 9 L B 4 2
RCC-M	S 2920

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Co	N	FN *
Min.	--	0.5	--	--	--	18.00	9.00	--	--	--	--	5
Max.	0.035	2.0	0.90	0.025	0.025	21.00	11.00	0.50	0.5	0.20	--	15
Typical	0.02	1.2	0.3	0.01	0.02	19.5	9.5	0.1	<0.1	0.04	0.05	8

* Ferrite calculated in accordance with DeLong diagram.

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	Typical	Min +350°C	Typical +350°C
Tensile strength (MPa)		520	600	--	410
0.2% proof strength (MPa)		320	440	125	300
Elongation (%)	4d	35	44	--	30
	5d	30	42	--	--
Reduction of area (%)		--	55	--	60
Impact ISO-V(J)	+20°C	60 (42) *	100	--	--

* Minimum average (minimum individual value).

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	450
kg/carton	11.4	13.5	13.5	16.5
Pieces/carton	627	411	261	159

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition (wt %)

Fe	Mn	Cr	Ni	Mo	Cu	F	OES (mg/m³)
8	5	5	0.8	-	< 0.2	16	1

308S92(N)

SOLID WIRES FOR TIG

PRODUCT DESCRIPTION

Solid wire for TIG welding that meets the requirements of RCC-M data sheet S 2910.

SPECIFICATIONS

AWS A5.9M	ER308L
BS EN ISO 14343-A	W 19 9 L
BS EN ISO 14343-B	SS308L
RCC-M	S 2910

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Co	FN *
Min.	--	1.00	0.30	--	--	19.5	9.00	--	--	--	5
Max.	0.030	2.50	0.60	0.020	0.025	21.0	11.00	0.3	0.3	0.20	15
Typical	0.01	1.7	0.4	0.01	0.015	20	10	0.1	0.15	0.04	8

* Ferrite calculated in accordance with DeLong diagram.

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min. +20°C	Typical +20°C	Min +350°C	Typical +350°C
Tensile strength (MPa)		520	605	--	400
0.2% proof strength (MPa)		320	465	125	290
Elongation (%)	4d	35	48	--	30
	5d	30	39	--	--
Impact ISO-V(J)	+20°C	60 (42) *	160	--	--

* Minimum average (minimum individual value).

TYPICAL OPERATING PARAMETERS

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

PACKAGING DATA

Diameter (mm)	1.2	1.6	2.0	2.4
TIG	5kg or 15kg spool	2.5 kg tube	2.5 kg tube	2.5 kg tube

FUME DATA

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

Fe	Mn	Cr[3]	Ni	Mo	Cu	OES (mg/m³)
32	12	16	8	< 0.5	< 0.5	1

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NUCLEAR 316L CONSUMABLES

ALLOY TYPE

316L austenitic stainless steels conforming to RCC-M for joining 316L base materials used in nuclear applications.

MATERIALS TO BE WELDED

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

UNS
S 31603
S 31600
S 31653

APPLICATIONS

Used to weld 316L (19/12/3) stainless steels for applications in the nuclear industry requiring conformance to the RCC-M code.

Standard 316L consumables for general purpose fabrication can be found in data sheet B-32. 316H consumables for elevated temperature service can be found in data sheets C-12 and C-13. Controlled ferrite 316L consumables for cryogenic applications can be found in data sheet B-38.

MICROSTRUCTURE

Austenite with a controlled level of ferrite, 5-15FN

WELDING GUIDELINES

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

ADDITIONAL INFORMATION

Requirements are taken from the relevant consumable data sheets in the French RCC-M code.

For consumable qualification data sheets (B-90 and B-92) in accordance with RCC-M S 5142 please contact Metrode Technical Department.

RELATED ALLOY GROUPS

See data sheet B-80 for related 308L consumables conforming to the RCC-M requirements

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Ultramet 316L(N)**	AWS E316L-16 RCC-M S 2925
	Ultramet B316L(N)	AWS E316L-15 RCC-M S 2925
TIG	**316S92(N)**	AWS ER316L RCC-M S 2915

ULTRAMET 316L(N)

RUTILE MMA ELECTRODE

PRODUCT DESCRIPTION

MMA electrode – special rutile flux coated 316L electrode on high purity 304L core wire. Versatile downhand and positional capability, **Ultramet 316L(N)** has a controlled composition and ferrite content designed to meet the requirements of the RCC-M data sheet S 2925.

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

SPECIFICATIONS

AWS A5.4M	E316L-16
BS EN ISO 3581	E 19 12 3 L R 3 2
RCC-M	S 2925

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Co	N	FN *
Min.	--	0.5	--	--	--	18.00	12.00	2.5	--	--	--	5
Max.	0.035	2.0	0.90	0.025	0.025	20.00	13.0	3.00	0.75	0.20	--	15
Typical	<0.025	0.7	0.6	0.01	0.02	19.5	12.5	2.6	<0.1	0.04	0.1	8

* Ferrite calculated in accordance with DeLong diagram.

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	Typical +20°C	Min +350°C	Typical +350/+360°C
Tensile strength (MPa)		520	600	--	470/470
0.2% proof strength (MPa)		320	500	140/130	340/340
Elongation (%)	4d	35	38	--	33/30
	5d	30	36	--	--
Reduction of area (%)		--	55	--	50/50
Impact ISO-V(J) +20°C		60 (42) *	65	--	--

* Minimum average (minimum individual value).

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	11.4	12.9	13.5
Pieces/carton	618	393	261

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition (wt %)

Fe	Mn	Cr	Ni	Mo	Cu	F	OES (mg/m³)
8	5	5	1	0.5	< 0.2	16	1

ULTRAMET B316L(N)

BASIC MMA ELECTRODE

PRODUCT DESCRIPTION

MMA electrode – special basic flux coated 308L electrode on high purity 304L core wire. Versatile downhand and positional capability, **Ultramet B316L(N)** has a controlled composition and ferrite content designed to meet the requirements of the RCC-M data sheet S 2925

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

SPECIFICATIONS

AWS A5.4M	E316L-15
BS EN ISO 3581	E 19 12 3 L B 4 2
RCC-M	S 2925

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

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

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Co	N	FN *
Min.	--	0.5	--	--	--	18.00	12.00	2.5	--	--	--	5
Max.	0.035	2.0	0.90	0.025	0.025	20.00	13.0	3.00	0.75	0.20	--	15
Typical	0.025	1.3	0.3	0.01	0.02	19.5	12.5	2.6	<0.1	0.04	0.05	10

* Ferrite calculated in accordance with DeLong diagram.

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	Typical +20°C	Min +350°C	Typical +350/+360°C
Tensile strength (MPa)		520	600	--	480/480
0.2% proof strength (MPa)		320	470	140/130	350/350
Elongation (%)	4d	30	39	--	30/30
	5d	30	37	--	--
Reduction of area (%)		--	58	--	50/50
Impact ISO-V(J)	+20°C	60 (42) *	85	--	--

* Minimum average (minimum individual value).

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	12.0	13.5	13.5
Pieces/carton	669	397	397

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.

For electrodes that have been exposed:

Redry 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.

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

FUME DATA

Fume composition (wt %)

Fe	Mn	Cr	Ni	Mo	Cu	F	OES (mg/m³)
8	5	5	1	0.5	< 0.2	16	1

316S92(N)

SOLID WIRES FOR TIG

PRODUCT DESCRIPTION

Solid wire for TIG welding that meets the requirements of RCC-M data sheet S 2915.

SPECIFICATIONS

AWS A5.9M	ER316L
BS EN ISO 14343-A	W 19 12 3 L
BS EN ISO 14343-B	SS316L
RCC-M	S 2915

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Co	FN *
Min.	--	1.00	0.30	--	--	18.00	12.00	2.5	--	--	5
Max.	0.030	2.50	0.60	0.020	0.025	20.00	14.00	3.00	0.3	0.20	15
Typical	0.01	1.7	0.4	0.01	0.015	19	12.5	2.6	0.15	0.04	10

* Ferrite calculated in accordance with DeLong diagram.

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	Typical +20°C	Min +350°C	Typical +350/+360°C
Tensile strength (MPa)		520	605	--	410/410
0.2% proof strength (MPa)		210	465	140/130	280/280
Elongation (%)	4d	--	48	--	30/30
	5d	30	33	--	--
Impact ISO-V(J)	+20°C	60 (42) *	110	--	--

* Minimum average (minimum individual value).

TYPICAL OPERATING PARAMETERS

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

PACKAGING DATA

Diameter (mm)	1.6	2.4
TIG	2.5 kg tube	2.5 kg tube

FUME DATA

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

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

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NUCLEAR 309L CONSUMABLES

ALLOY TYPE

309L austenitic stainless steel electrode conforming to RCC-M for dissimilar joints in nuclear applications.

MATERIALS TO BE WELDED

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

APPLICATIONS

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

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

MICROSTRUCTURE

Austenite with ferrite in the range 8-18FN.

WELDING GUIDELINES

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

ADDITIONAL INFORMATION

Requirements are taken from the relevant consumable data sheets in the French RCC-M code.

For consumable qualification data sheets (B-93, B-94 and B-95) in accordance with RCC-M S 5142 please contact Metrode Technical Department.

RELATED ALLOY GROUPS

See data sheet B-80 and B-81 for related 308L and 316L consumables conforming to the RCC-M requirements.

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**Ultramet 309L(N)**	AWS E309L-16 RCC-M S 2930
	Ultramet B309L(N)	AWS E309L-15 RCC-M S 2930
TIG	**309S92(N)**	AWS ER309L

ULTRAMET 309L(N)

RUTILE MMA ELECTRODE

PRODUCT DESCRIPTION

MMA electrode – special rutile flux coated 309L electrode on high purity 304L core wire.
Versatile downhand and positional capability, **Ultramet 309L(N)** has a controlled composition and ferrite content designed to meet the requirements of the RCC-M data sheet S 2930.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E309L-16
BS EN ISO 3581	E 23 12 L R 3 2
RCC-M	S 2930

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Co	FN *
Min.	--	0.5	--	--	--	22.00	12.00	--	--	--	8
Max.	0.030	2.5	0.90	0.025	0.025	25.00	14.00	0.50	0.75	0.15	18
Typical	0.025	0.8	0.6	0.01	0.02	23.5	12.3	0.1	<0.1	0.04	14

* Ferrite calculated in accordance with DeLong diagram

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	Typical
Tensile strength (MPa)		520	600
0.2% proof strength (MPa)		320	485
Elongation (%)	4d	30	40
	5d	25	38
Reduction of area (%)		--	55
Impact ISO-V(J)	+20°C	--	50

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	12.6	13.5	13.5
Pieces/carton	687	393	252

STORAGE

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

FUME DATA

Fume composition (wt % typical)

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m³)
9	6	7	1	0.1	< 0.2	17	0.7

ULTRAMET B309L(N)

BASIC MMA ELECTRODE

PRODUCT DESCRIPTION

MMA electrode – special basic flux coated 309L electrode on high purity 304L core wire.
Versatile downhand and positional capability, **Ultramet 309L(N)** has a controlled composition and ferrite content designed to meet the requirements of the RCC-M data sheet S 2930.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E309L-15
BS EN ISO 3581	E 23 12 L B 4 2
RCC-M	S 2930

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Co	FN *
Min.	--	0.5	--	--	--	22.00	12.00	--	--	--	8
Max.	0.030	2.5	0.90	0.025	0.025	25.00	14.00	0.50	0.75	0.15	18
Typical	0.02	1.2	0.3	0.01	0.02	23.5	12.3	0.1	<0.1	0.04	14

* Ferrite calculated in accordance with DeLong diagram.

ALL-WELD MECHANICAL PROPERTIES

As-welded		Min.	Typical
Tensile strength (MPa)		520	620
0.2% proof strength (MPa)		320	490
Elongation (%)	4d	30	37
	5d	25	35
Reduction of area (%)		--	55
Impact ISO-V(J)	+20°C	--	80

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

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0
Length (mm)	300	350	350
kg/carton	12.6	13.5	13.5
Pieces/carton	687	393	252

STORAGE

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

FUME DATA

Fume composition (wt % typical)

Fe	Mn	Cr	Ni	Mo	Cu	F *	OES (mg/m³)
9	6	7	1	0.1	< 0.2	17	0.7

309S92(N)

SOLID WIRES FOR TIG

PRODUCT DESCRIPTION

Solid wire for TIG welding that meets the manufacturing quality requirements of RCC-M.

SPECIFICATIONS

AWS A5.9M	ER309L
BS EN ISO 14343-A	W 23 12 L
BS EN ISO 14343-B	SS309L

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WIRE WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	FN *
Min.	--	1.00	0.30	--	--	23.0	12.0	--	--	8
Max.	0.025	2.50	0.60	0.020	0.025	25.0	14.0	0.3	0.3	18
Typical	0.01	1.7	0.4	0.01	0.015	23.5	13	0.1	0.05	12

* Ferrite calculated in accordance with DeLong diagram.

ALL-WELD MECHANICAL PROPERTIES

As-welded		**min +20°C**
Tensile strength (MPa)		590
0.2% proof strength (MPa)		450
Elongation (%)	4d	43
	5d	41
Impact ISO-V(J)	+20°C	>200

* Minimum average (minimum individual value).

TYPICAL OPERATING PARAMETERS

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

PACKAGING DATA

Diameter (mm)	**1.6**	**2.0**	**2.4**
TIG	2.5 kg tube	2.5 kg tube	2.5 kg tube

FUME DATA

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

Fe	Mn	Cr³	Ni	Mo	Cu	OES (mg/m³)
32	12	20	11	< 0.5	< 0.5	2.5

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NUCLEAR NAG 308L CONSUMABLES

ALLOY TYPE

308L austenitic stainless steels for joining Nitric Acid Grade (NAG) 304L base materials. The consumables are manufactured to BNFL (now Sellafield Ltd) specifications.

MATERIALS TO BE WELDED

ASTM
304L
BS
304S11
BS EN & DIN
1.4306
UNS
S30403

304L material that meets the specific NAG requirements.

APPLICATIONS

Used to weld **nitric acid grade (NAG) 304L stainless steels** used in the construction of waste nuclear fuel processing plant.

It is also suitable for the welding of conventional 304L stainless steels for **nuclear** applications – particularly for QA reasons where NAG and conventional 304L steels are being fabricated together.

MICROSTRUCTURE

In the as-welded condition the weld metal microstructure consists of austenite with ferrite content of about 6FN.

WELDING GUIDELINES

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

ADDITIONAL INFORMATION

These products are approved and certified by Sellafield Ltd (SL) and are only supplied to SL contractors for use on SL projects.

Huey tests on weld deposits achieve corrosion rates of <0.3mm/year as-welded and <0.6mm/year in the sensitised condition.

RELATED ALLOY GROUPS

Standard 308L consumables for general fabrication applications are in data sheet B-30. RCC-M nuclear grade 308L consumables are in data sheet B-80

PRODUCTS AVAILABLE

Process	Product	Specification
MMA	**NAG 19.9.L.R**	NF 0086/1
TIG	**NAG 19.9.L**	NF 0087/1

NAG 19.9.L.R

RUTILE MMA ELECTRODE FOR WELDING NITRIC ACID GRADE 304L STAINLESS STEEL

PRODUCT DESCRIPTION

MMA electrode – rutile flux coated 308L electrode on special high purity 304L core wire.
A special flux system is used to maintain carbon, sulphur and phosphorus within specified limits and also give porosity-free deposits.
All electrode sizes have optimum versatility for downhand welding with high cosmetic finish and weld metal integrity; and all positional welding with the 2.5/3.2 mm electrodes.
Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

SPECIFICATIONS

AWS A5.4M	E308L-16
BS EN ISO 3581	E 19 9 L R 3 2
BNFL (now Sellafield Ltd.)	NF 0086/1

ASME IX QUALIFICATION

QW432	F-No 5
QW442	A-No 8

WELDING POSITIONS (ISO/ASME)

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	W	B	FN
min.	--	0.2	--	--	--	18.0	9.0	--	--	--	--	3
max.	0.025	2.0	0.80	0.015	0.018	21.0	11.0	0.20	0.30	0.30	0.0010	10
Typical	0.02	1	0.5	0.01	0.015	19.5	10	0.05	0.1	0.01	0.0005	6

ALL-WELD MECHANICAL PROPERTIES

As welded		Min.	Typical
Tensile strength (MPa)		510	590
0.2% proof strength (MPa)		320	420
Elongation (%)	4d	35	45
	5d	30	42
Reduction of area (%)		--	55
Impact ISO-V(J)	+20°C	--	90

OPERATING PARAMETERS, DC +VE

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

PACKAGING DATA

Diameter (mm)	2.5	3.2	4.0	5.0
Length (mm)	300	350	350	350
kg/carton	12	13.5	12.9	12.9
Pieces/carton	684	411	237	156

STORAGE

3 hermetically sealed ring-pull metal tins per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.
For electrodes that have been exposed:
Redry 150 – 250°C/1-2h to restore to as-packed condition. Maximum 300° C, 3 cycles, 10h total.
Storage of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

FUME DATA

Fume composition (wt %) typical

Fe	Mn	Ni	Cr	Mo	Cu	F	OES (mg/m³)
8	5	0.8	5	--	<0.2	16	1

NAG 19.9.L

SOLID WIRE FOR WELDING NITRIC ACID GRADE 304L STAINLESS STEEL

PRODUCT DESCRIPTION

Solid wire for TIG welding.

SPECIFICATIONS

AWS A5.9M	ER308L
BS EN ISO 14343-A	W 19 9 L
BS EN ISO 14343-B	SS308L
BNFL (now Sellafield Ltd.)	NF 0087/1

ASME IX QUALIFICATION

QW432	F-No 6
QW442	A-No 8

CHEMICAL COMPOSITION (WELD METAL WT %)

	C	Mn	Si	S	P	Cr	Ni	Mo	Cu	W	B
min.	--	1.0	--	--	--	19.5	9.0	--	--	--	--
max.	0.025	2.0	0.65	0.015	0.018	22.0	11.0	0.20	0.30	0.30	0.0010
Typical	0.015	1.7	0.3	0.004	0.015	20	10	0.1	0.07	0.02	0.0003

ALL-WELD MECHANICAL PROPERTIES

As welded		**TIG**
Tensile strength (MPa)		605
0.2% proof strength (MPa)		465
Elongation (%)	4d	48
	5d	39
Impact ISO-V(J)	- 20°C	160

TYPICAL OPERATING PARAMETERS

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

PACKAGING DATA

Diameter (mm)	**0.8**	**1.2**	**1.2**	**1.6**	**2.4**	**3.2**
TIG	1kg or 5kg spool	5kg or 15kg spool	2.5 kg tube	2.5 kg tube	2.5 kg tube	2.5 kg tube