Sweet results from sour service

Scott Funderburk, Director – Global Marketing Pipeline Segment, The Lincoln Electric Company, explains how proper consumable selection can have a significant effect on welding success on subsea sour service pipelines.

Materials specification plays a crucial role in the success and integrity of welds on subsea pipelines, especially sour service pipelines, particularly when it comes to selecting welding consumables.

A sour service pipeline environment is defined by NACE International specification MR017 as "fluids containing water and hydrogen sulphide (H_2S) that is a total pressure of 0.4 MPa (65 psia) or greater, and if the partial pressure of hydrogen sulphide in the gas is greater than 0.0003 MPa (0.05 psia)."

More simply put, concentrations of H_2S, known as sour gas, are becoming increasingly more prevalent in subsea oil and gas transport conditions. Not only is this gas almost as deadly as carbon monoxide, but it also can be highly damaging to pipelines if the correct materials are not specified. On pipeline exteriors, welds are exposed to lower hydrogen concentrations than those in contact with the sour environment found on surfaces inside the pipeline. Hydrogen sulphide's corrosiveness can result in sulphide stress corrosion cracking in the welded material.

Consumables for sour service

Typically, high strength carbon steel, grade X70, is used for such subsea jobs. There are no major differences in welding X70 material compared to lower grade steel, such

Figure 1. On the Manifa pipeline project, VML needed to specify a welding process and materials that would work on heavy-duty pipe and in a sour environment, while keeping the project running at a productive pace, on time and on budget.

Figure 2. While working on the pipeline, welders were able to achieve precise wire placement. The cast and pitch of the spooled wire was maintained from start to finish. Once placed, it did not wander from the joint.

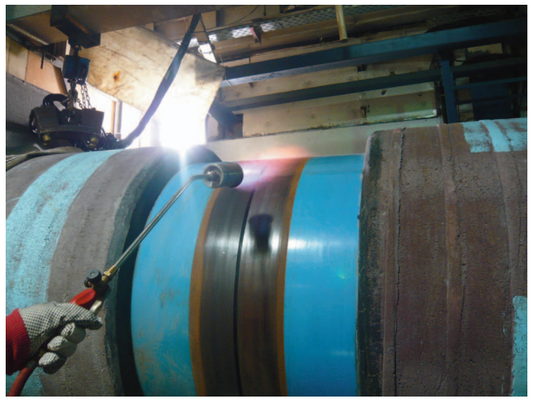

Figure 3. The consumable selected for the project, Lincoln Electric's Pipeliner 80Ni1 resisted micro porosity above the root up through the cap pass, delivering a consistent, smooth arc from every angle and for each weld.

as X65. However, welding consumables do need to be selected to obtain the specified mechanical requirements for this particular product.

Consumables for use with high strength X70 carbon steel must deliver high toughness, stand up to corrosion and hydrogen-induced cracking and be suitable to weld on this grade of steel with good weldability and high tensile strength and without lack of fusion (LOF) defects. Selected consumables must also stand up to such non-destructive testing (NDT) methods as radiography or automated ultrasonic testing (AUT).

Low alloy gas metal arc welding (GMAW) consumables are designed for semi automatic or automatic welding of root, hot, fill and cap passes in all positions on up to X80 grade pipe and root passes on up to X100 grade pipe, making this consumable category ideal for high strength carbon steel used in subsea sour service environments.

Some products are capable of producing Charpy V-Notch impact properties of 69 - 95 J at -50 °C – meeting the tough requirements in demanding pipeline jobs, such as the one Abu Dhabi-based Valentine Maritime (Gulf) LLC (VML) encountered in late 2010 – a 100 km subsea pipeline and cable installation project in the Manifa field for Saudi Aramco.

Subsea challenges

When the seasoned offshore contractor tackled construction on this portion of the Manifa oilfield redevelopment project for the world's largest oil producer, Saudi Aramco, it faced many challenges on the 42 in. subsea pipeline segment stretching 46 km, including welding materials selection.

VML specialises in the construction, installation, maintenance and subsea inspection of offshore platforms and submarine pipelines, as well as the chartering of barges and marine vessels. The company's main activity is the execution of major EPC offshore projects. The Saudi Aramco Manifa project was crucial, as it was a major EPC for VML.

The company had launched its operations 20 years prior with the acquisition of a derrick lay barge (DLB), the *Regina-250*. In 2010, it added another barge and was taking another major step forward in its growth by commissioning the construction of a third, even larger, DLB. According to Valentine Maritime's Project Manager, Subash Nair, a good showing with Saudi Aramco could go a long way towards making sure the fleet of pipelay and derrick barges stayed busy for years to come.

"It was an extremely important project for us as a company because it was a breakthrough with Saudi Aramco," Nair notes.

Although VML's crews had successfully installed hundreds of kilometres of subsea pipeline, they had not previously welded the hefty, 42 in. diameter, 1.25 in. wall thickness, X70 grade pipe that this project demanded. The project also had some areas that used X65 grade pipe, another suitable option for sour environments, including subsea valve skid tie-in.

On the Manifa pipeline project, VML needed to specify a welding process and materials that would work both with such a heavy-duty pipe and the sour environment, while keeping the project running at a highly productive pace, on time and on budget.

Welding engineers settled upon automated GMAW in short-circuit mode with a narrow J-groove design to achieve a high rate of welds. However, joints welded by an automated MIG process are more susceptible to lack of fusion defects, so VML needed to build strict controls for the welding details, including selecting the right welding wire.

The project at a glance

- Valentine Maritime, based in Abu Dhabi, constructed 46 km of subsea pipeline in the Manifa oilfield for Saudi Aramco.
- The project had stringent quality requirements and a strict completion deadline.
- The pipe specified for the project was 42 in. OD x 1.25 in. WT, X70 grade, high strength carbon steel.
- The pipe was welded using an automated GMAW process in short-circuit mode with a narrow J-groove design to achieve a high production rate.
- Engineers sought a welding wire that more than exceeded the tensile strength of X70 grade pipe and had little or no lack of fusion defects.
- After comprehensive testing of more than 30 different consumables, the welding team specified Pipeliner® 80Ni1 from Lincoln Electric.
- The selected wire far exceeded NDT requirement, as well as key mechanical requirements, including Charpy V-Notch, tensile strength and crack tip opening displacement (CTOD).
- On the job, welders achieved precise wire placement, improved productivity up to 18.5% with low downtime and averaged 79 joints/d with a repair rate of less than 3%.

Wire selection process

The next challenge? Selecting a suitable consumable that more than exceeded the tensile strength of the X70 grade pipe, offered little to no gas pores and delivered excellent weld metal properties under Saudi Aramco's stringent requirements for quality on a tight production timeline.

To identify the best consumable, VML tested wires from several different manufacturers. Engineers created a total of 35 test coupons, using different combinations of wires and gas mixtures. The coupons then underwent both 100% automatic ultrasonic NDT and mechanical testing. Rising to the top was Lincoln Electric's low alloy MIG wire, Pipeliner® 80Ni1.

This wire consistently beat out the competitors by delivering the needed results in all aspects. Competitive products revealed micro porosity above the root up through the cap pass, but Pipeliner 80Ni1 showed strong resistance to this phenomenon. It also met all the mechanical property requirements, including Charpy V-Notch, tensile strength and crack tip opening displacement (CTOD).

"There was a negligible amount of gas pores in the weld metal compared to other similar wires and brands," the welding engineer noted. "As a result of the consumable's good wetting nature, LOF was totally eliminated."

Because of the large diameter and 1.25 in. wall thickness, AUT with an approved engineering critical assessment (ECA) was the chosen method for NDT from a speed and sensitivity standpoint. This, however, was backed up by an excellent pipeline welding team, which is an in-house capability of VML.

On the job

Once on the job, VML's team of professional welders worked back-to-back shifts. They averaged more than 79 joints/d on the 42 in. OD x 1.25 in. WT pipe, with a repair rate of less than 3%. The peak production was 92 joints/d.

The welding engineer added that his welding team was "very comfortable" using the low-alloy GMAW wire, noting that the specified wire not only delivered excellent performance with "good side wall wetting and penetration," but that it also was easy to use.

"The wire stood out for its superior feedability and performance characteristics," he said. "It also delivered a consistent, smooth arc from every angle and for each weld."

While working on the pipeline, the welders were also able to achieve precise wire placement. This was possible because the cast and pitch of the spooled wire is maintained from start to finish of welding. Once placed, it did not wander from the joint. Overall, productivity improved by nearly 20% with low downtime and within budget parameters.

"Stopping production on a subsea job for a day incurs a few hundred thousand plus dollars of loss. It affects not only our quality of product but also our quality of service," according to the project manager. "What's more, thanks to this wire's broad acceptance criteria, it reduced pressure on welders. This allowed us to maximise our budget without compromising quality and production."

Many variables to consider

The specification of consumables for any offshore project, particularly subsea sour service pipelines, takes into careful consideration many selection factors; from welding process, to grade and thickness of the steel to stringent ECA requirements under consideration, choosing the right electrode takes time and testing.

In the end, this time and attention to choosing the specification/process delivers a definitive return on investment. With the right consumable, welds in sour environments will maintain integrity and avoid LOF defects and hydrogen sulphide cracking, among other failures.

Finally, properly specified welding wire can contribute to overall gains not only in quality but also project productivity. Joints welded right the first time can keep a job moving on or ahead of schedule, as the example of VML suggests.

"We were not expecting that level of performance," the project manager said, looking back at the job after the lengthy consumable specification process. "Saudi Aramco was also pleasantly surprised by the quality of production and the efficiency of the work by a contractor for the first time, working under stringent quality and safety requirements. VML now can bid future subsea projects for this esteemed client."

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