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PROTECTING LNG INFRASTRUCTURE WITH HIGH-PERFORMANCE COATINGS

How to Shore Up Specifications to Combat CUI, Safeguard Storage Tanks and Protect Pipelines

JUSTIN HAIR
Key Account Manager,
Sherwin-Williams Protective & Marine

11-14-25_acc Accessibility Statement

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How to Shore Up Specifications to Combat CUI, Safeguard Storage Tanks and Protect Pipelines

Natural gas takes a complicated journey from inland extraction sites to liquified natural gas (LNG) plants and coastal exporting terminals. Along the way, the infrastructure that moves and stores the material in either a gaseous or liquid state faces numerous corrosive threats that can create maintenance headaches for owners at best or lead to dangerous leaks and catastrophic events at worst.

Such threats exist, from upstream fracking sites to midstream pipelines and storage facilities to downstream processing facilities and distribution terminals. At every stage, owners must determine the best ways to stave off corrosion for as long as possible on pipelines, compressors, process vessels, storage tanks and numerous other infrastructure assets. The longer those assets can perform, the better for the owner's bottom line.

Specifying high-performance coatings is the optimal solution for buying extra time on the corrosion clock. Better-performing coatings lead to longer asset service lives, plus longer-term cost savings due to fewer planned and emergency maintenance shutdowns needed over the life of an asset. However, determining which solutions offer the best results can be difficult. This article will review some considerations for choosing the most appropriate coatings for various assets associated with LNG production and transmission, as well as reinforce the importance of having informed coating specifications for those assets.

SUCCESS HINGES ON SOUND SPECIFICATIONS

Steady LNG market growth has spurred the need for additional infrastructure – including pipelines, compressor stations, storage tanks and peak shaving facilities – to enable continued progress. This activity is keeping global Engineering, Procurement and Construction firms (EPCs) on their toes as they manage various logistics associated with LNG infrastructure. Because many such projects involve an array of international suppliers, a logistical nightmare could materialize if various plug-and-play assets are not compatible when connecting everything together – particularly if the coatings do not meet strict international standards, such as ISO 12944 and NORSOK M-501.

The success of installing those assets and ensuring everything will function as planned hinges on having solid specifications in place. Such protocols hold each supplier to the same standards, enabling a process vessel that's fabricated and coated in North America to connect seamlessly to piping produced in Latin America that connects to a storage tank made from steel produced and coated in Asia. Each coating system used on those assets must be compatible with the ones used on any connected assets. In addition, asset owners will want the colors to be uniform for aesthetic purposes. Clear specifications should ensure both outcomes, particularly when using a coating supplier that offers uniform products that are available at the same quality and performance standards anywhere in the world. Such universal coatings ensure compatibility, color matching and performance on projects spanning multiple regions.

A common practice for EPCs and asset owners alike is to base new coating specifications on previous ones that have worked well in the field over years of asset use. That certainly makes sense. However, there is a good reason to question even a specification with a sound performance history, as legacy specifications likely do not include newer materials now on the market. Those materials may offer better longevity, cost, maintenance and performance, but they could be left out of consideration if no one speaks up.

Knowing this, it is important for EPCs and asset owners to connect with coating suppliers well ahead of finalizing project specifications and before any infrastructure assets are created. Working together to understand the operating logistics and challenges of the project will help all parties consider every potential solution. With the longevity of assets being a primary goal, many newer coating formulations are likely to displace older specified materials.

COMBATING CORROSION UNDER INSULATION

Since older specifications are often used for new projects, it may be helpful to examine a particular category of coatings to demonstrate why considering newer solutions is advisable.

A good example are the coatings used to stave off the troublesome and potentially dangerous condition of corrosion under insulation (CUI) **(Figure 1)**. This bane of many energy-related operations occurs underneath the insulation and cladding that's wrapped around storage tanks, piping and other assets operating at hot or cold temperatures to insulate them. Moisture inevitably becomes trapped within those insulation systems and works its way down to the steel substrates underneath, accelerating corrosion potential.

Figure 1. *Corrosion under insulation (CUI) is a bane of many energy-related applications that can be mitigated or eliminated by optimizing coating selections at the outset of a project.*

Hidden from view, CUI can be very corrosive in nature due to moisture and condensation intrusion, varying pH ranges that occur based on the type of insulation materials used, and the intrusion of chlorides that is likely to occur due to the harsh coastal environments in which many LNG plants are located.

Consider stainless steel piping used to move process gas or fluid through an LNG facility. Covered in insulation, the piping is likely to encounter CUI at some point during its lifespan. In the coastal environments where LNG plants are typically located, that corrosion is likely to come in the form of chloride stress corrosion cracking (CSCC), which can cause cracking, pitting and even leaks.

An EPC using an older specification could miss the fact that better CUI-mitigation coatings have entered the market and would therefore miss out on the improved outcomes a newer technology would deliver. Some enhanced options in that realm include newer spray-applied organic liquid coatings such as high-temperature epoxy phenolics, high-temperature, high-solids alkylated amide epoxies and ultra-high-solids novolac amine epoxies.

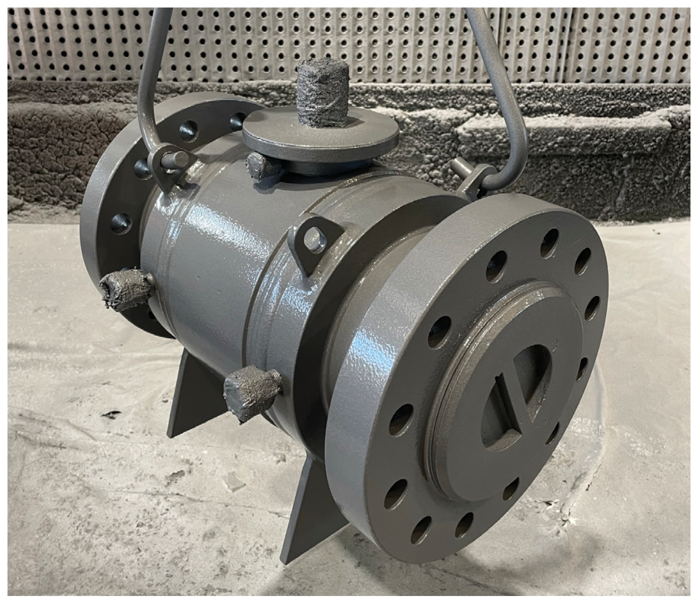

Figure 2. *Certain newer liquid CUI-mitigation coating options have a high concentration of at least 25% micaceous iron oxide (MIO) pigment to enhance durability against impacts, chemicals and corrosion.*

Among the newer liquid CUI-mitigation coating options EPCs may not know are formulations featuring a high concentration – at least 25% – of micaceous iron oxide (MIO) pigment, which reinforces the coating for greater durability against impacts, chemicals and corrosion **(Figure 2)**. In addition, an ultra-high-solids advanced epoxy novolac with a functional chemical enhancement for CUI mitigation is available that performs even better than the MIO-enhanced formulations per heat cycling, CUI, UV erosion, DFT tolerance and ISO testing.

EPCs may also not know they can eliminate CUI altogether by skipping the traditional insulation systems used on storage tanks, piping and process vessels. Newer thermal insulative coatings that provide an advanced energy barrier to curb the transfer of heat rival the thermal retention capabilities of traditional insulation. They enable asset owners to forgo traditional insulation and cladding in favor of a few layers of coatings **(Figure 3)**. Doing so literally eliminates the threat of corrosion forming underneath insulation because the insulation is no longer there.

Figure 3. *Using a thermal insulative coating system with an advanced energy barrier to curb the transfer of heat on process vessels and other assets can help LNG producers forgo the use of traditional cladded insulation systems while eliminating CUI altogether.*

SAFEGUARDING MASSIVE STORAGE TANKS

Protecting the massive storage tanks that hold processed LNG for distribution is also critical. However, coatings play less of a role on certain tanks. For example, the double-walled carbon steel tanks that are insulated with concrete and referred to as full containment tanks typically remain uncoated **(Figure 4)**, even when located in coastal regions. They may be coated for purely aesthetic reasons, using an acrylic-based coating due to its compatibility with concrete and its long-term gloss retention.

Figure 4. *Most full containment tanks made from double-walled carbon steel and insulated with concrete remain uncoated unless the owner prefers a coating for aesthetic purposes.*

The story is different for storage tanks used for peak shaving facilities. Such tanks may be located in coastal regions where they require a robust protective coating system to combat the corrosive forces of the C5M environment. They may also be located inland where they face a less harsh C2 or C3 environment. In either case, EPCs would typically specify a zinc/epoxy/polyurethane or a zinc/epoxy/polysiloxane protective coating system for increased performance.

For tanks that will be coated, builders will typically prime steel plate in a shop before shipping it to the installation site for assembly. Primers should be specified with durability in mind, as plate loading and shipping damage, extended on-site storage and on-site construction damage can all be issues. Using such primers can help dramatically with on-site construction schedules because if the shop primer fails during the construction process, complete removal is often required. That's a major problem that adds manhours – and costs – to the schedule.

At the fabrication shop, tank builders typically specify inorganic zinc coatings for shell plates due to their high zinc load and excellent corrosion protection. Their extended recoat windows also help. Once the tank has been constructed, coating applicators will address any damaged areas and field welds first, coating them with an organic zinc or an epoxy primer/intermediate product before applying a finish coat.

That topcoat should offer high performance and may take the shape of a polyurethane material. Alternatively, a polysiloxane that meets the ISO 12944-6 Rev 4 standard for very harsh C5M environments may be used as a finish coat on these large-scale assets. Polysiloxanes combine the properties of a high-performance epoxy and polyurethane to deliver effective long-term corrosion protection and weatherability. Robust zinc/epoxy/polyurethane systems have proven to have excellent long-term performance in multiple service environments, but an upgraded zinc/epoxy/polysiloxane coating system can potentially add an additional five years of coatings performance.

PROTECTING PIPELINES

Between inland gas extraction sites, peak shaving facilities and coastal import/export terminals, raw and processed natural gas requires a lengthy system of pipelines to transport supplies often hundreds of miles. These underground pipes require significant protection from corrosion to avoid deterioration that could lead to reduced pipe wall thicknesses and the potential for catastrophic leaks. That includes the corrosion protection applied to pipes in a shop environment, as well as the coatings used in the field to cover the girth welds that are made as installers fasten pipes together.

Today's natural gas pipelines face more challenging soil environments with even harsher, rockier and wetter terrain than before. As such, the pipes can benefit from using better-performing coating materials than the conventional fusion-bonded epoxies (FBEs) that have typically been used. The more robust coatings offer improved damage prevention and moisture tolerance.

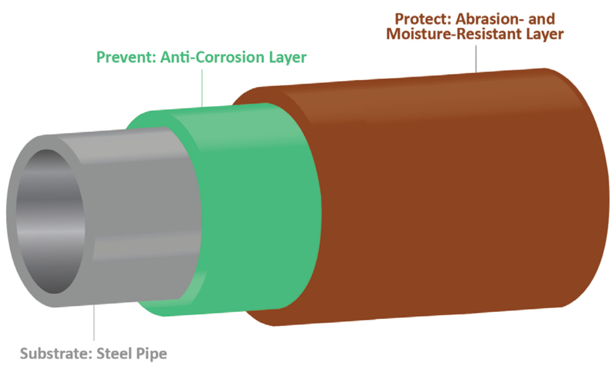

Figure 5. *A moisture-resistant overcoat (MRO) applied over top of a conventional fusion-bonded epoxy (FBE) discourages water from penetrating through the coating to reach the anti-corrosion layer.*

As an example, a moisture-resistant overcoat (MRO) applied over top of a conventional FBE exhibits exceptional damage prevention and moisture tolerance for challenging installations **(Figure 5)**. The dual-layer coating system offers a combination of corrosion prevention from the first layer and protection of that coating by the second layer. The topcoat creates a moisture barrier that discourages water from penetrating through the coating to reach the anti-corrosion layer. This damage-resistant layer also resists abrasion, helping the coating avoid many of the scrapes a pipe may encounter from handling to installation, including the rigors of horizontal directional drilling (HDD) and backfilling **(Figure 6)**.

Figure 6. *A moisture-resistant overcoat (MRO) applied to pipes also resists abrasion to maintain its integrity even during horizontal directional drilling (HDD) and backfilling.*

This newer MRO coating is a perfect example of why EPCs and owners need to continue working with their coatings suppliers to stay abreast of new technologies and update specifications accordingly.

For coating the girth welds that occur at every joint where new pipeline sections are connected together, installers have the option of using a powdered FBE that matches the native coating already applied to the pipe or a liquid epoxy that's made from the same chemistry **(Figure 7)**. Powder form materials can be optimized according to the service condition required, including using a dual-layer system with an anti-corrosion layer and a moisture- and abrasion-resistant layer. There are also powdered FBEs with low application temperature characteristics that make them ideal for cold-weather installations. On the liquid side, two-component, ultra-high-solids, amine-cured epoxies are available that provide outstanding resistance to impact damage, abrasion, chemical immersion and cathodic disbondment.

Figure 7. *Field-applied, powdered fusion-bonded epoxy (FBE) coatings provide excellent integrity with shop-applied mainline FBE coatings for outstanding resistance to impact damage, abrasion, chemical immersion and cathodic disbondment.*

CONSISTENCY IS KEY FROM SPECIFICATION TO APPLICATION

With corrosion a constant threat along the entire pathway from extraction sites to terminals, ensuring safety and longevity in LNG operations means choosing the optimal coating solutions to enable better outcomes. Doing so will help LNG asset owners and operators realize the longest lifespan possible for their investments.

Success begins by shoring up specifications. Owners, EPCs and coating suppliers should all convene early in the project planning process to review all the operating variables associated with each asset to be coated. They can look to legacy specifications for guidance, but they should also consider newer solutions that could offer better long-term performance. New specifications should include universal coatings that ensure quality, color and performance consistency, so modular parts built in different areas of the world can be assembled successfully on-site with no obvious signs the components were produced elsewhere. Consistency enables uniformity – which are both key characteristics owners are looking for when operating around the globe.

Following the guidelines above will help LNG asset owners and specifiers select the optimal high-performance protective coatings for their operations as they work diligently to combat CUI, protect massive storage tanks and safeguard pipelines and other infrastructure assets.

ABOUT THE AUTHOR

Justin Hair is a Key Account Manager for Sherwin-Williams Protective & Marine based in Tulsa, Oklahoma. With approximately 30 years of service dedicated to the oil and gas coatings industry, both as an industrial painting contractor and a Sherwin-Williams oil and gas team member, he has specialized in multiple subject matters related to aboveground petroleum storage tank industry challenges. Contact: Justin.M.Hair@sherwin.com