Repairing Small Blisters in Water Tank Linings

Answer
Curtis Peacock, Dixon Engineering, Inc., Lake Odessa, MI:
A thin film epoxy polyamide system is generally used to line potable water storage tanks for immersion service. In my experience, there are 3 main causes for blistering of a lining in the wet interior of a water storage tank: oil contamination, effect of soluble salts, and improper cure.

Oil contamination that has resulted in blistering could come from machinery, oil in the air from the blasting process, or oil from painters’ or blasters’ hands. If the oil is not properly removed from surfaces to be coated, the areas will fail, possibly resulting in blistering or flaking of the coating applied over the contaminated areas.

Soluble salts such as chlorides or sulfates promote blistering when present on any surface under the coating. This osmotic blistering results in pressure overloading of the coating applied over the soluble salts.

Blistering resulting from recoating an inadequately cured coating is generally attributed to solvent entrapment.

ASTM D 714, Test Method for Evaluating Degree of Blistering of Paints, can be used to rate the size and frequency of blisters and to measure them. In addition to the use of ASTM D 714, the blisters should be broken, and the substrate, if exposed, should be examined for corrosion and pitting. If the prime coat is found to be intact after the blisters are broken, the film thickness of the prime coat should be measured to determine if sufficient film build remains to provide continued protection of the steel substrate.

If the examined blister is exposing the steel substrate, the potential for active corrosion exists. Only by breaking the blisters and examining the exposed surfaces can a cause of blistering and recommendation for repair be determined. Once the cause of blistering is determined, the results of ratings from ASTM D 714 should be used to determine how extensive the repair or repainting should be.

A review of inspection records from the painting can also help put limits on the repair. If the cause was oil and the compressor is recorded as breaking down one day, then the repair could be limited to that day’s work. If the cause of the blisters is solvent entrapment, then most of those blisters should be visible. A brush-off blast (SSPC-SP 7) and recoat in these areas may be sufficient. Only break enough blisters to determine the cause. The method of repair and extent of the repair will be based on several factors. If the blisters are found during the warranty inspection, the owner will be more interested in total repair. If the blisters are not found for 5 years, the owner may prefer a wait-and-see attitude. 

Another factor is ice. If a blistered coating is subject to icing, damage will result from movement of the ice during tank usage. Ice movement will actually abrade the weakened coating, accelerating failure. Repair must be on a case-by-case basis and only specified after the cause of the failure is determined.

Answer
Jim Ellor, Corrpro Companies Inc., Alexandria, VA:
In answering this question, I assume that the coating is not under a warranty (i.e., is past the one-year inspection point). If the coating is under warranty, then the coating should be repaired as stipulated.

Before any non-warranty maintenance of a blistered coating is continued.
planned, one should answer several questions.
• How long has the tank been in service, and how much longer until the next maintenance availability?
• Is corrosion currently associated with ruptured blisters in the immediate vicinity of intact blisters?
• What is the consequence of significant coating failure?

Generally, it is common to find a few small blisters in water tanks after a brief service period (6 months). Such blistering is related to soluble contaminants on the substrate or between coats. This condition is especially true in overhead areas where the “pure” condensing water promotes blistering through osmotic forces. (Osmotic pressure is inversely proportional to the concentration of dissolved species in the electrolyte. The overhead condensate, a distillate, tends to contain less dissolved salt, increasing the local osmotic pressure and blistering tendencies.) This blistering may, however, not be cause for significant alarm.

In these cases, if the extent of blistering is less than 0.1 percent of the total area and is isolated (not scattered over the entire coating surface), one might be inclined to leave the blisters untouched. It is conceivable that the coating remains an effective barrier to the rapid ionic transport necessary to promote corrosion. A pseudo-equilibrium may also exist between the coated substrate and its environment, inhibiting further blister growth. Continued monitoring is suggested at 12-month intervals until remedial action is determined necessary.

Should the blisters be widely scattered, a more significant problem is at hand. If the total (actual) blistered area remains small, it may be acceptable to defer maintenance until a follow-up inspection, perhaps within 6 months.

In either case, if there is little blister growth between the inspection intervals, maintenance can be deferred. If there is evidence of blister growth, especially with scattered blisters, maintenance painting at the next outage is warranted. More than likely, complete recoating will be necessary. The results of the initial inspection should include detailed photographs and notes of the blistered areas. Rankings can be assigned in accordance with ASTM D 714 for each blistered area.

If at any time there are ruptured blisters and subsequent corrosion, immediate maintenance is suggested. The degree of maintenance should be as follows. If the ruptured blistering/corrosion is localized, only
such areas need to be maintained. If the ruptured blistering/corrosion is widespread, the entire surface will need maintenance. In addition, a new specification or quality assurance process is also warranted.

Each analysis must also address the consequences of failure. In a potable water storage tank, some blistering and substrate corrosion is common. The mere existence of some blisters is not a major reason for immediate concern. However, if a process stream is utilizing high-purity, distilled water, iron contamination from ruptured blisters may have significant consequences in other portions of the plant. In such cases, a more conservative approach is suggested.

Breaking of blisters to examine the substrate is problematic. Some may suggest that blisters be broken and the blister liquid examined. If the liquid is alkaline, little steel corrosion is expected. While this may be true, there are also examples where little underfilm corrosion occurs, and the substrate liquid is neutral in pH. In aqueous environments, substrate corrosion is more controlled by ionic permeability than the pH of the blister liquid. Permeability measurements would be of more value than destructive inspection of the blisters. Permeability can be investigated by field-electrochemical techniques that evaluate the DC resistance of the coating. Coatings with a resistance exceeding $1 \times 10^9$ ohm-cm$^2$ ($1.6 \times 10^8$ ohm-in.$^2$) remain effective (corrosion) barriers despite any blistering.

During destructive blister inspections, it is likely that some minor, localized corrosion will be found under a blister. This corrosion will typically be a thin spot of black iron oxide surrounded by bright steel. In most cases with blistered yet intact (non-ruptured) barrier coatings, such findings are not a large concern because corrosion is not propagating. Interestingly with some high-hardness coatings, one will find similar under-coat corrosion in the absence of any blistering. The low ductility of high-hardness materials inhibits blister formation despite the local disbondment of the coating.

This finding shows that blistering does not indicate more substrate corrosion than the absence of blistering. Blistering is simply the net response of a coating after it is locally disbonded from its substrate and acted upon by osmotic or internal coating stresses.

The single biggest advantage to a destructive examination is one of failure analysis. The presence of local contaminants (e.g., salts, sol-

continued
vents) within the blister may reflect on the application process. In such cases, analysis of the blister liquid may provide some insight into the likely propagation of blistering throughout the rest of the coating. If the likely cause of the initial blistering is common to the rest of the coating, significant rework may be warranted.

In all cases, any destructive inspection should be repaired before placing the tank back into service.

**Answer**

*Michael Doolittle, Tank Industry Consultants Inc., Indianapolis, IN:*

The decision to repair/repaint areas of blistering depends on the situation and the conditions. If the blistering was discovered in a newly coated tank and is within the coating warranty period, any areas of blistering noted should be repaired and repainted.

However, if the blistering has occurred in a tank where the coatings have been in service for an extended period of time, a few of the blisters should be broken to determine if corrosion or metal loss has occurred. If the blistering is between coats or the blisters reach bare substrate but no metal loss is noted, the broken blisters should be repaired with a coating that is compatible with the existing coating. The tank should be returned to service and evaluated on a regular basis to monitor future metal loss under the blisters.

The only exception to this guideline would be if the liquid in the blisters could contaminate the water in the tank. If there is metal loss, consideration should be given to repairing/repainting the affected surfaces in the near future. It should be noted that the blistered coating will most likely lead to premature failure.
of the coating system, if not in the near future, then in 5 to 10 years.

Regardless of when repair work is done, the cause of blistering should be determined and the problem should be corrected. There are 4 common possible reasons for blistering of an immersion coating system.

- Improper thinning or mixing of the coating material can result in blistering if the solids in the material are not thoroughly mixed from the bottom of each container prior to blending the components together, or the components are not thoroughly mixed together.
- There is inadequate ventilation during and after the coating operations, resulting in solvent entrapment in the coatings.
- The substrate was contaminated prior to the application of the coating, which did not allow the coating to adhere properly to the substrate. Substrate contamination can result from improper surface preparation or the presence of soluble salts on the substrate.
- Improper operation of the cathodic protection system can also lead to blistering.

**Answer**

Mike Swidzinski, Phillips Petroleum Company UK Limited, Woking, UK:
The approach depends on the coating type, tank material, type of water contained in the tank, and whether the tank has supplementary cathodic protection. My answer applies to tanks that receive a liquid-applied lining rather than a rubber or plastic sheet-applied lining. My answer is also not relevant to blisters formed during tank manufacture and original coating application.

In general, blistered tank coatings should be left intact unless there are obvious indications of corrosion activity. The repair of tank coatings can be costly and can result in more damage to the originally applied system than caused by blistering.

The level of tolerance to breakdown or deterioration of protective coatings for water tanks largely depends on their duty and frequency of inspection.

- If the coated tank is made from carbon steel and used to contain sea water, produced water, or brackish water, then rapid corrosion of the tank may occur if the coating is defective, especially if the water is warm or aerated. The problem may be mitigated if sacrificial anodes were part of the original design.
- Tanks containing potable water will corrode less rapidly beneath a defective coating. Once again, corro-
A blistered coating may still be sound. If there is no evidence of local discoloration due to rusting, the coating is probably intact and providing adequate protection. A quick test is to lightly depress a blister at its extremity. If fluid seeps out, then the blister is porous to water, and the underlying substrate is at risk of corrosion.

Ultrasonic inspection techniques can be used to measure the steel wall thickness beneath a blistered area without breaking the blisters. Where the ultrasonic measurements indicate reduced steel thickness, corrosion has probably occurred. If ultrasonic surveillance is possible, a routine inspection program could be devised and implemented to monitor the tank wall condition at the worst blistered areas.

If the blister is porous and ultrasonic inspection is not possible, then removal of a blister will be necessary if the tank condition beneath the blistered area must be established. In this case, a representative sample of blisters should be broken and the coating removed until sound, uncorroded metal surface is found. The diameter of the exposed area may be 100 percent larger than the original blister.

The need for remedial action should then be gauged against remaining tank life, the corrosion/pitting rate, and tank wall thickness for containment.

If no further action is required, then the exposed area beneath the blister must be re-coated. The existing coating should be cleaned back to achieve a sound, feathered edge (preferably by grit blasting), and a compatible tank coating repair system should be applied.

The original coating manufacturer should be consulted about selection of the required repair system.

Answer
Amy Forsgren,
Swedish Corrosion Institute,
Stockholm, Sweden:
Blistering of the paint system used in a steel water tank indicates that grease, rust, dirt, or similar contaminants were not removed during surface cleaning or that non-visible,
water-soluble salts contaminated the steel. Alternatively, the paint itself could have contained water-soluble or hydrophobic materials. For example, application of thick layers of solvent-borne paints containing glycols can cause blistering if the solvent becomes trapped in the coating.

If the blisters are not broken and the coating has good adhesion throughout and shows no discoloration, then corrosion of the substrate is probably very limited. In this case, the blisters should be left alone, since there should not be a problem with contamination of the water by rust or serious corrosion. This condition is particularly true when the blistering is in isolated areas.

If the coating is disbonding or becomes discolored with rust stains, then the coating should be repaired, either by spot repair or complete coating removal and repainting if the blistering is widespread. In either case, the reason for the initial blistering should be ascertained to ensure the problem does not recur.

**Upcoming Question**

SSPC-SP 12/NACE 5, Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultrahigh-Pressure Water Jetting Prior to Recoating, identifies 4 ranges of pressure for water cleaning of surfaces.

- 1,000-5,000 psi (7-34 MPa)
- 5,000-10,000 psi (34-69 MPa)
- 10,000-25,000 psi (69-172 MPa)
- Above 25,000 psi (172 MPa)

For what applications is each pressure best suited? Due November 20, 1997.

Fax answers to Karen Kapsanis, Editor, *JPCL*, at 412/431-5428.

Look for upcoming questions online at *JPCL*’s Web site, **Protective Coatings worldWIDE** [http://www.protectivecoatings.com].

**Reader Response**

Reader Response To This Question Appears In The March, 1998 Issue. pp 12,14