OIL, GAS AND POWER

Advances in welding consumables

Welding is an important and critical activity in fabrication, construction and erection of any component, machinery and plant. Oil, gas and power industries are no exception to this. A special report by Ador Welding Ltd.


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Over the years, the oil, gas and power industries have witnessed several technological advances which have enabled them to operate more efficiently. These technological advances have also resulted in the use of several newer materials as well as stringent quality requirements which ensure safe and efficient operation.

Welding technology has also grown hand in hand with these developments and today we have a number of welding processes, techniques, equipment and consumables to meet these requirements. While developments in all these four areas are very important, the consumable area is very vital and critical, as the weld metal will remain in service and has to match the service behaviour of the base material. So in designing the weld metal or the consumable a lot of effort is put in to ensure its service life, producing a defect-free weld joint.

In this article we will highlight the developments that have taken place in consumables for welding of carbon steels.

Table 1: Consumables meeting NACE requirements

Property	E7018-1	ER70S2 SPL	EH10K + FLUX
C	0.05	0.05	0.06
Mn	1.2	1.2	1.3
Si	0.25	0.5	0.25
S	0.008	0.008	0.012
P	0.010	0.010	0.012
UTS Kg/mm2	540	--	55
YS Kg/mm2	430	--	43
%El	26	--	23
CVN impact -30C	60J	--	75J
SSCC TM0177	OK	OK	OK
HIC TM0284	OK	OK	--

Consumables for carbon steels

Carbon steels are the most widely used materials in these industries. The common consumables like E6013, E7018 (SMAW), ER70S2 (GTAW), ER70S6 (GMAW), EL8, EM12K, and EH14 (SAW) have been standardised with respect to their properties and performance, and are being used for many carbon steel applications in these industries for many years now. However, several special consumables have been developed to meet specific application requirements.

Consumables for NACE applications: In the oil and gas industry, a number of components are exposed to hydrogen sulphide and sour gas environments resulting in stress corrosion cracking. Weld metals operating in these environments are normally tested to ensure that they with stand these service conditions. NACE specifications TM 01 77 and TM02 84 specify suitable tests to determine the behaviour of the weld metal. The details of the weld metals meeting these requirements are indicated in Table 1. With the availability of these consumables, several tons of carbon steels have been successfully welded in this industry.

Moisture resistant and vacuum packed electrodes: Moisture is a detrimental factor in welding. Higher moisture content in the environment, shielding gas and flux, base material can introduce more hydrogen in the weld metal. Hydrogen is not a desired element in the weld metal since it makes the steel brittle. So in carbon and low alloy steel welding, extra care is exercised to limit hydrogen in coating. When electrodes and fluxes are opened from their containers and exposed to atmosphere they absorb moisture and the amount of hydrogen absorption is dependent on the relative humidity of the environment at that time. In order to ensure that the electrodes, fluxes are dry at the time of usage, they are normally redried, particularly low hydrogen consumables. Most of the fabricators use this procedure during welding and satisfactory results are obtained.

Table 2: Moisture resistant electrodes

AWS	As received coating moisture	After exposure to 80% RH for 9 hrs at 27C
E7018	0.6%	Not specified
E7018R	0.3%	0.4%

However, there are many occasions when re-drying may not be possible. In order to meet this requirement electrodes have been developed which resist moisture pick up. These electrodes are designated with a suffix 'R' indicating they are moisture resistant electrodes. These electrodes are tested for moisture resistance by subjecting them to special tests as indicated in Table 2.

In order to preserve these electrodes in the factory packed condition till usage, they are vacuum packed which ensures quality at the time of usage. Another advantage of vacuum packing is that these electrodes don't require re-drying like conventional low hydrogen electrodes. There are a number of applications in oil and gas industries where re-baking is not feasible and the welding environment is always with high relative humidity. The development of vacuum packed moisture resistant electrodes is a great boon specifically for these applications.

Table 3: Specific impact requirements

Condition	Value J
AWS standard	27
No value less than	40
Minimum average value	40
Welding under specified heat input conditions	40

Weld metals with enhanced toughness requirements Weld metal toughness is an important property. It is usually measured with the CVN impact test which specifies a minimum value for the average impact strength at specified temperatures. While these values are the basic minimums, having a higher value is preferred by the fabricators which can to some extent take care of any procedural variations during welding and still produce a tough weld metal. Hence specifications today, call for minimum impact values which are much higher than the standard values. Some specification details are given in Table 3. This illustrates the stringent quality standards to which the weld metal has to conform.

Table 4: CTOD values specified weld metals

AWS classification	Electrode size	CTOD values (required min 0.25 mm)
E 7018-1	2.5	0.75
	3.2	1.08
	4	0.83

Apart from this, weld metals are today required to meet CTOD value; CTOD is a fracture mechanics test to ensure toughness of the material in the presence of a running crack. While the routine specifications do not talk about this, requirements in the oil and gas industries specify this. A sample requirement is indicated in Table 4.

AWS now specifies a separate 'J' designation for an E71T1 flux cored wire which can meet the impact properties at minus 40C.

Pipe welding electrodes

For pipe welding, traditionally, the use of cellulosic types, like E6010, has been in practice for a very long time. The use of this electrode is normally restricted to lower strength levels and for higher strength levels such as at 70000 psi, special pipe welding electrodes like E7010P1 are to be used. Electrodes are available for higher strength levels also. These are specially made for vertical down welding of pipes, (popularly referred to as stove pipe welding) particularly the root pass where penetration is of great importance. Table 5 gives details of these types of consumables. These grades are available now indigenously. Even low hydrogen electrodes specially designed for pipe welding are available and are included in the specifications.

Conclusion

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 requirements.

Table 5: Pipe welding electrodes (Typical where not mentioned)

Property	E6010	E7010 P1
C	0.2	0.2
Mn	1.2	1.2
Si	1.0 max	0.6
Ni	0.3 max	1.0 max
Cr	0.2 max	0.3 max
Mo	0.3 max	0.5 max
V	0.08 max	--
S	0.03 max	0.03 max
P	0.03 max	0.03 max
UTS KG/mm2	44	50
YS KG/mm2	34	42
CVN AT -30C	27 J	27 J

Ador Welding consumables for carbon steels in oil, gas and power industries and tests performed

Aws Code	Process	Awl Product Name	Nace Test	C.T.O.D Test At (-10 Deg C)
E 7018-1	Smaw	Tenalloy Hh Spl	Done	N.A.
E 7018-1	Smaw	Tenalloy S Plus	Done	Done
E 7018 -1	Smaw	Tenalloy Z Plus	Done	N.A.
E 6010	Smaw	Celwel 60	Done	N.A.
E 7010 G	Smaw	Celwel 70 G	Done	N.A.
E 8010 G	Smaw	Celwel 80 G	Done	N.A.