Submerged arc welding with fused flux and basic cored wire for low temperature applications

no re-baking of fluxes necessary

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ESAB introduce a basic cored wire/fused flux SAW package, OK Tubrod 15.24S/OK Flux 10.47 for use in offshore fabrication. Rebaking of the flux is avoided.

Introduction

Today, the commonly applied fluxes for high strength/low temperature applications are agglomerated basic types, to provide dependable CVN and CTOD toughness properties at sub-zero temperatures. The greatest disadvantage of agglomerated fluxes, however, is that they are hygroscopic and must be re-baked prior to welding in order to avoid potentially high weld metal hydrogen contents with the inherent risk of cold cracking. The routine of removing flux from bags into ovens and re-baking it for several hours is time consuming and costly for fabricators. Fused fluxes, although non-hygroscopic, never became established in offshore fabrication, mainly because of poor mechanical properties with solid wires. This is overcome by the use of a basic cored wire with active agents in the flux to improve the mechanical properties.

ESAB have now introduced a basic cored wire/fused flux consumable package, OK Tubrod 15.24S/OK Flux 10.47, fulfilling low-temperature weld metal requirements down to –40ºC and CTOD-tested at –10ºC, but without the necessity to re-bake the flux before welding. In the field of submerged arc welding, this is as much a breakthrough as the introduction of

Table 1: Classifications	
OK Flux 10.47	EN 760: SF AB 1 65 AC
Combination	AWS A 5.23: F8A4-EC-G

Table 2: All weld metal chemical composition and mechanical properties (as welded).					
%C	%Si	%Mn	%Ni	%P	%S
0.05-0.10	0.10-0.40	1.50-2.00	0.60-0.90	<0.025	<0.025

Rp 0.2	(MPa)	>470
Rm	(MPa)	550-700
A5	(%)	>20
CVN at –40ºC	(J)	>47

Table 3: Typical CTOD values at –10ºC for OK Tubrod 15.24S/OK Flux 10.47.			
	Single-V	Double-V	K-prep.
1st	>0.934	0.731	>0.916
2nd	>0.934	>0.893	0.866
3rd	>0.919	0.753	–

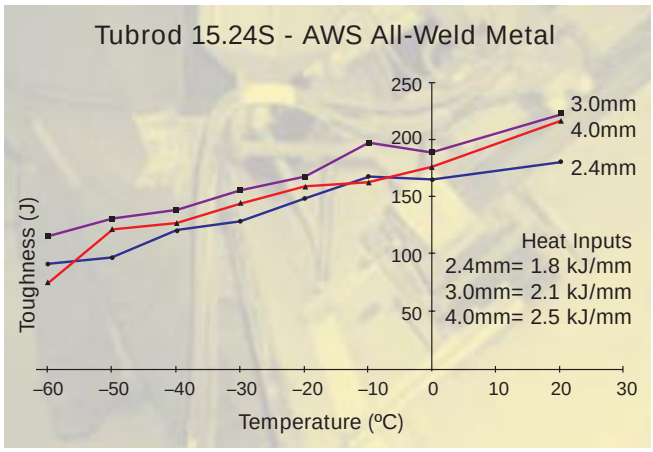

Figure 1: CVN transition diagram.

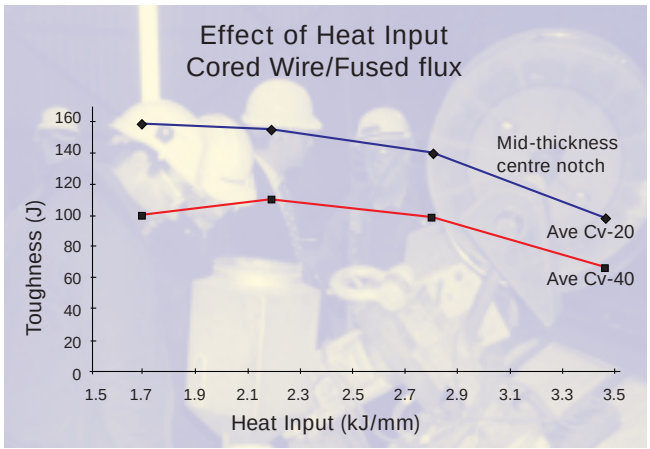

Figure 2: Influence of heat input on CVN properties.

vacuum packaging for stick electrodes in the eighties. It simplifies storage and handling procedures enormously.

In addition, fabricators get a bonus in the form of an increased welding economy, due to the use of a cored wire. Deposition rates may be 20 to 30% higher than with solid wire SAW, depending on the type of application. More benefits in the area of weldability are discussed below.

In the near future, ESAB will launch other consumable packages with basic cored wires and fused flux for general construction and other segments where the low-hydrogen weld metal is a factor for consideration.

Next, the new SAW consumable package is introduced and product characteristics are reviewed. In addition, we discuss its successful implementation for the fabrication of components of the Saga Petroleum Snorre B oil and gas platform by two UK subsidiaries of Kværner Oil & Gas.

Mechanical properties of OK Tubrod 15.24S/OK Flux 10.47

The objective of the development was to create a consumable package based on a basic cored wire and fused flux meeting the following weld metal requirements (as welded) for structural welding in the offshore segment:

- Yield strength >470MPa
- CVN toughness >47J at –40ºC
- CTOD >0.25mm at –10ºC

The use of a basic cored wire, instead of a solid wire, allows the weld metal toughness properties to be engineered through the cored wire rather than through the flux.

A highly basic flux is no longer a prerequisite and this opens the way to the use of a lower basicity fused flux with very distinctive advantages for offshore welding applications.

OK Tubrod 15.24S is a 1% nickel alloyed basic cored wire meeting the all weld metal mechanical requirements stated above in combination with the fused flux OK Flux 10.47. Table 1 gives the classifications and Table 2 shows the chemical composition and mechanical properties. It is clear that the combination exhibits the required tensile properties as well as sufficiently high CVN toughness, even down to -50ºC.

CTOD properties have been tested for single-V, double-V and K-joints in 50mm wall thickness with excellent results (Table 3).

Figure 1 surveys the CVN temperature transition curve, showing a gradual decrease down to a level of –60ºC for all three wire diameters. Figure 2 shows that the CVN toughness decreases with increasing heat input, but stays well above the 47J level at –40ºC.

These results establish that the SAW consumable package OK Tubrod 15.24S/OK Flux 10.47 clearly provides the mechanical properties needed for offshore fabrication. Additional benefits are found in the use of a fused flux, described below.

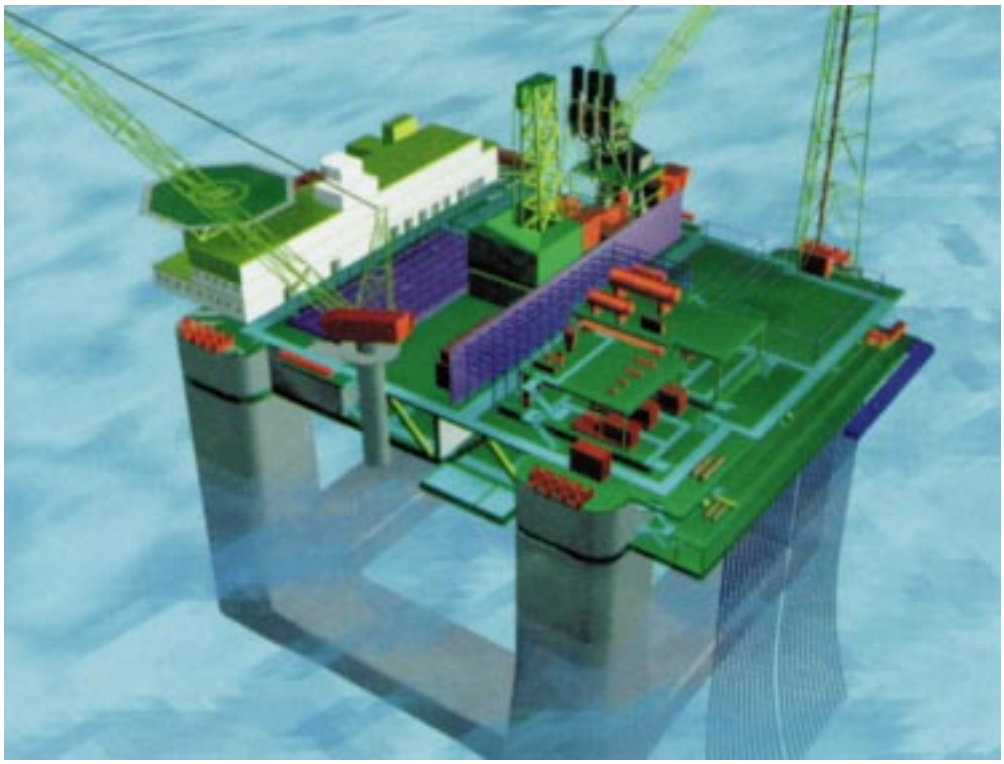

Figure 5: Snorre B. Artist's impression.

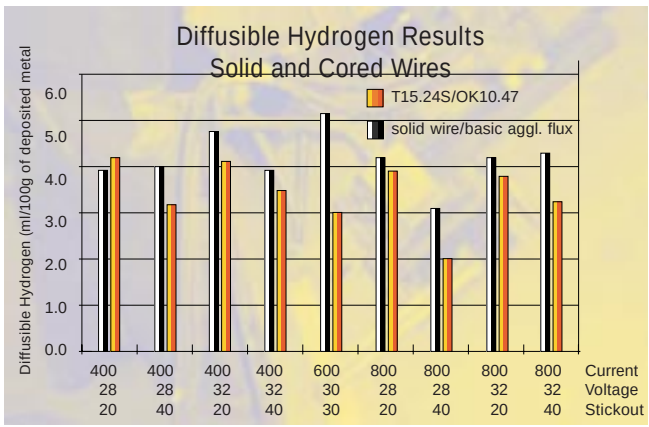

Figure 3: Diffusible hydrogen results for competitor EN 760: SA FB 1 55 AC type agglomerated basic flux used with solid wire and OK Tubrod 15.24S/OK Flux 10.47.

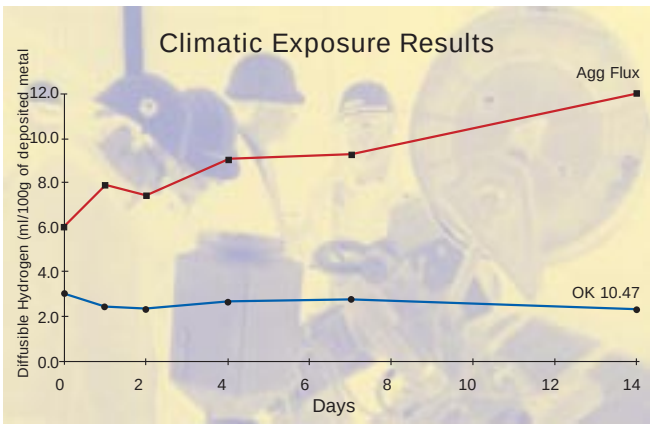

Figure 4: Climate exposure tests at 80%RH and 25ºC for EN 760: SA FB 1 55 AC type competitor agglomerated basic flux and fused flux OK Flux 10.47 with OK Tubrod 15.24S. Diffusible hydrogen determined at 600A/30V/ 30 mm stickout.

OK Flux 10.47

The fact that this fused flux has a very low moisture content and a moisture re-absorption rate close to zero is, undoubtedly, the biggest advantage for applications where low weld metal hydrogen contents are crucial. This enables the flux to be used without the costly, and time-consuming procedure, of re-baking.

Figure 3 compares the hydrogen performance of the consumable package OK Tubrod 15.24S/OK Flux 10.47 with a well established competitor basic agglomerated flux/solid wire combination. Diffusible hydrogen tests have been carried out at increasing current levels covering the work range of the flux, for various stick-out lengths. Both wire/flux combinations gave values below 5ml/100g with OK Tubrod 15.24S/OK Flux 10.47 tending below 4ml/100g. Note that the agglomerated basic flux has been re-baked according to the manufacturer's instructions whereas OK Flux 10.47 has been used directly from the original bags.

The moisture re-absorption characteristics of both fluxes have been tested by means of climatic exposure tests in a humidity cabinet at 80% RH and 25ºC for up to 14 days. It shows that OK Flux 10.47 is not sensitive to moisture re-absorption, due to its non-hygroscopic character and can be used safely without re-baking.

The basic cored wire OK Tubrod 15.24S hydrogen values and re-absorption behaviour is comparable with that of solid SAW wire. When stored and used according to the manufacturer's instructions it does not regain moisture.

The second big advantage for fabricators is an increased deposition rate due to the use of a cored wire as a consumable. As with cored wires used for FCAW, the current is conducted by the metal sheath, instead of

the complete wire cross section resulting in a higher current density. In combination with the fused flux this higher current density is converted to increased deposition rates and higher applicable travel speeds. How much fabricators can benefit from this depends, of course, on the type of application. Our experience with cored wire/flux combinations in general, is such that an increase in welding productivity can be expected in the order of 20–30%.

Weldability characteristics are excellent; comparable to the best basic agglomerated fluxes available on the market. Slag release is very good even in the bottom of butt joints near the root area and even narrow gap applications are possible. Due to the glass nature of the flux, the grain strength is significantly higher than that of the fully basic agglomerated fluxes. This results in less breakdown and hence no problems with "dusting" and therefore allround improved recyclability. The finished weld appearance is very good, both in butt and fillet welds.

Next we will describe the use of OK Tubrod 15.24S/OK Flux 10.47 for offshore fabrication by two UK based yards who were the first customers for this new combination.

Fabrication of deck modules for Snorre B

The Snorre B oil and gas platform for Norway's Saga Petroleum (Figure 5) is currently under construction for delivery in the Spring 2000. Aker Stord of Norway is the main contractor. Part of the deck was sub-contracted to Kvaerner Oil & Gas (KOG) Methil, in Scotland, which in turn sub-contracted parts to KOG Teesside in England.

Applications at both UK yards are very similar. They consist of box structures and beams in BS 7191-450 EMZ steel with a minimum weld metal CVN toughness requirement of 47J at –40ºC. Figure 6 shows the fabrication of beams at KOG Methil. Fillet welds with a throat thickness of 8.5mm were made in one pass with OK Tubrod 15.24S/OK Flux 10.47 at 630A/31V/36cm/min. In this application, the cored wire/fused flux combination welds 25% faster than the competitor solid wire/basic agglomerated flux combination used previously for similar work.

KOG Teesside also reported impressive productivity improvements in the welding of box structures, involving V-joints in 35mm thick plates (Figure 7). Compared with the solid wire/basic agglomerated flux combination used previously with metal powder addition, the number of passes was reduced from 23 to 15 (-35%) while maintaining good mechanical properties. Note that OK Tubrod 15.24S/OK Flux 10.47 is used here without metal powder addition. They also reported marked improvements in actual flux consumption as the basic cored wire contributes its own fluxing agents to the weld pool.

Both yards benefitted from not having to re-bake the flux prior to welding, which enables easy handling procedures and is very time and cost efficient. Additionally, the improved slag release and cosmetic appearance of the completed welds was highly appreciated.

Figure 6: Fabrication of beams at KOG Methil.

Figure 7: Fabrication of box structures at KOG Teesside.

To conclude

Summarising, the basic cored wire/fused flux combination OK Tubrod 15.24S/OK Flux 10.47 introduced by ESAB has been developed for low temperature applications such as offshore fabrication. Product benefits are found in easy storage and handling without re-baking of the flux, increased welding productivity, very consistent mechanical properties, and an excellent weld quality. The SAW combination has been used successfully for the fabrication of critical components on the Snorre B project.

About the authors

Neil Farrow is a Senior Development Engineer who has been working at Waltham Cross in the UK for the past 15 years.
Neil holds a BSc in Metallurgy and Materials Science and an MSc in Welding Technology from Cranfield University. He has recently been very active in the development of cored wires for submerged arc welding.

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