Primeaux Associates LLC

Polyurea Technology & Application Consulting

Technical Note

Cold Wall Effect

Blistering in Tank Lining Applications

Written by:

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Technical Note: Cold Wall Effect

Cold Wall Effect is a condition that can exist in structures such as tanks, vessels, buildings, and other structures that have coatings / linings applied on areas where their opposite sides have a temperature lower than the face of the side that is being coated / lined. In other words, when there is a thermal gradient between one side of a contained area and another. Blisters may occur between the liner and the surface due to permeability of the applied lining compared to non-permeability of the substrate. An example is a steel tank that holds a heated liquid inside, and outside the tank it is a lower or cold temperature. This is forced condensation of moisture on the back-side of the liner system and this "force" can disrupt adhesion, resulting in blisters.

Still trying to grasp what is going on? Well next time you head out to your favorite eating establishment and order a cold beverage in a glass container, what happens? The container gets wet on the outside, not because it is leaking or you spilled, but because moisture in the air (which is warmer) condenses on the cold substrate of the glass. The more humidity in the air, the more moisture you may notice on the glass. It is basically the same concept that occurs with the Cold Wall Effect.

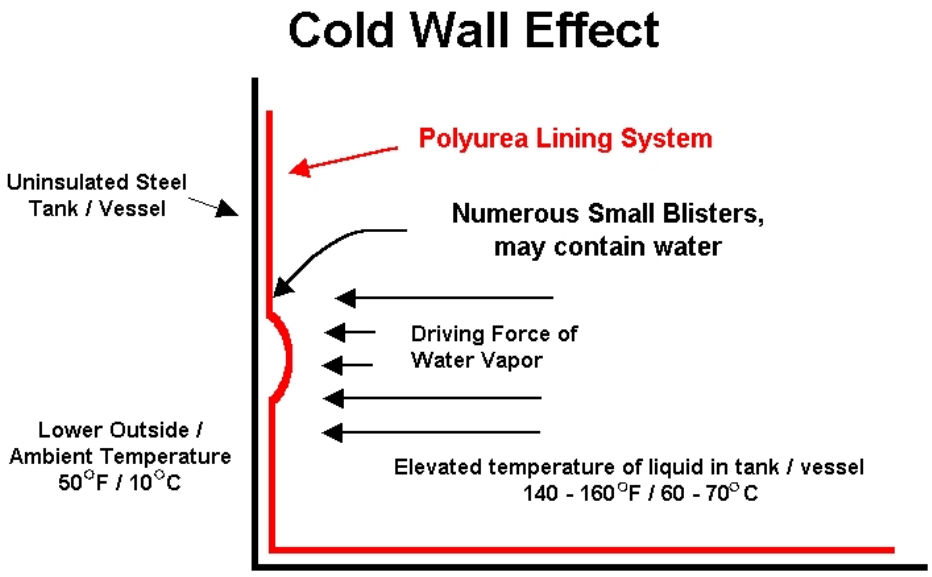
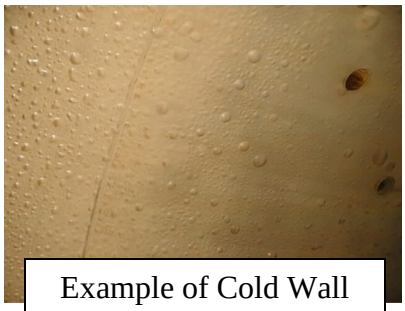


Figure I: Diagram of Cold Wall Effect

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Example of Cold Wall Effect Blistering in a Steel Tank

The water vapor pressure is higher on the warm side of the lining than on the cool side. This vapor pressure gradient causes moisture vapor to pass into and through the lining, by osmosis, more rapidly than it egresses. There is a continuous force drawing liquid from the warm side to the cold side and blisters occur at weakly bonded areas beneath the liner. The greater the thermal gradient between the hot and cold sides, the larger and more numerous the blisters. A temperature spread of 100°F, 38°C (Example: 140°F, 60°C inside and 40°F, 4.5°C outside) will produce more blisters than a difference of 50°F, 10°C. **Where there are soluble salts present on the substrate the process is greatly accelerated!**

Studies indicate that lining systems with the lowest permeability (perm rating) are more resistant to Cold Wall Effect than systems with higher permeability. Compared to many systems, polyurea spray elastomers have a very low perm rate but not as low as the flake or carbon filled vinyl esters on the market. And also with that, not all polyurea systems have the same perm rating. This will depend on formulation, as well as spray processing conditions.

Of course, this phenomena can also be affected by surface preparation techniques from the standpoint of achieving sufficient adhesion to the substrate. The lower the initial (prior to putting into service) adhesion values, the worse that this blistering can be.

The phenomenon of Cold Wall Effect occurs more often on un-insulated steel tanks rather than concrete because the concrete acts as insulator (but it **CAN** still happen!). Open top tanks are less vulnerable. Cold wall effect can also occur where a cold liquid is inside and the exterior is very warm, and the external coating system exhibits blistering.

Typically, if you cut into these type blisters, there may be "liquid" present. For a steel tank, you may also observe a clean, profile to the substrate, much like the appearance when preparation work was completed prior to lining work.



Bottom line, the moisture vapor "ingresses" through the lining faster than it can "egress" back through the lining.

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Soluble Salt Effect / Osmotic Blisters

The presence of soluble salts on the substrate act as a hydrophilic point and will actually "pull" moisture vapor through the coating / lining system. This then will create a corrosion cell resulting in the blister formation and disbondment of the polyurea coating / lining system. Inspection of the blister may show the contents of water, gas generated from the corrosion cell and substrate corrosion.

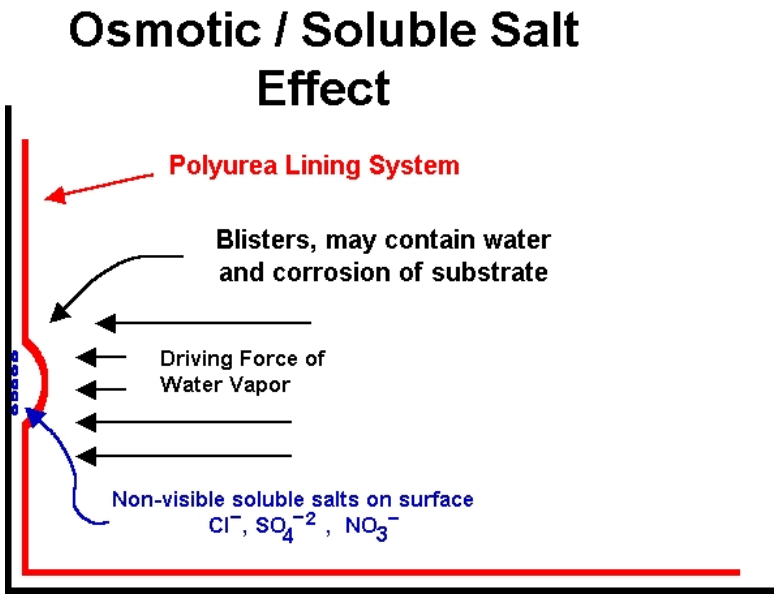
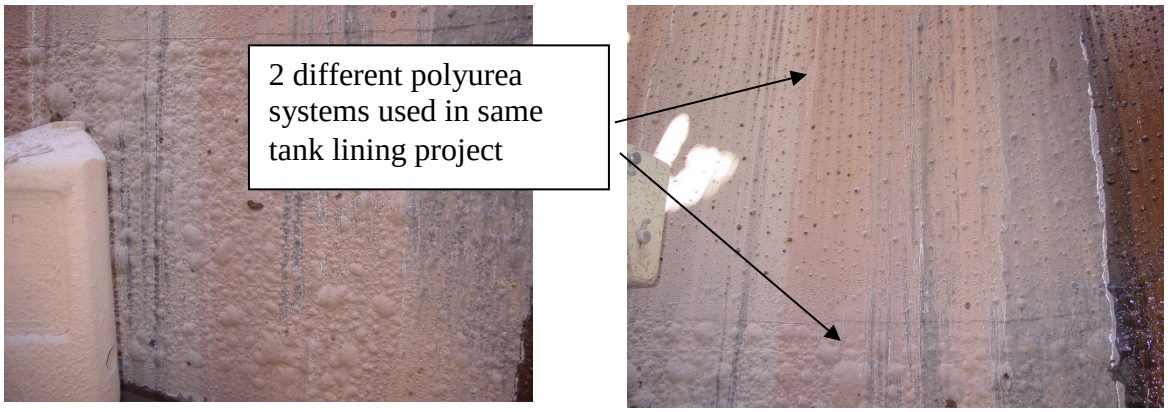


Figure II: Soluble Salt Blisters



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Testing:

There is no real field testing that can be used to test for cold wall effect, only a laboratory screening test. A safe rule of thumb would be to avoid a thermal gradient of no more than 10% for un-insulated steel tanks. There is testing however for soluble salt contamination on a substrate. This should be verified and the following substrate surface soluble salt content should be used:

Soluble salts shall be removed to an acceptable level for the coating / lining application. These contaminants are directly related to osmotic blistering of the coating system and subsequent delamination. In general, the following soluble salt levels are noted:

chloride (Cl^-) level should be < 2 $\mu g/cm^2$
sulfate (SO_4^{-2}) level should be < 8 $\mu g/cm^2$
nitrate (NO_3^-) level should be < 8 $\mu g/cm^2$

(of which the above combined combination of all three should not exceed a total of 10 $\mu g/cm^2$)

Note:

- Similar blistering can occur from the same phenomenon in other structures where a polyurea spray elastomer system would be applied on the cold side of a cavity wall if the opposing side of the wall were subject to warm, humid air. (Example: clean rooms, food processing facilities, etc.)
- A good barrier coating / lining system should have good electrical barrier properties; i.e. “insulative”
  - Electrical Impedance Spectroscopy
- API 652, Section 10.1, it has been noted that blistering of a lining system may be a common mode of lining deterioration. However, blistered linings may remain fully functional providing corrosion and leak protection as per the scope of the specification work. In most cases, blistering usually appears prior to the lining system being put into service, especially with polyurea-based lining system.
- Be cautious of storage tanks that have bottom internal heating tubes. These often are actually much hotter localized heat.

Solutions:

- Check for soluble salt content, remove as required;
- Insulate steel tanks and check the gradient for adequacy;
- Verify insulation and vapor barrier in cavity walls;
- When in doubt, ***ask question***, or avoid the application!

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Note: This is an update to the original version of this article, written by the same author, in 2003, and then used by PolyureaUniversity.com in 2012.

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