SUBJECT

Soluble Salts

PURPOSE

The purpose of this bulletin is to provide a brief description of soluble salts and a technical overview for the testing and removal of soluble salts from steel surfaces prior to coating.

GENERAL

Soluble salts refer to substances that can easily dissolve in water. These salts are made up of sharded particles called ions. When these salts come in contact with water, they break apart into the ions and become part of the water solution. In context of steel or metal surfaces, soluble salts can be problematic. When water is also present, these salts can contribute to corrosion.

Why are soluble salts bad?

Soluble salts can be detrimental to steel because they can cause accelerated corrosion. Corrosion is the process in which metals, like steel, react with their environment and oxidize. Due to coatings being a semi-permeable membrane, soluble salts must be removed or reduced to an acceptable level before coatings are applied. The presence of soluble salts, particularly chloride and sulfates, accelerates the corrosion of the steel through various mechanisms.

1. **Ionic Contamination:** Soluble salts introduce ions, such as chloride ions, onto the surface of the steel. Chloride ions are particularly aggressive in promoting corrosion. They can penetrate the protective oxide layer on the steel surface and initiate corrosion reactions.
2. **Pitting Corrosion:** Chloride ions are known to cause pitting corrosion on steel surfaces. Pitting corrosion occurs when localized areas of the metal surfaces are attacked, leading to the formation of small pits. These pits can grow and compromise the structural integrity of steel.
3. **Stress Corrosion Cracking:** The presence of certain soluble salts, especially chlorides, can contribute to stress corrosion cracking of steel. Stress corrosion cracking occurs when the combination of static and tensile stress and a corrosive environment leads to the formation of cracks in the metal.
4. **Accelerated Corrosion Rate:** Soluble salts can increase the rate of corrosion reactions. The corrosive ions facilitate the breakdown of the protective oxide layer on the steel, making it more susceptible to corrosion over time.
5. **Osmotic Blistering:** Salts can play a significant role in osmotic blistering of coatings because they contribute to changes in solute concentration with the coating. Osmotic blistering is driven by the principle of osmosis, where the movement of water occurs across a semi-permeable membrane in response to differences in solute concentrations.

Common Testing Methods

The most common field-testing kits are the CSN (Chlorides, Sulfates, and Nitrates) kit by Chlor*Rid and conductivity test kits. Both methods utilize a similar method for extracting soluble salts from the surface of the steel. This extraction method utilizes a small latex patch or sleeve that attaches to the surface. A known volume of deionized water is injected into the patch and left for a period of time. During this time, the deionized water works to dissolve and extract soluble salts from the surface. After the extraction period, the water is collected from the patch and analyzed for chloride concentration.

The CSN kit and the Conductivity Meter are the two most widely used test methods for determining the presence of soluble salts on the surface.

1. **CSN Kit:** This kit uses a titration tube that is filled with a chemical that readily reacts with sodium chloride, changing its color. The solution collected from the patch is wicked into the tube, causing the reaction to take place. Based on how far up the tube the reaction happened (how far the color change made it), this gives you a measurement of micrograms per square centimeter (µg/cm2) and in some cases PPM. This kit also uses testing strips that change color depending on the amount of nitrates and sulfates on the surface.
2. **Conductivity Meter:** This method measures the conductivity of the solution, before and after being injected into the patch. The meter produces two different forms of measurement, microsiemens per centimeter (µS/cm) and micrograms per square centimeter (µg/cm2). µS/cm is the measurement of conductivity of a solution and µg/cm2 is the surface density of soluble salt expressed as sodium chloride.

Several other methods are available for checking for soluble salts.

1. **Potassium Ferricyanide:** Blotting paper moistened with potassium ferricyanide solution is placed on the steel surface to be tested. The potassium ferricyanide paper is left on the surface for a specified time and allowed to react with the ions on the steel. When ferrous ions come into contact with the blotting paper, blue spots will appear on the paper.
2. **Salt Contamination Meter:** Blotter paper moistened with deionized water is placed on the steel substrate for two minutes, then the paper is removed and placed on the contamination meter for reading. Both the Bresle Patch Test Method and the Salt Contamination Meter measure the concentrations of salts on a substrate; however, they use different techniques.
3. **Surface Swab or Wash:** This method requires a ruler, clean beakers, tweezers, cotton balls, and reagent water. Start by marking off a 15cm x 15cm (5.9” x 5.9”) area to be tested. Pour off a measured amount of reagent water into the clean beaker. Using the tweezers, dip the cotton ball into the reagent water and swirl around. Then, remove as much water as needed not to drip off the cotton ball when removed. Saturate the marked off area on the steel with the cotton ball. Complete this method four times then test the water in the beaker.

Different testing methods can provide different measurements other than µg/cm2. Not all measurements are able to be converted to µg/cm2. (Consult with the testing kit manufacturer for information.) Additionally, µg/cm2 does not directly convert to part-per-million (PPM). However, some kits are manufactured to provide results that are a one-to-one ratio of µg/cm2 and PPM.

Industry Standards for Soluble Salt Testing

Testing for soluble salts on surfaces, especially metals like steel, is crucial to assess the potential for corrosion and to ensure the effectiveness of surface preparation and coating processes. There are several methods and standards for detecting and measuring soluble salt contamination.

1. **SSPC-Guide 15 – "Field Methods for Extraction and Analysis of Soluble Salts on Steel and Other Nonporous Substrates"**: This guide describes the most commonly used field methods for extraction and analysis of soluble salts on steel and other nonporous substrates.
2. **SSPC-Guide 24 – "Soluble Salt Testing Frequency and Locations on New Steel Surfaces"**: This guide is intended to assist owners and specifiers to determine the location of tests sites and the frequency of testing for measuring the amount of soluble salts on steel and shop primed steel.
3. **ISO 8502 – "Preparation of steel substrates before application of paints and related products – Tests for the assessment of cleanliness"**: There are several sections (Parts) in this standard that are used for the testing of soluble salts.
    a. **Part 2: "Laboratory determination of chloride on cleaned surfaces"**: This part of ISO 8502 describes a method of determination of chloride-containing salts that are readily soluble in water and are present on a steel surface.
    b. **Part 5: "Measurement of chloride on steel surfaces prepared for painting (ion detection tube method)"**: This part of ISO 8502 describes a field test for the measurement of chloride ions using specific detection tubes.
    c. **Part 6: "Extraction of soluble contaminations for analysis – The Bresle method"**: This part of ISO 8502 describes a method of extracting, for analysis, soluble contaminants from a surface by use of flexible cells in the form of adhesive patches which can be attached to any surface, regardless of its shape and its orientation.
    d. **Part 9: "Field method for the conductometric determination of water-soluble salts"**: This part of ISO 8502 specifies a field method for the assessment of the surface density of various water-soluble salts on steel surfaces, before and/or after surface preparation, by conductometric determination.
4. **NACE SP0213 – "Definition of Set Soluble Salt Levels by Conductivity Measurements"**: The purpose of this standard is to present a relevant and reasonably achievable set of soluble salt contamination values obtained from surface conductivity measurements and based on known common industry-specified values.
5. **NACE SP0716 – "Soluble Salt Testing Frequency and Locations on Previously Coated Surfaces"**: The purpose of this standard is to establish requirements for soluble salt testing frequencies and locations before the application of a coating system.
6. **NACE 6G186 – "Surface Preparation of Soluble Salt Contaminated Steel Substrates Prior to Coating":** The purpose of this standard is to avoid problems by ensuring understanding about when soluble salts could be an issue and the steps that could be taken to mitigate the consequences of salt contamination.

Methods for Removing Soluble Salts

1. **Abrasive Blasting** is not an effective way to remove soluble salts from surfaces. When using abrasive blasting alone you run the risk of not being able to reduce the levels of salts below the recommended levels. You also run the risk of flash rusting depending on the environmental conditions. Abrasive blasting in tandem with the use of certain additives can achieve a surface clean of soluble salts and inhibit the onset of flash rust.
2. **Water Washing** is an effective method of removing soluble salts from surfaces; however, water is the most common electrolyte for facilitating corrosion. Water washing in tandem with the use of certain additives can achieve a surface clean of soluble salts and inhibit the onset of flash rust. Typically, water washing happens before abrasive blasting procedures. This is due to the possibility of 'impregnating"

the steel with soluble salts. Impregnating the steel means that the soluble salts on the surface are driven down into the valleys of the angular profile making them difficult to remove.

3. **Water Jetting** is a surface preparation technique that involves the use of high-pressure water without an abrasive to remove coatings, contaminants, and other substances from the surface. Water jetting is an effective alternative to dry abrasive blasting in certain applications. Like water washing, the water can facilitate corrosion. Water washing in tandem with the use of certain additives can achieve a surface clean of soluble salts and inhibit the onset of flash rust.
4. **Wet Abrasive Blasting** is a surface preparation technique that combines the use of abrasive materials with water to achieve effective cleaning and coating removal. In this method, abrasive particles are introduced into a high-pressure water stream, creating a slurry that is directed onto the surface to be treated. Wet abrasive blasting is often chosen for its ability to reduce dust emissions, improve visibility, and enhance the overall safety for the blasting process. However, without the use of additives you also run the risk of facilitating corrosion due to the water.

Soluble Salt Removers and Flash Rust Inhibitors

Products designed to remove or reduce the presence of soluble salts on surfaces, particularly on metals like steel, can be used in tandem with traditional abrasive blasting procedures. Soluble salt removers work by either dissolving the salt or facilitating in its removal from the substrate. Flash rust inhibitors are substances or compounds designed to minimize or prevent the formation of flash rust on metal surfaces during the period between cleaning or surface preparation and the application of protective coatings.

Always follow the manufacturer's recommendations and industry standards when selecting and using the additives to achieve the desired results without causing harm to the substrate or inhibiting the performance of applied coatings.

Tnemec has performed internal testing using various products in our industry. While there are many products for use in our industry, not all products have been tested by Tnemec. Please contact Tnemec Technical Services for information and guidance on products not listed here.

PRODUCT	MANUFACTURER	WEBSITE
HoldTight®102	HoldTight Solutions Inc.	holdtight.com
Chlor*Rid® Soluble Salt Remover	Corrosion Innovations	chlor-rid.com
Hold*Blast™ Surface Passivator	Corrosion Innovations	chlor-rid.com
CleanWirx 207	WirxGroup LLC.	cleanwirx.com
SP8/ SP8 Rinse	Corrosion Innovations	chlor-rid.com
Corr-Ze 100	Corrosion Innovations	corrinnovations.com
Corr-Ze 200	Corrosion Innovations	corrinnovations.com

Testing Summary:

Based on the conditions and methods tested, the products listed above did not inhibit the adhesion of Tnemec coatings to the steel substrate. It should be noted that water quality, chlorides, humidity, and temperature are all variables that can affect the dilution rates and results.

Acceptable Chloride, Sulfate, and Nitrate Contamination Levels

The acceptable level of soluble salt contamination can vary depending on the environment where coatings will be applied. Depending on the severity of the environment, tolerance levels may be stricter to ensure the success of the applied coatings. Tnemec categorizes these environments by the following exposures:

1. **Atmospheric Exposure:** This environment is any exterior surface that will not be in an extended or constant immersion service.
   a. 7.0 µg/cm2 Chlorides
   b. 10.0 µg/cm2 Sulfates
   c. 5.0 µg/cm2 Nitrates
2. **Ambient Potable Water Immersion Exposure:** This environment is any potable water tank or container, at ambient temperatures, that will be in constant immersion or the headspaces above the immersion service.
   a. 5.0 µg/cm2 Chlorides
   b. 10.0 µg/cm2 Sulfates
   c. 5.0 µg/cm2 Nitrates
3. **Chemical Immersion Exposure:** This environment is any tank or container that will be in constant immersion or the headspaces above the immersion service (other than ambient potable water).
   a. 3.0 µg/cm2 Chlorides
   b. 10.0 µg/cm2 Sulfates
   c. 5.0 µg/cm2 Nitrates

Summary

Soluble salts on steel refer to compounds that can dissolve in water and may be present on the surface of steel structures. Common soluble salts include chlorides and sulfates. These salts can pose a threat to steel by initiating corrosion processes, especially in the presence of moisture. Corrosion can lead to structural deterioration and compromise the integrity of steel components.

Using proper testing methods to assess salt contamination levels can mitigate risk. Soluble salt removers are used to remove or reduce the salts before applying coatings. Flash rust inhibitors may also be employed to temporarily prevent the formation of rust during a period between surface preparation and coating application.

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