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Using a new low-hydrogen stick electrode has helped a contractor improve productivity, reduce costs and beat the construction deadline on a carbon-dioxide pipeline constructed of 24-inch by 0.469-inch, API 5L X80 steel.

With increasing global energy demand and fluctuating oil prices, there is renewed interest in maximizing known energy resources. With a focus on maximizing crude oil reserves, enhanced oil recovery (EOR) methods were developed to recover up to 30-60% of a field's original oil reserves.

In one EOR process, carbon dioxide (CO_2) pushes additional oil to a production well. CO_2 injection is one of the most efficient methods for enhanced oil recovery. Transporting the CO_2 to an oil field is accomplished through high-pressure pipelines. Welding on these pipelines can be challenging, making the selection of a low-hydrogen welding consumable critical.

Progressive Pipeline Inc., of Meridian, MS recently used low-hydrogen vertical-down electrodes for the construction of a CO_2 pipeline owned and operated by Denbury Onshore LLC, a wholly owned subsidiary of Denbury Resources Inc., an oil and gas company headquartered in Plano, TX. Using Lincoln Electric's Pipeliner® LH-D100 electrode, the company beat the construction schedule and achieved a 15-20% increase in productivity on the pipeline, which runs 80 miles from Tinsley, MS to Delhi, LA.

The Emergence Of CO_2 Pipelines

It is important to understand the role CO_2 plays in enhanced oil recovery. The CO_2 is transported through a pipeline in dense phase from a CO_2 source to an injection well. The CO_2 is injected into the oil reservoir where it mixes with oil droplets, expands them and moves them to producing wells. The CO_2 also reduces the viscosity of the oil, which helps remove the oil from the reservoir formation.

The production stream consists of oil, water and CO_2. On the surface, production components are separated. The oil is sold, produced water is disposed of and the CO_2 is recycled and re-injected into the reservoir. After the process is completed, the CO_2 can be injected and sequestered in the oil reservoir. In the future, CO_2 EOR should become an important process supporting carbon capture and sequestration, while producing crude oil that would not otherwise be produced.

The construction of the CO_2 pipeline is critical to this type of oil recovery. The pipeline in this specific case is constructed of 24-inch x 0.469-inch API 5L X80 steel. It is designed to operate under a maximum pressure of 2,160 psi, making the integrity of the welds critical.

Why Is The Consumable Important?

High-strength steel enables gas pipelines to withstand higher operating pressures and achieve higher throughput. It may also allow for a reduction in wall thickness which reduces costs associated with hauling and handling of material, as well as in time spent welding the pipe. However, the move to higher strength steels results in a greater susceptibility to weld metal hydrogen-assisted cracking (HAC). Manufacturers, such as Lincoln Electric, have focused on developing low-hydrogen vertical-down (LH-D) electrodes that address this challenge, while providing increased productivity, greater Charpy V-notch impact toughness and reduced repair rates.

Today, high-strength steel pipe grades like X80 are widely used for long-distance transmission pipelines, but present a challenge for welding. In the past, field girth welds on X70 and lower strength grades were completed almost exclusively with cellulosic electrodes. However, with high-strength X80, cellulosic electrodes are typically only used for root and hot passes and not for fill passes due to the increased risk of HAC.

The Electrode Benefits

Project Consulting Services Inc. (PCS), headquartered in Metairie, LA served as construction manager for the project and engaged Det Norske Veritas (DNV), whose Columbus, OH office focuses on research, testing and engineering, to assist in evaluating many of the commercially available welding options for the project. The DNV Columbus effort was managed by Bill Bruce, director of welding technology. Progressive furnished the welding services required for completing these evaluations. At the conclusion of the evaluation, DNV Columbus (formerly CC Technologies) recommended the use of the low-hydrogen vertical-down Pipeliner® LH-D electrodes from Lincoln Electric. This recommendation was accepted by Denbury for use on the project.

"We had worked with Lincoln as they were developing the electrode and recognized the advantages it would provide to the project in terms of preventing hydrogen cracking," explained Brad Etheridge, welding engineer at DNV Columbus. "And with the vertical-down approach, they were likely to see an increase in productivity as well."

Traditionally, low-hydrogen electrodes are welded vertical-up, which is a slow process. Welding vertical-down with low-hydrogen electrodes allows almost twice the deposition rate of vertical-up, significantly increasing productivity. Also, once opened, low-hydrogen electrodes usually need to be stored in heated ovens, which is difficult to manage in the field. Lincoln Electric's Pipeliner® LH-D electrodes — packaged in small hermetically sealed 10-pound steel cans — may eliminate the need for rod ovens.

Korey Adams, assistant spread superintendent at Progressive, describes the welding process for the Tinsley-Delhi pipeline. First, the pipe end bevels are cleaned, then the pipe is preheated to 300 degrees F (150 degrees C), and the pipe ends are clamped together. Using the shielded metal arc welding (SMAW) process, an E6010 electrode is used for the open-root pass, followed by an E9010-G hot pass. An E10045-P2 H4R low-hydrogen downhill electrode is used for the remaining fill and cap passes.

Progressive exclusively used Lincoln Electric consumables on this project: Fleetweld® 5P+ (E6010) for the root pass; Shield-Arc® 90 (E9010-G) for the hot pass; and Pipeliner® LH-D100 (E10045-P2 H4R) for the fill and cap passes.

Chris Moody, P.E., project manager for Denbury, said that when they were considering the transition to the Pipeliner® LH-D

electrode, they wanted to make sure that the production rate would be as good or better than a cellulosic weld procedure would produce. It was also important that the process not require special equipment and be one that pipeline welders would accept readily and be proficient in using.

"While the cost for the low-hydrogen vertical-down electrodes was higher than cellulosic electrodes, we've more than made up the cost difference with the increase in productivity," Moody said.

Before the start of the project, Progressive, PCS and Denbury were expecting to be able to complete 50 joints per day with the LH-D electrodes. They were thrilled when the Progressive team hit 70 per day.

Reinforcing these strong numbers were low repair rates, with radiographic inspections detecting very few defects in the low-hydrogen vertical-down fill and cap passes.

Moody and Adams said the welders responded positively to the new electrode and saw no issues with its weldability. Adams noted, "Additionally, our welders saw noticeably easier starting with the Pipeliner® LH-D electrode's tapered tip design, which allows for easy touch-start arc strikes, making it easier to get it up and running."

Moody added, "Our use of Lincoln's Pipeliner® LH-D electrode significantly reduced the overall cost of construction. When you're able to build a pipeline less expensively and faster, without compromising the integrity of the pipeline, you're ahead of the game."

Conclusion

For high-strength pipeline construction projects, a low-hydrogen vertical-down electrode - such as Lincoln Electric's Pipeliner® LH-D80, LH-D90 and LH-D100 — offers an excellent solution to satisfy managers, engineers and welders alike. It provides the high productivity and low repair rates managers need, and engineers prefer it for higher strength, greater toughness and lower diffusible hydrogen levels than traditional cellulosic electrodes. Welders appreciate its smooth arc, low spatter, excellent control and easy slag removal.

For Progressive Pipeline's application — a pipeline for enhanced oil recovery — the Pipeliner® LH-D electrode provided a distinct, competitive advantage. As the industry continues to grow, Progressive, Project Consulting Services and Denbury will continue to use advantages such as this to grow their business and help meet our nation's energy needs. ***P&GJ***

▶ Certain high-strength steel pipe grades present new challenges for welders.