A GAME-CHANGING SOLUTION

Mario Moreno P.Eng.,
Seal for Life Industries, Canada,
discusses revolutionising pipeline field joint coating with high flexibility epoxy coatings.

Figure 1. After application with Canusa HBE FLX the pipeline is installed.

Corrosion prevention for underground structures is essential to ensure their long-term integrity and reliability. A combination of a durable coating and cathodic protection (CP) is necessary for effective corrosion prevention. When focusing on field joint coatings, there are many advantages and disadvantages of the different coating technologies available. We take a look at what those are and introduce a new epoxy formulation that promises extraordinary corrosion protection properties and flexibility.

Background

For optimal corrosion prevention in underground structures, a robust coating combined with CP is the recommended approach. The protection cost comprises both the coating and the CP system.

Since its introduction in 1960, single-layer FBE has demonstrated remarkable effectiveness as a pipeline coating. It currently enjoys widespread use as the preferred pipeline coating in North America and has a strong following worldwide. Its exceptional performance characteristics, as well as its track record of success in underground and undersea applications, make it an ideal choice for line pipe, fittings, and bends.

However, for field joint coatings there are several reasons why liquid epoxies are often preferred over FBE to treat the joints between pipes.

Ease of application

Liquid epoxy is easier to apply than powder FBE epoxy, especially in field conditions. The liquid form allows for easier mixing and application, making it more convenient and efficient for use onsite.

Faster cure time

Liquid epoxy has a faster cure time than powder FBE epoxy. This means that the coating can be applied

and cured more quickly, reducing the overall downtime for the pipeline.

Better adhesion

Liquid epoxy has better adhesion properties than powder FBE epoxy, particularly in wet or humid conditions. This makes it more effective in protecting the pipeline against corrosion and other forms of damage.

More sustainable

Liquid epoxy installation requires no force curing or external energy compared to FBE. Plus the material has minimum waste during application.

In order to ensure the long-term integrity and reliability of a pipeline, it is important for the field joint coating to possess mechanical properties similar to those of the main line coating. This approach helps to promote corrosion protection, compatibility, uniformity, and reduces the risk of delamination, stress concentrations, and potential cracking or damage due to thermal expansion.

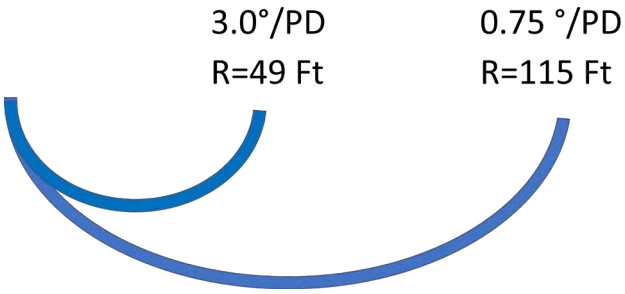

Figure 2. Bending radius example 18 in. OD pipe.

Table 1. OEM FBE vs field applied liquid epoxy qualification requirements

Thickness	CSA 245.20 System 1A	CSA 245.30 System FC1
24 hr cathodic disbondment at 65°C	< 6.5 mm	< 6.5 mm
28 d cathodic disbondment at 20°C	< 8.5 mm	< 8.5 mm
28 d cathodic disbondment at max rated service temp	< 20 mm (95°C)	< 10 mm (95°C)
Flexibility (-30°C)	2.0°/PD	0.75°/PD
Flexibility (23°C)	3.0°/PD	N/A
1.5 J impact resistance	No holiday -30°C	No holiday -30°C
Adhesion to steel substrate	N/A	Rate 1
Adhesion to existing coating	N/A	Rate 2
Adhesion to steel after hot water immersion (95°C, 28 d)	Rate 1 - 3	Rate 1
Adhesion to existing coating after hot water immersion (75°C, 28 d)	Rate 1 - 3	Rate 2

Generally, liquid epoxy coatings used for field joint coating applications must undergo a series of qualification tests before they can be considered for pipeline use. These tests are specified in the standard CSA Z 245.20 (plant applied coatings) and CSA Z 245.30 (field applied coatings). The main difference between the two standards lies in the flexibility value, which is the performance limit between the two. A liquid epoxy that meets the required flexibility level will also satisfy the other parameters.

In the realm of pipeline engineering, flexibility plays a crucial role in the performance of joint coatings, especially for pipelines that undergo thermal expansion, ground movement, and other environmental stresses. The ability of a coating to flex and move with the pipeline, without experiencing cracking or fracturing, is of paramount importance. Ideally, both the mainline and field joint coatings should exhibit similar behaviour and movement patterns.

For instance, let's consider the flexibility requirements outlined by CSA Z245.20 (plant applied coatings) and CSA Z245.30 (field applied coatings). While the former specifies a flexibility limit of 3°/PD, the latter mandates a more stringent limit of 0.75°/PD for an 18 in. OD pipe (Figure 2).

In the context of field joint coatings, flexibility requirements differ from those of mainline coatings during installation. This trade-off exists to enable better performing epoxy coating systems, as adhesion and cathodic disbondment properties also significantly impact the coating's long-term performance. The engineering decision is justified, provided no alternatives that offer comparable performance alongside flexibility are available.

To achieve enhanced flexibility, alternative modifiers have been introduced in the market. One such alternative resin is a polyurethane-epoxy hybrid, which improves the epoxy matrix's flexibility through the addition of polyurethane functionality. However, this solution's drawback is that the material's temperature performance is affected, leading to a compromise in performance characteristics such as cathodic disbondment test results and temperature resistance.

Canusa, a division of Seal for Life Industries, conducted a benchmarking exercise to compare the performance of epoxy field joint coatings, which highlighted a significant performance gap between the epoxy-polyurethane hybrid technology and traditional epoxy field joint coatings.

In the search to meet the requirements for effective corrosion control and mechanical properties, the development of the next generation of field joint coatings is crucial. CANUSA CPS Division of Seal for Life Industries has created a new epoxy formulation that delivers exceptional flexibility and corrosion protection. Known as HBE FLX, this coating system is based on epoxy polymer modified with core-shell rubber nanoparticles. These nanoparticles improve the tensile properties, fracture toughness, and glass transition temperature of the epoxy resin. Core-shell FJC epoxy formulation is patent-pending technology.

Core-shell rubber nanoparticles are a type of nanocomposite material that consists of an elastic rubber core surrounded by a shell made of another material, such as polymers, metals,

ceramics, or other types of nanoparticles. This technology offers a promising approach to enhance the mechanical properties of coatings while maintaining their corrosion resistance.

The performance characteristics of the novel product HBE FLX in addition to being highly flexible are:

- Excellent adhesion to well-cleaned steel.
- Good chemical resistance.
- Low oxygen permeability.

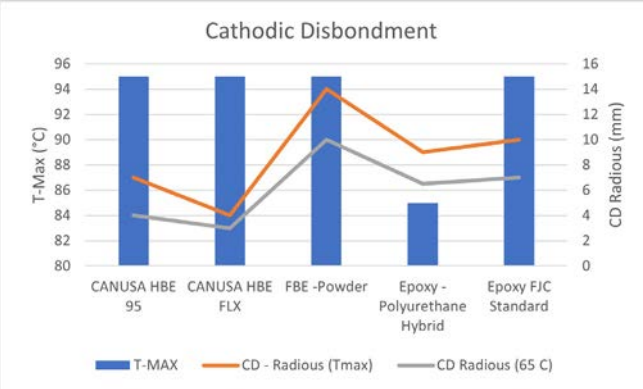

Figure 3. Cathodic disbondment comparative and T Max.

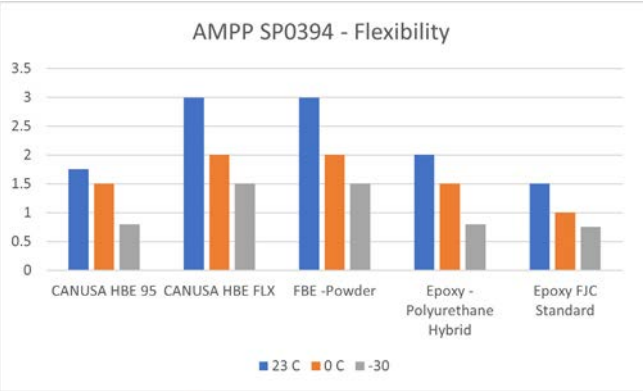

Figure 4. Flexibility at different temperatures comparative.

Figure 5. Canusa HBE FLX being applied.

- Non-shielding – works with CP.
- No reported cases of stress-corrosion cracking (SCC) of pipe coated with FBE (6).
- The coating remains bonded to the extent that it separates the pipeline steel from an SCC chemical environment.
- It allows the passage of current in case of bond failure.
- Resistance to biological attack.
- Tough.
- Excellent penetration resistance.
- Good impact resistance.
- Good abrasion resistance.

When it comes to the performance of a coating, several factors come into play, such as the mixing process, environmental conditions, and surface preparation. Among these factors, the ease of application is crucial for the coating to be effective. The new coating technology offers exceptional ease of application, with excellent spreadability and sag resistance. The product can be applied to high dry film thickness without any need for correction or reapplication, ensuring a consistent dry film thickness for optimal coating performance.

Coatings in action: Trans Mountain Pipeline

The Trans Mountain pipeline project, which involved expanding an existing pipeline running from Edmonton, Alberta to Burnaby, British Columbia, in Canada, was completed during the COVID-19 pandemic, during severe pressure on the supply of construction materials. The project increased the pipeline's capacity from 300 000 to 900 000 bpd of oil per, allowing for increased transportation of crude oil from central Canada to the west coast.

The project incorporated the HBE FLX technology, which was approved for use and installed in several sections of the pipeline with great reviews from the application crews. Despite challenging weather conditions, this new technology proved to be highly effective.

The successful completion of the Trans Mountain pipeline project is a significant milestone for the adoption of the HBE FLX technology in Canada, and is expected to pave the way for its use in other major projects. The technology's ability to overcome difficult environmental conditions and increase pipeline efficiency makes it a disruptive force in the industry.

Conclusion

The development of the HBE FLX epoxy formulation by CANUSA CPS Division of Seal for Life Industries is a significant step forward in pipeline corrosion protection. Its core-shell rubber nanoparticle technology provides exceptional flexibility and mechanical properties while maintaining other important characteristics such as adhesion, chemical resistance, and non-shielding with CP. The HBE FLX's ease of application and consistent dry film thickness make it a highly attractive option for pipeline coating. By mimicking the behaviour of FBE and offering outstanding consistency, HBE FLX promises to ensure the long-term integrity and reliability of underground structures, particularly on FBE-coated pipes that are expected to experience thermal cycling, vibration, or mechanical stress. Overall, this promising solution has the potential to transform average pipeline performance into excellence.