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Product Update

SUPERGEN 320

ADVANCES IN WELDING CONSUMABLES FOR OIL, GAS AND POWER SECTORS- PART II

INTRODUCTION

In the last issue, we reviewed the importance of development of welding consumables for meeting requirements of special service conditions in the Oil, Gas and Power industry. Development of consumables for welding carbon steels for critical applications in these industries was described in detail. In this issue we will discuss the development of welding consumables for welding of alloy steels and stainless steels for this sector.

CONSUMABLES LOW ALLOY STEELS

Low alloy steels are widely used for low, high temperature and high strength applications in all the three industries, particularly in the power industry. In the power industry a number of low alloy steels are used for elevated temperature applications. Over the years a variety of quality requirements have been introduced in these groups of weld metals. Apart from the chemical and mechanical properties, today emphasis is on properties like toughness, embrittlement, creep, hot strength which are very essential for satisfactory performance in service.

Consumables for Cr-Mo steels

Cr-Mo steels find use in elevated temperature applications in Oil, Gas and Power industries. A number of these steels with varying amounts of Cr, Mo and other elements are used to manufacture components. **Table 1** details the various consumables in this group and their typical weld metal chemistries. While some of the grades have been in existence for a long time, many new versions have been introduced to suit specific needs. These are

- Weld metals with temper embrittlement resistance

Motor Generator Welding Set

- Ideal for welding with cellulosic electrodes for cross country pipelines and thermal/nuclear power plants
- Three Phase motor as prime mover
- DC Welding generator of a special patented design
- Positive protection against overload and single phasing

ADOR Institute of Welding Technology

- Weld metals with hardness control
- Weld metals with properties after prolonged PWHT
- Weld metal meeting Inter - granular corrosion (IGC) test requirements
- Weld metals with creep properties
- Non-Synthetic types
- Special grades with additions of V, W, B, N, Nb, Ti

Table 1: Cr-Mo weld metals

AWS classification	Typical weld metal major elements
E8018B2	0.07C-1.25Cr-0.5Mo
E9018B3	0.07C-2.25Cr-1Mo
E8018B6	0.07C-5Cr-0.6Mo
E9018B8	0.06C-9Cr-1Mo
E9018B9	0.06C-9Cr-1Mo-0.4Nb-0.04N-0.5Ni-0.2V-0.03Al
E7018B2L	0.045C-1.25Cr-0.5Mo
E8018B3L	0.045C-2.25Cr-1Mo
Special type	To meet step cooling, J,X factor and temper embrittlement resistant
Special type	To meet prolonged PWHT

Weld metals with temper embrittlement resistance

Cr-Mo steels get embrittled when exposed for long periods in the temperature range of 400-500C.Tramp elements like P, As, Sb, Sn are the root cause for this problem. By controlling the tramp elements it is possible to overcome this problem. This is done by using two parameters X and J factor as detailed below

Factor	Formula- Elements in %wt	Requirement
Bruscato X factor for Base and weld metal	(10P+5Sb+4Sn+As) / 100	<10
Watnabe J factor for base metal	(Mn+Si)+(P+Sn) 10000	<80

A step cooling heat treatment is also performed to determine the susceptibility of the base and weld metals to this problem. All these go to show the stringent quality standards within which consumables are being developed today to meet the industry needs.

Weld metals with hardness control

Weld metal, HAZ and base metal hardness are important factors which determine the performance of the welded joint in service. Hence in many situations the weld metal chemistries are controlled to lower carbon levels to achieve lower hardness. **Table 2** gives the different grades of Cr-Mo weld metals with lower carbon.

Table 2: L- versions of Cr-Mo weld metals

AWS classification	Typical weld metal major elements
E7018B2L	0.045C-1.25Cr-0.5Mo
E8018B3L	0.045C-2.25Cr-1Mo
E8018B6L	0.045C-5Cr-0.5Mo

Weld metals with prolonged PWHT

Most of the Cr-Mo steels are subjected to Post weld heat treatment after welding to relieve the stresses. The AWS specifications also specify the PWHT for various weld metals. But in actual practice many times the weld metals are subjected to prolonged, repeated heat treatment cycles in which the standard AWS testing may not give the correct picture. Therefore many weld metal specifications, today, specify many changes in the PWHT. In order to meet these requirements the weld metal compositions have to be adjusted to optimum levels so that the desired properties are achieved. **Table 3** gives details on some of the heat treatments **for weld deposits from a few different electrode types.**

Table 3

AWS classification	Heat treatment details
E 8018 B2	690 C FOR 2 HRS
E 8018 B2	690 C FOR 12 HRS
E 9018 B3	740 C FOR 4 HRS
Cr-Mo-V type	690 C for 2 hrs + WQ from 940 C + tempering at 720 C
E7018 B2L	720 C FOR 2 HRS
E 8018B 3L	710 C FOR 2 HRS
E 9018 B9	760 C FOR 4 HRS

Creep Properties

For any elevated temperature application, creep data is very important. Providing creep data for weld metal has now become a regular feature, at least for normal grades. However generation of

this data is time consuming and also expensive.

Non-Synthetic types

SMAW electrodes can be made with carbon steel core wire or with alloyed steel core wire. In Cr-Mo steels, especially at higher alloy levels, it is preferable to use non-synthetic types as they produce consistent properties. Today, non-synthetic electrodes are available even in 9Cr-1Mo types, which produce consistent mechanical properties.

Special grades with additions of V, W, Nb, N, B, and Ti

With the operating temperatures and pressures going higher and higher and with increasing concern for increasing operational efficiency, controlling emissions, super and ultra super critical boilers are being considered which use Cr-Mo steel with additions of the above elements. Materials like P91, P911, P92, P23, P22V, and P24 belong to this category. Welding consumables meeting these requirements are under development and testing. In future many power plants will use these types of consumables.

CONSUMABLES FOR STAINLESS STEELS

Stainless steels are used widely in Oil, Gas and Power industries with the former two using them in good quantities. A variety of grades are used and they have been standardized for many applications. The common varieties like 'L' grades, stabilized grades and their combinations have been in existence for quite some time now.

Inter granular corrosion (IGC) test

This is a test to ascertain the suitability of austenitic stainless steel material under corrosive conditions. A pass or failure in this test will forecast the behavior of the material under actual service condition. Normally the IGC test is conducted as per ASTM 262 practices like A-B-C-D-E. All these tests are different and are used for different conditions.

Cryogenic service applications

For some applications, the stainless steels and the resultant weld metal have to withstand temperatures of up to -196 DEG C. Consumables have been developed for this application and some of them are detailed in the last table given below.

AWS	Properties
E308L-15	Meeting impacts and lateral expansion at minus 196C
E316L-15	Meeting impacts and lateral expansion at minus 196C
ER308L	--do--

Duplex and Super Duplex stainless steels (DSS and SDSS)

Of particular interest to us at this juncture are the duplex and super duplex stainless steels which are increasingly used in oil and gas industries especially for components which are subjected to stress corrosion cracking. **Table 4** shows the details of the popular weld metal grades for these materials and the base materials on which they can be used. Indigenous developments are still in progress to deliver these weld metals with detailed corrosion data and also to understand the effect of various welding variables on these properties.

Table 4: DSS-SDSS materials (Typical major elements)

Property	E2209	E2553	E2595
C	0.03	0.04	0.03
Cr	22	25	25
Ni	9.5	7	9.5
Mo	3	3.5	4
N	0.12	0.2	0.25
Cu	--	2	1
W	--	--	0.7
Mn	1.5	1	2

'H' versions of standard grades

The higher carbon versions of 308, 347 are now being considered for their elevated temperature properties. New weld metals with higher carbon in the range of 0.04-0.08 are now available for these materials.

CONSUMABLES FOR NICKEL ALLOYS

Nickel alloys form one of the important material groups used in these industries. Many consumables have been developed to meet the welding requirements of this group**. Table 5** gives details of some of the consumables in this group.

Table 5: Nickel alloys (Typical major elements)

Property	ENiCrFe2	ENiCrFe3	ENiCrMo3	ENiCrMo6
C	0.05	0.05	0.05	0.05
Mn	2	7	1 max	3
Fe	8	7	5	7
Cr	15	15	22	15
Nb+Ta	2	2	4	1.5
Mo	2	--	9	7

Ni	62 min	59 min	55 min	55 min
Ti	--	1 max	--	
W	--	--	--	1.5

Grade	Typical application
E NiCr Fe2	Dissimilar metals, low temp and high temperatures up to 820C; for welding B163, B167, B168, UNS N 06600
E NiCrFe3	Dissimilar metals, low and high temperature applications up to 480C; for welding UNS N 06600
ENiCrMo3	For welding UNS N 06625, B 443,444,446; dissimilar metals; for temperatures from cryogenic to 540C.
ENiCrMo6	Popularly used for welding 9%Ni steels; A333,334,353,522,553, UNS K 81340

CONCLUSION

As we saw earlier, the Oil, Gas and Power industries offer a number of challenges for welding by constantly using improved and newer materials. This has been the constant factor fuelling the development of a host of new and modified consumables to suit the application and also the service condition. Thanks to these cooperative efforts, today we have a wide spectrum of welding consumables meeting many service conditions.

Some Ador Welding Ltd. consumables for welding alloy steels and stainless steels in Oil, Gas and Power industries and tests performed.

Please click on the electrode name to know more about its properties

AWS CODE	PROCESS	AWL PRODUCT NAME	NACE TEST	IGC TEST	IMPACT AT (-196 DEG C)	C.T.O.D TEST AT (-10 DEG C)
E 7018 G	SMAW	TENALLOY Ni (Spl Batch)	N.A.	N.A.	N.A.	DONE
E 8018 G	SMAW	TENALLOY 60 NX	N.A.	N.A.	N.A.	DONE

		(Spl Batch)				
E 347 - 16	SMAW	SUPERINOX 1B	DONE	N.A.	N.A.	N.A.
E 308L - 15	SMAW	SUPERINOX 1C 15(LT)	N.A.	PRACTICE E	DONE	N.A.
E 316L - 16	SMAW	SUPERINOX 2C	N.A.	PRACTICE E / B	DONE	N.A.
ER 308 L	TIG	TIGINOX 308L	N.A.	PRACTICE E	DONE	N.A.
ER 316 L	TIG	TIGINOX 316 L	N.A.	PRACTICE E / B	N.A.	N.A.
ER 308 L	MIG	MIGINOX 308 L	N.A.	PRACTICE E	N.A.	N.A.
ER 309 L	MIG	MIGINOX 309 L	N.A.	PRACTICE E	N.A.	N.A.
ER 316 L	MIG	MIGINOX 316 L	N.A.	PRACTICE E	N.A.	N.A.
ER 70 S 2	TIG	TIGFIL 70 S 2	DONE	N.A.	N.A.	N.A.
ER 70 S 2	TIG	TIGFIL 70 S 2 (SPL)	DONE	N.A.	N.A.	N.A.
EH 10K (WIRE)	SAW	AUTOMELT EH 10 K	UNDER WAY	N.A.	N.A.	N.A.
B41 (FLUX)	FLUX	AUTOMELT B 41	UNDER WAY	N.A.	N.A.	DONE
ER 308 L	SAW	SUBINOX 308 L	N.A.	PRACTICE E	DONE	N.A.
S 33 (FLUX)	FLUX	AUTOMELT S 33	N.A.	PRACTICE E	DONE	N.A.
ER 309L	SAW	SUBINOX 309 L	N.A.	PRACTICE E	N.A.	N.A.
ER 316L	SAW	SUBINOX 316L	N.A.	PRACTICE E	N.A.	N.A.

To know more about the special requirements and availability of welding consumables in the Oil, Gas and Power sectors please contact us at cmo@adorians.com. or visit us at www.adorwelding.com

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