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Corrosion Protection for Pipeline Weld Joints

FACTORY-APPLIED PERFORMANCE IN FIELD-APPLIED SYSTEMS

Pipeline networks are a safe and efficient means of transporting significant quantities of crude oil and natural gas over land or through bodies of water. When it comes to protecting the pipeline asset from corrosion, pipe lengths, which are typically sourced 12 meters long from a steel mill, are pre-coated in a coating plant, strung together, and welded in the field at the construction site. The type of external coating that is employed depends on many factors, but based on global anticorrosion coating demand, three-layer polyolefin coatings are the most commonly used. The three-layer polyolefin systems consist of an epoxy, a bonding adhesive or co-polymer, and either a high density polyethylene or polypropylene sheet as the topcoat. To achieve a consistent protective coating across the entire pipeline length, similar systems are used in the field to coat the welded joints formed once the pipe sections are laid in place. For many years, the standards for these field-applied coatings have been lower than those of the factory-applied systems for the pipe lengths given that early field-applied technologies could not provide the same level of performance. Advances in coating and automated application technologies, however, are making it possible to apply heat-shrinkable systems in the field that provide equal or better protection than that afforded by factory-applied coatings.

Pipe lengths (typically 12 meters) are coated in a pipe mill or coating plant, with each end left uncoated (bare steel cutback approx. 150–200 mm on each end). These ends are then welded in the field. That weld (field joint) is then coated in the field setting. Corrosion protection of pipelines is becoming more challenging, particularly for oil and gas applications, according to Jarrod Shugg, Shawcor's global marketing manager for Canusa-CPS products. “Today, pipelines are being installed in even more remote locations at greater depths and under extremely harsh conditions, and are also expected to perform at higher fluid temperatures. As a result, it is imperative that the protective coatings applied to pipelines be seamless for the whole length, with no disparities between the systems on the pipe lengths and the weld joints,” he observes.

Since three-layer polyethylene (3LPE) and three-layer polypropylene (3LPP) polyolefin coatings are the most widely used systems for external anticorrosion protection of mainline coating lengths globally, polyolefin-based coatings are used on the field joints (i.e., polyethylene- and polypropylene-backed heat-shrink sleeves). In fact, heat-shrink sleeves are the preferred technology for girth-weld field joint protection of oil, gas, water, and pre-insulated pipelines, according to Shugg. "Heat-shrink sleeves are compatible and practical for ease of installation in the field environment—offering fit for use performance or, in some cases, factory-grade quality on the field joint area," he notes.

There are several different types of heat-shrinkable coatings that can be used for the protection of pipeline weld joints. In addition to three-layer technologies, there are two-layer systems, and both come in varying widths, lengths, and thicknesses, and with different types of adhesive technologies. Selection of a specific system, according to Shugg, is based on many variables, including project requirements, allowable surface preparation, pipeline operating temperature, onshore or offshore construction methods, the environmental conditions, mainline coating compatibility soil type/conditions, cycle time requirements, performance expectations, design life of the pipeline, and of course cost.


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On a project in Western Canada, with 388 km of 36-in. NPS pipe, a Shawcor end-to-end pipeline coating system was employed with factory applied coatings, Canusa-CPS^{T} coatings, and IntelliCOAT automation used at the field joint.

Heat-shrinkable sleeves include an adhesive layer and a polyolefin backing layer. The adhesive is generally a type of viscoelastic, mastic (asphalt or butyl based), hybrid, hot melt, and/or copolymer (polyolefin modified with polar groups such as carboxyl and carbonyl substituents for bonding the polar epoxy layer with the nonpolar polyolefin layer). Mastics are tacky, pressure-sensitive, and relatively soft adhesives that flow when heat is applied. They are more tolerant of less-than-desirable installation conditions (such as poor surface preparation) than hot melts, which are harder and nontacky and are typically used for applications involving high operating temperatures.

The backing is generally a sheet of high or low density crosslinked (via radiation) PE or PP that is pre-stretched. When heated, the sheet shrinks to its original length. Radial shrinking forces are generated as the sleeve conforms to the pipe and press the melted adhesive into the surface irregularities of the pipe to enhance bonding. The sleeves are typically 2–3 mm thick, but when additional mechanical protection is required, a higher thickness can be used; recent offshore projects have employed 6-mm-thick sleeves. The choice of backing is dependent on project construction conditions, pipeline in-service conditions, and the type of mainline coating.

In typical three-layer factory-applied coatings, a fusion bonded epoxy provides excellent resistance to corrosion, and a copolymer, which is either a chemically modified PE or PP depending on the top layer, bonds the nonpolar PE or PP outer layer to the polar epoxy. The top polyolefin layer protects the epoxy from external forces and moisture absorption. PE systems are used for applications with operating temperatures up to 80°C, while PP systems can withstand higher temperatures up to 130°C.

Today, due to increased scrutiny on asset integrity and cost for new pipeline projects, as well as a better technical awareness of the available coating options and their associated performance characteristics, pipeline owners are empowered to consider the use of "end-to-end" pipeline coating systems, according to Shugg. "End-to-end refers to the implementation of an entire protective coating system designed with the same material types, matching performance and full compatibility using a combination of both factory-applied and field-applied coating processes from a common manufacturer," he explains. Shawcor follows this approach, with mainline coatings and field-joint coatings mutually developed, tested, and deployed—providing consistent performance across the entire length of the pipeline with no weak links at the field joints.

The Canusa-CPS systems from Shawcor also consist of an epoxy layer that is applied only to the steel cutback portion of the weld and force-cured so that it can be fully inspected prior to application of the outer layers. Use of the same copolymer adhesives and the same grades of polyolefins as those applied to the main pipe lengths ensures the same mechanical strength and resistance to moisture absorption, according to Shugg. "These

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The heating coil is lowered onto a pre-positioned heat shrinkable sleeve, and then the application cycle is initiated directly from the control panel or by a remote control.

field-applied coatings fuse together and are inseparable from the mainline coating at the critical overlap area because the same copolymer technology is employed. The result is consistent coating performance, thickness, and material grades over the entire length of the pipeline," he says.

In addition to the development of these more advanced coating systems that provide factory-grade performance, Shawcor has developed a fully automated system for controlling the application of their class-leading, heat-shrinkable sleeves in the field. The IntelliCOAT™ system consists of a PLC-equipped control panel and a clamshell style infrared heating coil connected by rugged plug-and-play" umbilical cables, according to Shugg. One control panel can operate a range of standardized heating coil sizes to coat pipelines with a wide range of diameters. The heating coil is lowered onto a pre-positioned heat shrinkable sleeve, and then the application cycle is initiated directly from the control panel or by a remote control. The coil is removed when the cycle is complete, which for typical applications is about 2.5 min.

"The programming on the system is done in advance of the project and fully tested and validated to ensure that specific project needs are met. In addition, the operating parameters are tightly controlled so that each coating is applied in the same manner every time, which provides consistent quality and increased productivity while reducing the risk for application error," Shugg asserts. A further benefit is the ability of the contractor to accurately forecast daily productivity, and it is possible to achieve rates of up to 15–20 joints per hour per system for both onshore and offshore projects, according to Shugg. Operators benefit as well because of the enclosed heating design of the IntelliCOAT system, enhancing operator safety. Only standard personal protective equipment is required. There is also no need for open gas torch flames typically associated with conventional FJC application methods, according to Shugg.

The IntelliCOAT system has been used successfully on both onshore and offshore projects. For instance, for a project completed in Western Canada, the pipeline construction contractor exceeded productivity requirements using IntelliCOAT, according to Shugg. For an offshore project spanning the shores of the Black Sea, Shugg notes that the IntelliCOAT system replaced expensive and more complicated injection molding equipment. He adds that IntelliCOAT has been employed on several other onshore and offshore projects to coat more than 35,000 joints to date. ❊