



BE PREPARED!

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discuss the importance of surface
preparation of steel prior to coating.*

One certainty in coating application is that inadequate surface preparation almost always guarantees that any coatings applied will fail prior to their intended service life. Surface profile and visual blast cleanliness are usually checked but invisible contaminants, such as salts, are often overlooked. In many respects, the conditions that buried pipe is in is very similar to immersion service. Pipelines can be subjected to varying extreme temperatures in the presence of moist soil and sometimes just water. Internal pressures from operation of the pipeline and external pressure due to ground movement are also critical factors that affect the life of the pipeline coating.

Most oil and gas transmission pipelines are underground and cannot be visually inspected without digging them out. Because of this, salts, which can lead to blistering and delamination, must be removed from surfaces prior to applying coatings to ensure the maximum life cycle of the coating is achieved.

Pipe coatings

Most of the time, the pipe that is being coated has crossed at least one ocean, where it is often exposed to salt spray and the environment. It is essential that, whether the pipe is coated in a shop or in the field, adequate surface preparation be performed. There are many possible areas in surface preparation where errors can occur. Inadequate surface profile can easily be measured and prevented with proper quality control. Inadequate visual surface cleanliness is also easy to control with proper quality control. Unfortunately, invisible contaminants, usually salts, are often not checked for and can result in premature coating failure.

Salts and chlorides

Over the years, there has been much written about salts and chlorides. Some of it is misleading and some of it is downright wrong. Sometimes, problems start with the coating specifications. A problem with many specifications is the specifier often inter-mixes the term 'salt' and 'chlorides'. While it is true that most of

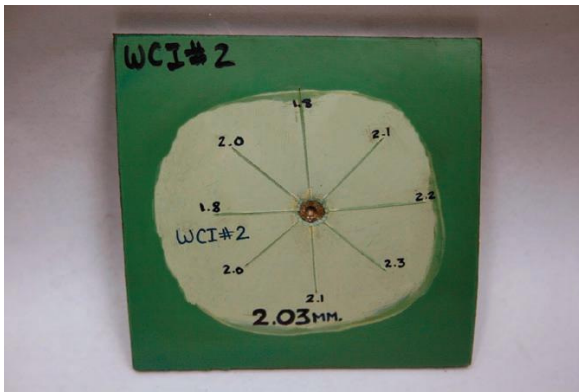


Figure 1. NACE RP0394 Cathodic Disbondment Test, 2.03 mm average disbondment radius.



Figure 2. NACE RP0394 Hot Water Soak Test, number 1 rating.

the salts on metal or concrete surfaces are generally chloride salts, not all salts contain chlorides. The only way to determine 'salt' in the field is to measure conductivity and make some assumptions to calculate total salts or Total Dissolved Solids (TDS). The only way to measure 'chlorides' is to use an ion specific test using a test specific for chlorides. To determine which test is best for a specific project, we need to understand the specific concern of invisible surface contaminants.

Bad salt verses good salts

The industry has been deluged with articles on chlorides and salts that infer or state that some salts are worse than other salts (e.g. chlorides, sulfides and nitrates are the 'Bad' ions). While there are more technical explanations for the following terms, in general:

- Osmosis is a property of solutions and is independent of what the solution is composed of.
- Corrosion cell. For a corrosion cell to occur requires an Anode, Cathode, Metallic pathway, and an electrolyte.
- Anode. The anode corrodes by loss of electrons:
 $M = Mz^{+} + ze^{-}$

Processes that occur at the anode are:

- Anodic reaction.
- Oxidation reaction.
- Electron generation.
- Cathode. The cathode does not corrode. The most important cathodic reactions:
 - (i) $pH < 7 \quad 2H^{+} + 2e^{-} = H_2$
 - (ii) $pH > 7 \quad 2H_2O + O_2 + 4e^{-} = 4OH^{-}$
- Other cathodic reactions are possible depending on the environment.
- Metallic pathway. The anode and cathode in a corrosion cell must be in electrical contact. The difference in free energies between the anode and the cathode produces electrical potential which is the driving force for corrosion reaction.
- Electrolyte. An ionic conductor. The better the conductor, the more efficient the corrosion cell.

If you coat over a surface contaminated with salts, unless there is moisture present under the paint, corrosion cannot occur because there is no electrolyte present. Most coatings are semi-permeable which means they will let gases pass through but not solids or liquids. When water is on the surface of the coating, small amounts of water enter the vapour phase and migrate through the coating. When it reaches the surface, it will condense and if any salts are present, an electrolyte will form. The salts affect the vapour pressure of the water, preventing it from going back in to the vapour phase. Since the coating will not permit a liquid to pass through, the water is trapped with the salts as a solution.

At this point, we have developed both a corrosion cell as well as an osmotic cell. If the concentration of the solution behind the coating is greater than the concentration of the solution on the outside of the coating, osmotic pressure is created. Water vapour will go from the side with the lower concentration (outside of the coating) to side with the higher concentration (the metal surface) until a balance is reached. If there is not room for the water, a blister will form.

One additional consideration is with the disassociation reaction due to the corrosion cell. If the solution is acidic, according to equation (i) above, H_2 will form at the cathode forcing the solution to be more acidic. If the pH is basic, according to equation (ii) OH will form, causing the solution to be more basic. The more acidic the solution, the greater the corrosion reaction will be. On the basic side of the equation, corrosion will be inhibited.

As you will notice in the above discussion on osmosis, the ions composing the solution have no bearing on osmotic pressure. However, if acid salts are present in the solution, the nature of the corrosion cell will be more corrosive than if the solution is basic.

KTA Panel No	Treated with HoldTight	Coating	Dry film thickness, mils
AKF 001	Yes	Plasite 7122	7.3
AKF 002	Yes	Plasite 7122	6.8
AKF 003	Yes	Devchem 256	7.4
AKF 101	No	Plasite 7122	6.8
AKF 102	No	Plasite 7122	6.5
AKF 103	No	Devchem 256	9.5

Coating	KTA	DFT (mils)	Location	PSI	Average	Mode
HoldTight/7122	AKF 002	6.8	1	>2500	>2500	None
			2	>2500		None
			3	>2500		None
Control/7122	AKF 102	6.5	1	>2500	>2500	None
			2	>2500		None
			3	>2500		None
HoldTight/256	AKF 003	7.4	1	>2500	2487*	None
			2	2450		19% cohesive, 1% adhesive, 80% glue
			3	>2500		None
Control/256	AKF 103	9.5	1	2200	2400*	Glue
			2	>2500		None
			3	2500		Glue

General note: Averages were calculated using 2500 psi, adhesion may be greater than 2500 psi.

Removal of salts

In many situations, the use of high pressure water is sufficient to remove salts to a low enough level to satisfy most purposes. It is important to use good quality water to prevent contaminating the surface even more than it may be.

High purity water wants to dissolve salts so with good pressure, water with less than 40 ppm TDS and a relatively smooth un-pitted surface, the use of additional cleaners may not be required. As the water quality decreases, or the surface is corroded or pitted, surface cleaners can help remove salts from the surface. If the water is too contaminated, not even cleaners will help clean the surface.

The average TDS for surface water in the US is generally between 250 ppm to 400 ppm TDS. For most surface waters, the use of a chemical additive should help increase the efficiency of the wash water. Measuring TDS can not be done directly in the field. However, you can measure conductivity using a simple conductivity meter. The conversion factor to convert conductivity (micro-mhos) to TDS (ppm) can vary based on what the ions are, but in general, multiplying conductivity by 0.7 should be close enough for most purposes.

There are two types of cleaners on the market: ionic and non-ionic cleaners. As the names imply, ionic cleaners dissociate in water to form a conductive solution. Ionic cleaners are salts. Non-ionic cleaners, contribute little conductivity to the water since they are generally amines and not salts. The majority of ionic cleaners on the market are acid based cleaners which mean that once they remove the salts, the cleaners themselves must be removed. If the cleaner is still present when the surface is coated, it will cause the problems you are trying to prevent. Since they are acid based, once they form a solution, per equation (i) above, it will become more acidic and accelerate corrosion under the film.

Non-ionic or Amine based cleaners contribute little conductivity to wash water and some are 100% volatile meaning they evaporate from the surface with the water. Should any amine be left behind, the low solubility of the amine and the non-ionic nature of the amine means it will contribute little to forming an osmotic or corrosion cell. Should a corrosion cell form, per equation (ii), the solution will become more basic inhibiting corrosion.

Field testing of salt remover

Womble Company, Inc. is a large pipe coating facility located in Houston, Texas. They had several sections of pipe that had been contaminated with seawater. The quality control check of the steel using Potassium Ferrocyanide paper showed chloride contamination to be present on the surface. Potassium ferricyanide paper is very sensitive to ferric ions (Fe⁺⁺) and turns blue when it contacts these ions. The presence of Ferric ions indicates the presence of an anion which is generally a Chloride ion (Cl⁻). It was found that high pressure water by itself would not remove chlorides to less than detectable by this test method.

It was decided to try a salt removal product to see if it would lower the chlorides to less than detectable using

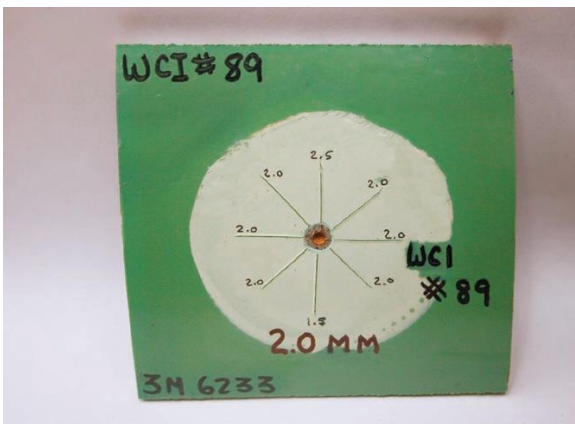


Figure 3. NACE RP0394 Cathodic Disbondment Test 2.0 mm average disbondment radius.

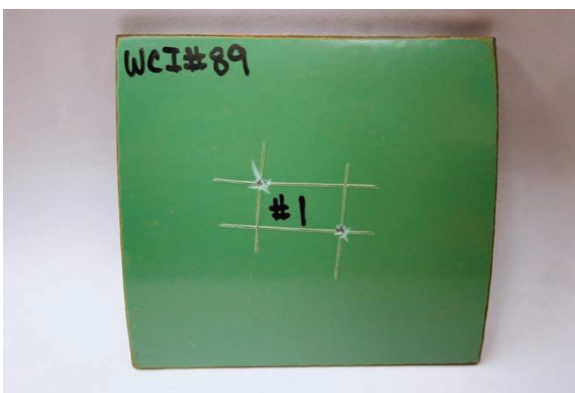


Figure 4. NACE RP0394 Hot Water Soak Test, number 1 rating.

the Potassium Ferrocyanide paper test method. Non-acidic, slightly alkaline chemical cleaner was used. The recommended manufacturer dilution was 1 part cleaner mixed with 50 parts water. It was found that the chemical cleaner did reduce the chlorides to less than detectable using the Potassium Ferrocyanide paper.

Another critical factor when using cleaners to make sure they are not present prior to coating. The product selected for the study was Holdtight®102 - a 100% volatile product that evaporates off the surface leaving a clean surface. To ensure that no product was left to contaminate surfaces, Cathodic Disbondment testing in accordance with RP0394-2002, "Application, Performance, and Quality Control of Plant-Applied, Fusion-Bonded Epoxy External Pipe Coating" was conducted.

Cathodic Disbondment testing measures a combination of the permeability of the coating along with its adhesion to the substrate. If salts or the salt remover are present on the surface, it will adversely affect cathodic disbondment.

On sections that were cleaned and coated, cathodic disbondment was found to be 3 mm or less. 8 mm is the maximum passing so sections were considerably less than this. Illustrations of the Cathodic Disbondment test are shown in Figures 1 - 4.

Other independent adhesion testing by KTA Tator, Inc. and Weldon Labs has shown no adverse results when using chemical cleaners when compared to controls. In

many cases, it showed improved adhesion rates. Results of the adhesion tests with their Dry Film thickness values are shown in Table 1 and Table 2.

Conclusion

Since buried pipelines exist in an environment similar to immersion service, cleanliness criteria similar to those used for coating steel for immersion service should be used. It is well established that salts can adversely affect the service life of coating systems.

Prior to coating steel (pipelines, tanks, bridges or other steel structures), it is important to remove all salts, not just the chlorides. While the exact amount of salts that is safe to leave on the surface is often disputed, lowering salts to less than detectable is the best insurance to make sure they do not cause a problem. When water by itself is not sufficient to remove all salts, a non-ionic, 100% volatile surfactant can be the difference between reducing salts a little, to reducing salts to less than detectable. Further, testing by both adhesion and cathodic disbondment showed that slightly alkaline (non-acidic) chemical cleaners had no adverse effect on the coating applied after the surfaces were cleaned.

While often, water alone is sufficient to remove salts, when additional cleaning is needed the choice of a proper salt remover can increase cleaning efficiency without having any adverse effect on the coating system. **WP**