MEET THE CONDITIONS

Anti-corrosion coating failures are a significant factor in the reduced operational life of pipelines, says Dinko Cudic, Business Line Director, Seal For Life Industries, the Netherlands.

In the endless fight against corrosion, where we seek to extend the life of assets that initially had a fixed lifetime but now need extension, corrosion protection must go further and include prevention. Constant doubts over coatings performance and the blame game over who is at fault – manufacturer, contractor or timeframe to

Figure 1. Pipework remains protected in case of mechanical damage or environmental conditions.

complete the job – can sacrifice quality too. Can coating manufacturers create something that will satisfy both the contractors and end users at the same time? Of course they can, but will these new innovative technologies meet the stringent standards and approvals? That is the flip side of the coin.

It's easy to stop corrosion or decay of the material, eliminate the oxygen and water/electrolyte, and we break the corrosion cell that leads to electrochemical corrosion. This is done by placing a barrier over the surface to be protected and blocking it from the environment. This is often done in the food processing industry by vacuuming groceries to be kept fresh for extended periods of time. Such ways do not offer adhesion to the surface but still have the functionality, such as a method used in the water industry known as polyethylene encasement for ductile iron, or 'sleeving'.

In the past, conservation was done by keeping moisture away from wood and steel using fat, wax, tree sap or honey. So, whether using advanced impermeable barriers like PE or PP, or more rustic solutions like honey, they all create encapsulation of the material and therefore prevention of decay. In the following cases, the analogy of honey certainly works as it does not age or crack, and offers superior adhesion to the surface.

Figure 2. Simple and easy to install solution providing long-term corrosion protection.

Obviously, the point is not to protect the corroding steel with honey, but instead use polymers that behave in a similar way by avoiding sagging. To give it a proper ISO 21809-3 standardised term; a non-curing, non-crystalline and fully amorphous low viscosity polyolefin coating. A coating offers immediate and constant full wetting of the surface, creating a barrier that blocks oxygen and water, thus avoiding corrosion. The non-crystalline part is based on a glass transition temperature of lower than -60˚C (-76˚F). The compound structure is not able to crosslink, leading to non-ageing and therefore a barrier that can meet or exceed the life of the protected material.

This kind of approach opens new possibilities in protecting not only new projects but also existing and aged assets – specifically buried pipelines and components found in remote areas, and distant locations where accessibility is a challenge. Accessibility is also being challenged by the changing environmental conditions in harsh winters, rain seasons or extreme heat in desserts.

Conventional or existing coatings are generally found to be broken down due to ageing, sagging, and flaking, and in some cases even contain lead, chromates or asbestos. None of these toxic materials tend to cause an issue whilst in service, but removal and subsequent storage is another issue that impacts those tasked with transporting it, as well as the environment.

Technology

An integrated approach based on a non-crystalline, fully amorphous and non-crosslinkable anti-corrosion system was the starting point of the idea to use this visco-elastic material as the anti-ageing corrosion prevention system. The invention was based on the fact that the polymer already contains a sufficient set of intrinsic properties as a barrier; pure Polyisobutene (PIB), has proven to be the material of choice, containing between 180 - 650 isobutene units in a polymer chain, having only covalent bonds and containing only hydrogen and carbon. This polymer chain cannot be cross-linked and will remain as a single polymer chain for a lifetime, and leads to an interesting effect called 'cold flow'. Even at a very low temperature, the pure polyisobutylene will, over time, creep into structures of substrates like steel, alloys, polypropylene, polyethylene or epoxy coated substrates, by removing loose rust or flaking coating.

Molecular adhesion instead of mechanical interlocking

The material will permanently remain uncured and tacky, remain resistant to weathering and chemical attack, and stay impermeable to moisture, water vapour, air and bacteria. These properties maintain at operating temperatures of -45 to 95˚C (-49 to 203˚F).

The non-polar, non-crosslinkable liquid-like polymer having a glass transition temperature lower than -67˚C (-89˚F) exhibits very low surface tension, resulting in visco-elastic behaviour. It is impervious to moisture and gases which give it the advantage that corrosion cannot occur

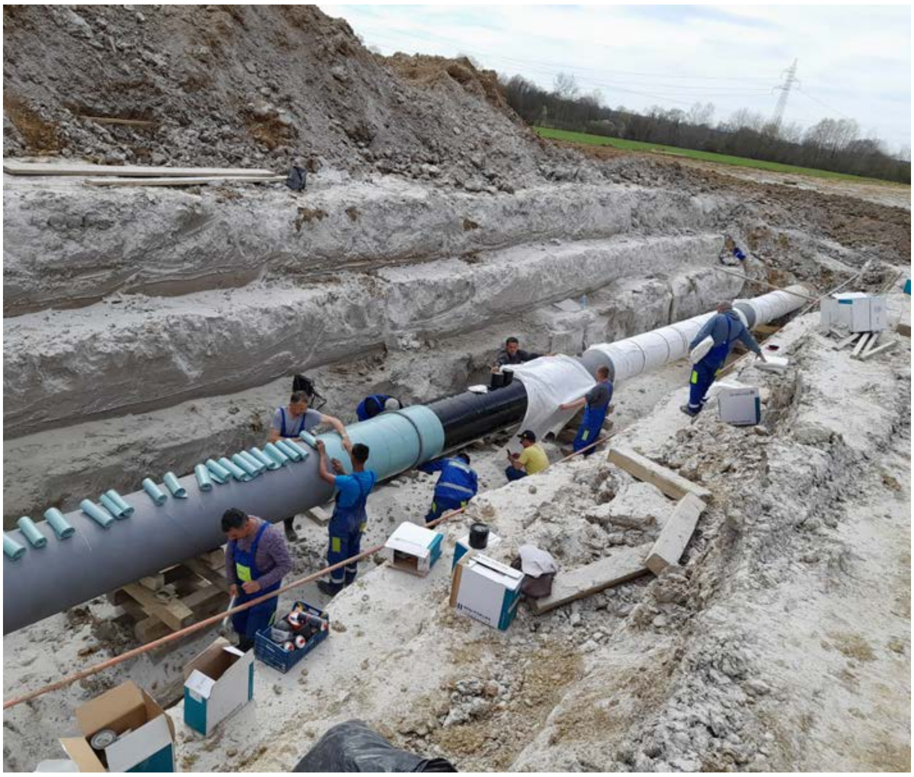

Figure 3. **STOPAQ complete protection system for underground installations.**

beneath the surface, theoretically, even without adhesion. Due to its high electrical resistivity, it is ideal for use in conjunction with cathodic protection when used in underground applications, since it will lower the current required for protection but also isolate from stray current issues.

Adhesion tests of the anticorrosion compound on ST2 prepared steel, polyethylene, polypropylene, coal tar enamel or other coatings show cohesive fractures. Furthermore, as the internal coating remains liquid even far below 0˚C (32˚F), any breach in the mechanical top layer causes the inner layer to flow out and 'self-heal' the top layer, therefore eliminating concerns with maintenance or premature failure.

The coating forms a monolithic coating over time as it flows into itself, thereby preventing 'tenting', which has been an industry issue when using traditional wrap and sleeve coatings, not just at overlaps but also seam welds. A homogeneous layer without air enclosures is formed, creating skin-like behaviour working with the expansion, contraction, and torsion of the protected asset.

Wetting

Wetting is a key factor when trying to achieve adhesion between product and surface. It has been proven many times that the best adhesion is achieved by brush application as the bristles would push the liquid coating into the pores of the surface. The liquid coating therefore creeps better into the pores of the surface during its viscous phase: slower drying gives more flow, anchoring itself to the rough surface to maintain mechanical adhesion once cured.

Modern trends, when it comes to coating applications, are airless spray and use of fast-curing liquid coatings. This raises concern that by increasing productivity, we have sacrificed wetting. It can theoretically be true that the pressure from the spray gun should force the coating into the pores, which surely depends on the pressure at which coating is applied, as well as distance from the structure. The wetting phase, however, is cut short due to speed of curing, creating shrinkage and thinning of the coating by evaporation of volatile organic compounds (VOCs).

Having a coating that is constantly wet would lead to constant adhesion but also to impregnation of loose micro particles on the surface that have the tendency to interfere with adhesion among the coating that cures quickly and turns solid.

Out in the field

Apart from rehabilitation, where it is very difficult to achieve the same coating lifetime as when it was newly installed, it is important to always consider the following formula in both new build and rehabilitation: *Materials cost + application cost + maintenance cost + hidden cost.*

Taking this formula into consideration, a low-cost coating would not necessarily provide long-term savings. We can also consider that high value coatings may have high application cost due to application equipment complexities, creating a thin line between win and lose.

Hidden costs can play a big role when it comes to health, safety and environment (HSE) as many items may not be foreseen. By looking at the whole picture rather than itemising it, the cost can vary drastically.

Challenges

There is a standardised approach to rehabilitation work and things to consider:

- Timeframe and weather or season consideration.
- Right of way and accessibility to remote locations.
- Logistics of delivering equipment and personnel to the location.
- Installation of safety barriers or habitats with climate control.
- Degreasing and removal of chloride contamination.
- Removal of existing coating by abrasive blasting, water jetting, power tooling or hand brushing.
- Application of the coating system – at least two layers.

- Clean up, filtering of removed coating from abrasive, waste segregation.
- Removal of scaffolding.

Preference for a production plant would of course be that a job can be done without hassle and without a shutdown, no blocked areas, and no fear of abrasive media getting near sensitive equipment like pumps and other moving parts.

The preferred scope would be towards the following:

- Limit amount of scaffolding and barriers.
- Limit personnel due to HSE and evacuation plans.
- Limit or prevent the need for abrasive blasting.
- Application not limited to surface or ambient temperatures.
- Reduce waste and impact on the environment.

Solution

The solution; remove loose and scaling rust and non-adherent existing coating. The following process has been achieved:

- Surface preparation to St2 or St3.
- Water jetting to remove loose material.
- Application of Wrappingband and Outerwrap.
- Clean up, segregation of recyclable waste, paper and PE.

Considering the formula mentioned earlier, and seeing the complete cost during the rehabilitation phase, the solution demonstrated here showed initial savings on the project of over 40% for a complete solution, which will extend well beyond the lifetime of the original encapsulated coating.

Total cost of ownership

When the adhesive strength of a material is in the same range or higher than the cohesive strength, whenever you try to remove the coating in a wrap form, a certain portion of the coating material will always fully remain as a film on the surface of the metal pipe substrate, further protecting the pipe in case of mechanical damage or external forces like soil stress.

The cost of this system is currently extremely attractive to end users when compared to traditional coating systems. Due to the trend of outsourcing technical control and inspection by major companies and field repair costs, demand for failure-proof systems is high and competition from traditional products is being eroded by a growing acceptance of the PIB-based technology by end users. It is common knowledge that no traditional anticorrosion system completely meets the needs of the end user.

Traditional products are specified because they are deemed to be the 'best that are available', or sometimes just what has 'always been done that way'. What's more, the use of many traditional coating products is being maintained due to a failure of the end users to properly research and investigate the newer technologies available, and therefore adjust the approvals accordingly. The facts are that the PIB based coating technologies can provide end users with anti-corrosion coatings as rehab systems with:

- Much stronger physical properties, providing the end user with longer return on investment.
- Less maintenance and reduced costs over time.
- Reduced instance of damage during service due to self-healing properties.
- Highest levels of corrosion resistance.
- Higher levels of chemical resistance.
- Higher process temperature ranges.
- Faster and easier application and installation without need for special equipment and operator skills.
- Encapsulation of existing adherent coatings.
- Compatibility with cathodic protection.
- Minimised coating breakdown factor.
- Lower surface preparation and application costs.

Conclusion

Anti-corrosion coating failures are a significant factor in the reduced operational life of pipelines. The failure of a pipeline's coating system accelerates corrosion and can result in leaks requiring repair, clean up and, in some cases, replacement of the pipeline and its components. The costs of repair and replacement are significant, as are costs associated with spill containment and clean ups. The cost involving environmental impact and negative publicity associated with failures are something every major oil and gas company seeks to avoid. The overwhelming evidence of this data clearly shows that traditional coating systems commonly utilised are not performing over the design life of the asset exhibiting consistent high failure rates, resulting in either major repair works or replacement of expensive distribution systems.

Apart from finding an initial solution to the ease of application, in correlation with the production process of a plant, without shutdown and with a system that does not age, you eventually increase the value of the asset. The asset is kept from ageing and degradation due to corrosion, thus making it safe from a HSE aspect, which in our modern world must be the highest priority.