The challenges and protection of internal storage tanks for oil & gas and chemical industries

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Authors:
Fabiana Requeijo, Subject Matter Expert Tank Linings
Michael McGlamry, Group Product Manager

Hempel A/S
Lundtoftegårdsvej 91
2800 Kgs. Lyngby
Denmark

Phone: +45 4593 3800
Fax: +45 4588 5518
E-mail: R&DSupport-Marine@hempel.com

Used to store essential fluids and chemicals, storage and process tanks are indispensable in the oil & gas and chemical industries. Each tank is normally dedicated to the storage of the same type of chemical for its entire service life. However, there are cases when the product being stored will change during the tank's lifetime.

Internal protection of storage and process tanks is challenging, and several factors have to be considered when selecting the right lining system to protect the interior substrate from corrosion. These include, but are not limited to, the condition of the substrate, the chemical to be stored, tank operating conditions, required system durability and applicable approvals and/or certificates.
Whether protecting a new tank or maintaining an existing one, the condition of the substrate is extremely significant to choosing the correct lining system. This white paper looks at how to overcome the main challenges related to the condition of the substrate when lining a newly constructed tank or repairing a tank already in-service.

Not only protecting steel: why you need a tank lining

The most obvious reason for lining storage and process tanks is to protect the internal surface against corrosion. Many commonly stored materials – such as crude oil containing seawater, such as acids and alkalis and crude oil containing seawater, – can quickly corrode unprotected steel. However, this is not the only reason. In many cases, the lining helps maintain the purity of the stored material, by preventing it from being contaminated by corrosion products from corroded steel. This is the case when storing aviation fuels, potable water or products used in chemical manufacturing processes that must be very pure, such as monoethylene glycol or phosphoric acid. The tank lining is also extremely important for secondary containment, as it helps prevent leaks and spillages from storage or process vessels entering the soil and groundwater.

Understanding the challenges: maintenance and repair of internal storage tanks

Lining a new process or storage tank is generally easier than lining a tank that has been in service for some time, as the latter may need repair due to damage from corrosion. After time in service, tanks that contain crude oil, hydrocarbons or chemicals experience some degree of corrosion, especially the bottom and lowest two metres of the vertical walls.
The more aggressive the chemical is (sour crude oil, fuels contaminated with water, such as acids and alkalis and crude oil containing seawater), the faster the corrosion takes place. Selecting the right lining system for the operating conditions will extend the lifetime of the tank, but it will not eliminate the need for maintenance at some point in time.

Causes of Corrosion

Several types of corrosion can occur in an operating tank. Usually two or more types develop simultaneously.

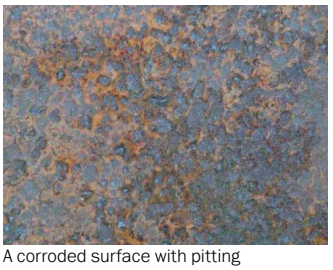
- Corrosion due to the inherent corrosive nature of the stored product:
  - In sour crude oils, heavy fuels and similar oils contaminated with water, the corrosive components concentrate at the bottom, leading to corrosion in the lower part of the tank (in these cases, the bottom of the tank and first 1-2 metres of the vertical walls must be repaired)
  - Corrosive chemicals such as acids, alkalis, amines, seawater, etc., can cause corrosion throughout the tank (in these cases, the entire internal surface of the tank must be coated)
- Galvanic cell corrosion due to leftover mill scale from the surface preparation step prior to application of the lining
- Microbially induced corrosion (MIC), usually caused by sulphate reducing bacteria (SRB) in water and hydrocarbons containing water

In the case of newly constructed tanks, adequate preparation of the surface prior to applying the protective lining should be relatively simple, as the steel is new, with no defects in the substrate. In operating tanks, this step is more complex – not least because the tank is already assembled and in service. In addition, corrosion of the substrate makes surface preparation challenging: the more severe the corrosion, the more challenging the surface preparation becomes.

Understanding the challenges: maintenance and repair of internal storage tanks

Pitting

Extensive corrosion can cause pitting on the internal surface of the tank bottom and walls. This is a localised type of metal deterioration in the form of small pits or holes on the surface of the steel. Eventually, these pits can go through the steel plate, causing a breach that can end up in product leaking into the environment. Provided the steel structure is still sound, pitting can be repaired by filling the holes with paint.



A corroded surface with pitting

Pitting after cleaning and abrasive blasting – the surface alternates between pits and smooth regular areas

Solvent-free epoxies are suitable linings for pitting repair. Traditional solvent borne epoxy systems are not suitable for this work for the following reasons:

- When solvent evaporates, the film shrinks and therefore the full internal surface of the pit may not be covered by the remaining dry film
- When trying to fill the pits, the applicator may apply a wet film thickness over the surrounding areas, including corners, that is too high. This will lead to solvent retention and the build-up of residual stress within the film, resulting in cracks and loss of adhesion
- Coverage of the pit edges may be poor

Pit filling can be carried out in tank bottoms that are light, moderately or severely pitted, as long as the steel is structurally sound. If the steel plate has become too thin, this steel must be replaced. No alternative reinforcement can be used as a substitute.

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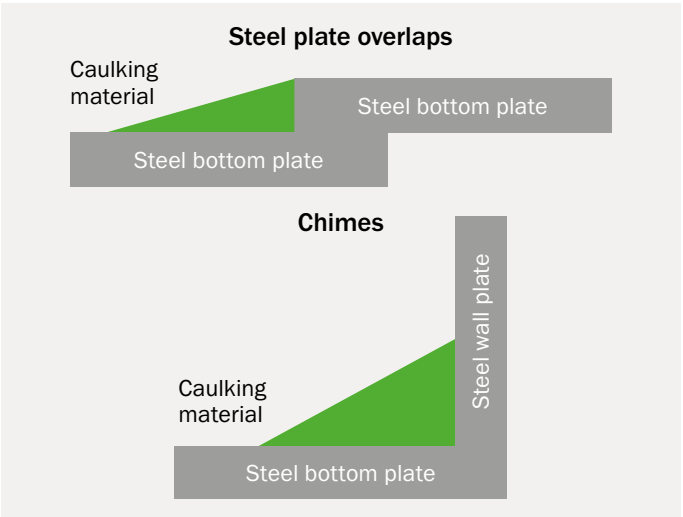
Fast Turnaround Times
Operating tanks must be returned to service as soon as possible in order to reduce costs associated with downtime, so a fast return-to-service lining solution is required. As repairs may need to be carried out at different times of the year, the lining solution must have a wide application window, independent of climatic conditions. This is not so critical for newly constructed tanks, as the timing of lining application is usually built into the project plan.

Areas of Special Attention
Edges, bolts, fasteners, welds and seams can all be challenging when applying a tank lining, regardless of whether the tank is newly constructed or already in service. These irregular and/or difficult-to-reach areas make it hard to achieve the specified dry film thickness (DFT) with spray application. Therefore, stripe coating by brush is done to ensure the areas are properly wetted and filled with paint. This step is not a replacement for spray application; it is simply a way to achieve the specified DFT in these complex sections. It is essential that the DFT of the stripe coat is carefully controlled in order to ensure that the total DFT of the full lining system is kept within the specified range when it is spray applied.

Chime and Overlap Areas
Plate overlaps and chimes can also be a challenge. In both new building and maintenance, steps must be taken to ensure that the surface of these areas is as regular and smooth as possible before applying the full system, especially in the case of glass fibre reinforced systems. The chemical and temperature resistance of the caulking materials used must at least be similar to the specified lining system in order to ensure robustness in performance.

Chalking methods when lining Tanks



Internal Tank Lining Solutions
The condition of the substrate has a big influence on selecting the type of lining system. The American Petroleum Institute (API) Standard Recommended Practices (RP) 652 and 653 are a useful guide when selecting the right lining system to match the condition of the steel substrate.

Based on the API RP 652/653 the following recommendations for selecting systems DFTs for pitted surfaces can be given:

- Lightly pitted steel: low DFT systems (200-500 microns total)
- Moderately pitted steel: high DFT systems (500-1000 microns total)
- Severely pitted steel (assuming the steel is still structurally sound): glass fibre reinforced lining systems with a very high DFT (above 1000 microns total)

This first application on the pitted area does not contribute to the specified DFT: it is merely to ensure the pits are properly filled and sharp edges covered. This will provide a smooth, even surface for the spray application of the full lining system. The full lining system will usually be based on the same solvent-free epoxy used for pit filling in order to ensure a high robustness of performance throughout the whole the tank.

In some cases, reinforced systems are needed to repair severely pitted tank bottoms. There are two main alternatives when building reinforced systems, both based on solvent-free epoxies.

- **Fibreglass mats:** This is the most common and widespread method in the industry today. It consists of laying out fibreglass mats by hand over a coat of solvent-free epoxy. The mat is rolled onto the paint to ensure proper wetting and to ensure the release of trapped air. A second coat of the same solvent-free epoxy is then spray applied on top of the mat. The system is completed with a final topcoat, usually of the same paint.

- **Chopped fibres:** In this case, a special chopper gun is used to cast small glass fibre filaments onto the surface as the lining is spray applied, ensuring both the lining and filaments reach the substrate at the same time. A special roller is then used to compact the fibres inside the wet paint film. Before applying the next lining layer, any protruding glass fibres are sanded to ensure minimum perforation. This method is less expensive and labour intensive than hand laying mats.

Although glass fibre reinforced lining systems are mainly used in maintenance and repair, they can also be considered for newly constructed tanks in order to extend the expected durability of the tanks. According to API RP 652/653, glass fibre reinforced linings are expected to add five years to the expected lifetime of newly constructed tanks compared to non-glass fibre reinforced systems.

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Summary
Internal protection of storage and process tanks in the oil & gas and chemical industries can be challenging, and several factors must be considered. The key difference is whether the lining is being applied to a new building tank or for maintenance and repair of a tank already in operation, as both situations have unique challenges. In maintenance and repair, the condition of the substrate will determine the type of lining system to use. In the case of pitting – a fairly common occurrence in tanks used to store aggressive chemicals and other corrosion materials – pit filling and glass fibre reinforced lining systems are common. Whichever method is used, specific procedures must be followed in order to obtain the desired results.

Hempaline Defend epoxies at a glance

Hempel's Internal Tank Lining Solutions				
	Thin Film	Thick Film		Thick Film Reinforced
Product	Hempadur 85671	Hempaline Defend 400	Hempaline Defend 630	Hempaline Defend 640
General description	Solvet borne epoxy novolac	Solvent free epoxy	Solvent free epoxy novolac	Solvent free glass flake epoxy novolac
General resistance	• Crude oil < 130°C • Refined petrochemicals, fuels, diesel < 93°C • Mild and aggressive chemicals (incl. methanol) < 40-60°C • Produced water < 95°C	• Crude oil < 60°C • Refined petrochemicals, fuels, diesel < 60°C • Mild and aggressive chemicals (except methanol) < 40-50°C • Produced water < 60°C	• Crude oil < 120°C • Refined petrochemicals, fuels, diesel < 93°C • Mild and aggressive chemicals (except methanol) < 40-60°C • Produced water < 93°C	• Crude oil < 120°C • Refined petrochemicals, fuels, diesel < 93°C • Mild and aggressive chemicals (except methanol) < 40-60°C • Produced water < 93°C

Key characteristics	• Easy application
	• Excellent chemical resitance
	• 2 or 3 thin film coats system
	• EI 1541 compliance
	• US FDA 21 CRF for Foodstuff cargo contamination, liquid foods
		• Fast return to service
		  • Cure 72 (full cure after 72 hours at 20°C)
		  • Cure 24 (full cure after 24 hours at 20°C)
		• Versatility
		  • 1 or 2 coats system (400-500 microns each coat)
		  • "Pit filler"
		  • Part of a fiber reinforced scheme (with chopped glass fibers or glass fiber mat)
		  • Caulking material for steel plate overlaps, chimes, seams, welds, ...
		  • Same base for 2 curing options, same base for 2 different shades
		  • EI 1541 compliance (only applys to Hempaline 630)
				• Fast return to service
				  • Cure 72 (full cure after 72 hours at 20°C)
				  • Cure 24 (full cure after 24 hours at 20°C)
				• Meets API 652 requirements
				• Alternative to chopped fibre and glass mat systems
				• Same base for 2 curing options, same base for 2 different shades