Soluble Salts and Specifications

By James R. Johnson

Soluble salts are very much at the forefront of discussion in the coatings industry, but are often overlooked in specifications. In an effort to provide the industry with comprehensive information about soluble salts and corrosion prevention, CoatingsPro *and ChlorRid are pleased to present the first in an on-going series of articles, "Salts 101."*

Salts: The Economic Impact On Coatings

In 2002, the U.S. Federal Highway Administration released a major study which estimates the annual direct cost of corrosion at over $150 billion, in 2007 inflation-adjusted terms. Over 88 percent of this cost, or an adjusted $124 billion, is attributable to coatings. Proper surface preparation is a critical condition necessary for coatings to provide surface protection for an expected average of 14 to 15 years.

Salts are attributed as a major cause of premature coating failure, with claims from forensic failure inspections running over 60 percent. This means that salts left on the surface prior to coating have an economic impact of over $74 billion per year. For the doubter, even if salt-related premature coating failures represent only five percent of the cause of the failure (and it is highly unlikely that it is this low), the economic impact is over $6 billion per year.

What becomes obvious is that the economic penalty for not taking salt testing and removal into account is tremendous and it is a controllable variable. Whatever the number, would it not be in our best collective interest to save billions of dollars annually?

ABOVE ▲ Surface contamination by soluble salts has long been an issue for the corrosion industry. Lead-based paints used to be the first line of defense. A unique property of lead is that it reacts with soluble salts to form insoluble salts, thereby preventing those salts from causing or increasing corrosivity. But, of course, lead-based paints resulted in toxicity problems that outweighed their usefulness as anti-corrosives.

How Are Specifications Changing?

A few years ago specifications and surface preparation instructions rarely called for testing of salts or even for limiting them. Today, testing and allowable limits are included in a large percentage of specifications. In a few more short years, it is probable that most specifications will address salts in some manner. Asset owners are beginning to understand that salts are causing coating life spans to fall short of their intentions. Coating manufacturers are finding salts to be the cause of increasing warranty claims. Unaddressed salts are a major cause of expensive rework for coatings contractors. Consequently, coating professionals throughout the industry are making changes in specifications.

For decades the coatings industry has worked with visual standards and visual comparators. As we begin to deal with soluble salts we enter the realm of the non-visible. Suddenly we are testing for and removing something that cannot be seen. This requires change, but human nature resists change, so such transition is not easy. Engineers, specifiers, and coating manufacturers frequently require testing and establish allowable limits; however there is resistance to change, so such efforts are not always successfully implemented. To provide a sound specification addressing salts, the specification writer should understand the significance of soluble salts, the problems caused by those salts and the appropriate methods

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of testing, evaluating, and removing salts. Some specifiers are attempting to incorporate salt provisions into specifications without a good understanding of them and, consequently, many specifications still do not capture the essence of testing and decontamination that would effectively provide for intended or maximum coating performance.

Surface contamination by soluble salts has long been an issue for the corrosion industry; however, it was the banning of lead-based paints that caused closer scrutiny of salts with regard to coating service life and premature coating failures. A unique property of lead is that it is capable of reacting with soluble salts, forming insoluble salts, thereby limiting salts from causing or increasing the corrosivity of the immediate environment. The widespread use of lead-based paints gave us a sense of security but the legislated ban of such products requires reevaluation of surface preparation requirements. Also, as new "high performance" coatings are developed, film thickness is decreasing. The thinner coatings get, the more critical soluble salts become.

What Are Soluble Salts?

An explanation voiced in a NACE International committee meeting some years ago stated that anything conductive should be considered a salt.

Soluble salts are described in the Society for Protective Coatings (SSPC) Protective Coatings Glossary as — "An ionic chemical compound that dissolves in water to form a solution of positive and negative ions."

Coatings professionals have long realized that soluble salts are detrimental to the substrate and to coatings. Though they did not have the means to perform the ion-specific testing that we do today, they realized that if a clean, uncontaminated surface were washed with de-ionized (DI) water, the water remained relatively non-conductive. But when contaminants were present, an increase in conductivity was observed. Since they did not have the means to identify specific ions, especially in the field, estimates were used to determine percentages of chlorides and other ions based on assumptions. That was the best they could do with the technology available at the time. Since then it has been found that these estimates are highly unreliable. Today we do have the means to identify and measure specific ions. Everything conductive is still frequently considered a salt; however, this conductivity could be comprised of hundreds of different constituents and not everything conductive is detrimental to coatings.

Clearly, the cleaner the surface, the better the coating performance — but some conductive materials have little effect on corrosion or coating performance, while other conductive materials can affect it to a great degree. The prime detrimental salts most commonly encountered are chloride, sulfate, and nitrate, though specific industries may encounter others. These salts can be so detrimental that they can cause premature coating failure in as little as weeks in the right environment. Salts definitely can affect the overall life spans of coatings, even if the coating system survives beyond the warranty period.

The question industry is asking today is, "How much of what salt can be left on a surface and not significantly affect a coating's life span?" There are so many different coating systems available and so many different operating environments that a consensus number will probably never be attained. Best practices engineering dictates that the lower the number the less risk of premature failure and the highest probability of maximum service. As time progresses we are continually gathering more information as to what has and has not worked.

NASA engineers identified chlorides for their extreme corrosion effect in the late 1970s and they established a chloride threshold limit of 5 micrograms per square centimeter (µg/cm2) as the acceptable limit on surfaces prior to coating. Although there was no adequate, reliable, and accurate nondestructive test method for metallic surfaces, NASA held firm with their specification (KSC-STD-0001-D). Until recently they had to allow contractors variances to specifications because of the inability of contractors to meet the specification limits.

All liquid-applied coatings are moisture-vapor permeable, which allows the salt on a substrate to "draw" moisture through the coating. This can cause the active corrosion of the substrate long before the protective coating fails.

The US Navy started limiting chlorides in the early 1990s, setting limits of 10 µg/cm2 for non-immersion service and 5 µg/cm2 for immersion service. For various reasons, including premature failure, these limits were reduced to 5 µg/cm2 for non-immersion service and 3 µg/cm2 for immersion service. These lowered limits appear to be providing better results. Some state departments of transportation (DOTs) have used a limit of 10 µg/cm2 but many are also still encountering unacceptable premature failures. Today, at least one state has adopted the US Navy standard as they find it is an achievable level and that coatings are performing as desired. The more knowledge the coatings and surface preparation industry gains about the direct relationship between salts and corrosion, the more they are beginning to realize how damaging salts are.

Where Do Salts Come From?

Our environment is filled with sources of salt contaminants, both natural and man-made. Chlorides from marine environments, water treatment, paper bleaching and deicing products are only a few of the many sources of chloride contamination to which steel surfaces and uncoated rebar in concrete become exposed. Sulfates are produced by natural sources and are generated from stack gas and diesel emissions (oxidized from sulfur dioxide) and nitrates from diesel and auto emissions (oxidized from nitrous oxide). Converted to weak sulfuric and nitric acid in the atmosphere, when in contact with

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moisture, these are deposited on surfaces as acid rain. Chlorine and sulfuric acid are the two most widely produced and used chemicals in the world. Nitrogen fertilizers, in their manufacture, transport, use and runoff, result in oxidized nitrates, another salt, which is corrosive on metallic surfaces. Even without human intervention, nitrogen is in a constant cycle, alternating between soil and atmosphere. Nitrogen is constantly available in the atmosphere for deposition, and lightning readily converts atmospheric nitrogen to nitrogen oxides, which can form nitric acid.

It is important to remember that surface contaminating salts are not localized to coastal areas or locales where de-icing salts are used. Industrial and automotive emissions transform to acids, which can convert to surface salts. Salts are all around us and in so many products that we do not even realize their presence. Salts are so widely spread from so many diverse sources that virtually every surface is subject to salt contamination at some level.

Even accepted surface preparation methods can leave behind the beginnings of corrosion. A common practice is to acid-etch concrete surfaces prior to applying coatings. If hydrochloric acid is used in this process, chlorides may be left behind. Etching the substrate with sulfuric acid can leave a sulfate residue.

A Salty Impact On Coating Performance

Salts left on a surface prior to the application of coatings can be the cause of several occurrences. Soluble salts, as often encountered in the coatings industry, are hygroscopic, meaning they draw moisture to achieve their highest level of chemical stability. For example, in many households around the world there are grains of rice or pieces of cracker in the saltshaker to absorb moisture. Without the rice to absorb the moisture, the salt will draw the moisture from the air and cake. Salts, such as chlorides, sulfates, and nitrates, do the same thing when left on a metallic surface — they draw moisture.

An active corrosion cell requires four components: an anode, a cathode, a metallic pathway, and an electrolyte (a conductive liquid). The surface of a piece of steel consists of many thousands of minute areas that are either anodic (repellant) or cathodic (attractive) to each other. The steel itself provides the metallic pathway connecting them. Introduce a chloride ion into the equation — which will draw moisture from the air and become the electrolyte — and there are now all the components needed for an active corrosion cell.

All liquid-applied coatings are moisture-vapor permeable, thereby allowing the salt on a substrate to “draw” moisture through the coating, causing active corrosion of the substrate *long before* the protective coating fails.

The coating is applied, the salt ion draws moisture through the coating and provides an electrolyte behind the coating and an active corrosion cell is formed. The products of the corrosion cell activity are acidic and will corrode the metallic surface around the cell. We have all seen blistered paint which, when the blister is broken, exhibits rust on the backside. In nearly all cases, that paint was applied over salts. In immersion service and some atmospheric service, other than very dry environments, this same hygroscopic action will cause osmotic blisters.

The scenario is much the same with coatings applied to concrete. Salts left on the surface will absorb moisture through the coating, which will produce weak acids on the concrete surface. The weak acids will react with the concrete and cause it to deteriorate beneath the coating. These same acids/salts, in immersion or damp service, can also

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cause osmotic blistering of concrete coatings. These salt contaminants can also be introduced onto a concrete surface when etched by or exposed to hydrochloric or sulfuric acid.

Salts also can interfere with adhesion or bonding between coats. For example, at a lighthouse in the Florida Keys, the specifier was aware of probable contamination from the marine environment, so the specification required that the surface be washed with potable water into which a salt remover had been added. The surface was washed, the prime coat applied and left to dry overnight. The next day, an intermediate coat was applied. The third day, a finish coat was applied. In a few weeks time the coating began blistering and peeling. It was not blistering from the surface, but from between coats. Subsequent investigation determined that in the time period in between the coats, the surface had become recontaminated with salts.

When it comes to salts, specifications have to be specific. Future articles will explore a variety of tests for determining the presence of, and methods for removing, soluble salts. Nature, time lapse, location, all are potential sources of soluble salts. And all can doom a project to premature coating failure and corrosion before anyone even steps onto the jobsite. The good news is that there are methods for combating salts and the opportunity to do so starts with the project specification. CP

JAMES R. JOHNSON has over 20 years experience in the fields of protective coating sales, application, and inspection. He served as a two-term Chairman of NACE STG-04 Surface Preparation Committee; Chairman of TG-142 joint NACE/SSPC task group on Decontamination of Contaminated Surfaces; and as Vice-Chairman of TG-288, NACE Task Group, Designating Non-Visible Contaminant Levels. He is a member of the joint NACE/SSPC task group on Wet Abrasive Blasting, as well as a member and previous Chairman of SSPC C.2.7 Soluble Salts Committee.

Soluble Salts and Specifications

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Soluble salts are at the forefront of discussion regarding corrosion. In an effort to provide the industry with comprehensive information about corrosion prevention, CoatingsPro *and ChlorRid are pleased to present the second article in an on-going series.*

Soluble Salts and Flash Rust

Virtually all rust on metallic surfaces is influenced or induced by salt contamination. We have been taught to believe that whenever there is bare steel and humidity, there will be flash rust. This is so ingrained into our thinking that some have a hard time believing that bare steel can be wetted and not rust. Take a clean uncontaminated steel coupon, abrasive blast it to White Metal, hold it at a 45 degree angle, and pour deionized (DI) water over it. Even though it will be thoroughly wetted, it will not rust! Take the same piece of steel and pour tap water over it, and then watch a light flash rust form, caused by the ions in the tap water. Add salt to the water and pour it over the same panel, it will flash rust much more heavily. As stated in the executive summary by Dr. Gerald Soltz in his research work for the National Shipbuilding Research Program, “Clean uncontaminated steel will not rust, even in 100% humidity, for thousands of hours.”

The old habit of “blast it and paint it quick before it flashes” now has been found to be inappropriate. If flash rust occurs to any great degree, the substrate should be tested for contamination, because the rust is probably the result of non-visible soluble salt contamination. Without some ionic species present, there will not be rust. Even very low soluble salt levels can cause an appreciable amount of flash rust.

ABOVE ▲ If flash rust occurs on the steel substrate, the steel should be tested for contamination, because the rust is probably the result of non-visible soluble salt contamination. Without some ionic species present, there will not be rust. Even very low soluble salt levels can cause an appreciable amount of flash rust.

Identifying And Testing For Salts

There are several common field methods to test for and assess contamination levels. None of the field test methods can quantitatively measure the contaminants directly on the surface. The contaminants first must be extracted from the surface into a solution where they can be measured in parts per million (ppm). The ability of a certain method to perform this extraction is called the extraction efficiency, typically stated in the percentage of contaminants extracted from the surface versus the total on the surface. No method provides 100% extraction and the efficiency differs greatly from one method to another. Once the contaminant is in solution, a variety of methods can be used to measure the parts per million (ppm) of a particular ion. This also varies from method to method, with differing degrees of difficulty, accuracy and other limitations, such as the minimum detection limit. The chosen test method is, therefore, a combination of two separate critical steps blended in a single methodology. Whichever methodology is chosen, in order to have useful information, the ppm must be converted to micrograms per square centimeter ($\mu g/cm^2$), meaning a specific amount of salt over a specific area, a prime concern for adequate surface preparation. To perform this conversion, multiply the concentration of salts in solution (ppm) by the volume of extract liquid (milliliters) and divide that by the surface area sampled (square centimeters). The result is micrograms per square centimeter, expressed as $\mu g/cm^2$.

The Society for Protective Coatings SSPC-Guide 15, Field Methods for Retrieval and Analysis of Soluble Salts on Substrates, provides information on the commonly used field methods. It explains the swab method, the adhesive cell method, and the adhesive sleeve method. It also describes the advantages and disadvantages of each method. Unfortunately, the Guide does not provide any information as to efficiencies of the different extraction methods. The primary differences between the test methods are the extraction efficiency, degree of accuracy, lower limit of detection, ease of use, and the degree of potential operator error. Errors usually occur because of complexity of procedures, accuracy in measuring, and cross-contamination from reuse of components. Several factors should be considered when choosing a test method. No matter how cautious an operator is or how accurately he measures, he cannot overcome the accuracy, efficiency, limit of detection, or other limitations of a particular test method.

Regarding extraction efficiencies, there is limited data available. Stated in an outdated document, SSPC-TU-4, retrieval efficiency of the swab method is between 25% and 35%, as determined under controlled laboratory conditions. The same document reports the retrieval efficiency of the adhesive cell as 45% to 60%. The manufacturer of the adhesive sleeve reports retrieval efficiency as 75% to 80%, as tested by an independent laboratory.

Specifying the correct test method is important. For example the swab method is extremely hard to execute on a vertical surface and all but impossible overhead. Conversely, the other two methods — adhesive cell and adhesive sleeve — can be performed in any direction. It is easy to see that when critical areas are vertical or overhead surfaces, good quality assurance requires that the appropriate method be used.

Another important variable that must be considered is the test limit of the kit, more specifically the lower limit of the method used to determine the concentration of salts in solution. Typically, this has been measured by titration strip or detection tube. One common titration strip has a lower limit of ~ 30 ppm, while a common titration tube has a lower limit of ~1 ppm. Since concern for soluble salts is generally in the lower concentrations, this lower limit comes into the equation, therefore, using certain kits can cause false negatives. Another method uses reagent chemicals which provide a result within a certain range, such as over 10 but less than 20.

Specifiers should also consider potential error from factors such as cross contamination from test to test, inaccurate measurement of liquids and area, and overall complexity of the test procedures. Directions for performing these tests are included in SSPC Guide 15. This same document can be very helpful and informative to the inspector or contractor so they may fully understand the requirements.

In view of the variables involved in testing for soluble salts, it is reasonable to say that a correctly written specification should require that a specific test method be used and it should indicate the maximum test result permissible by that method. A specification that simply says, for example, “chlorides are not to exceed 5 ppm” leaves much to be interpreted. Does the specifier intend the test result to not exceed 5 micrograms per square centimeter? Can any method be used? It is easy to see how an inspector or contractor could be left in controversy by such a specification. A specification should stipulate a particular test method, an acceptable test result and/or a factor (multiplier) to be used for different test methods.

The real life situation is that any amount of soluble salt, particularly chlorides, sulfates, or nitrates, is probably detrimental to some degree to the overall lifespan of the coating. The cleaner the surface, the greater the potential for a successful life cycle performance of a coating . A literature review found that virtually every coating is formulated to be applied to a clean, uncontaminated surface. After NEPCOAT (a consortium of north eastern state DOTs) spent years testing coatings in the laboratory, these coatings were applied to salt-contaminated surfaces in the field and every one of them failed, even though they had passed testing in the lab.

Since salts are a relatively new subject to many people, it is easy to understand that people are also not aware of the costs or methods of salt removal. Many specifiers fail to specify low allowable concentrations of soluble salts for fear of cost; others simply do not want to spend any additional funds. When all costs of asset downtime, surface preparation, and coating application are factored into a cost analysis, the cost of a premature failure is exorbitant when compared to the cost of taking reasonable steps to identify and remove soluble

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ABOVE ▲ Testing methods for soluble salts include the swab method, the adhesive cell method, and the adhesive sleeve method. When choosing a test method, it is important to remember several factors. No matter how cautious an operator is or how accurately the measurements are taken, the accuracy, efficiency, limit of detection, or other limitations of a particular test method must be considered.

salts. Costs of surface preparation and coating application are generally estimated in dollars per square foot, while reasonable costs of soluble salts testing and removal are generally estimated at only cents per square foot.

Why Ion Specific Testing For Salts Versus Conductivity?

In a previous article, ("Notes From The Field," *CoatingsPro*, March 08), we established the importance of even low levels of specific salt anions when considering the corrosive effect and impact to the performance of a protective coating. Conductivity was developed as a quick way to estimate conductive species on metallic surfaces in and around marine environments. The use of this estimation method in a marine environment for testing surfaces subject to sea water exposure only is a widely used indicator of the amount of chloride present.

In non-marine areas however, many other ionic species will interfere with the detection of corrosion-inducing salts because not everything that is conductive is corrosion-inducing. A simple example is the dissolution of carbon dioxide in the atmosphere in moisture vapor to form carbonic acid. Carbonic acid is conductive, yet in and of itself, it does not have the same corrosion-inducing effects of salt anions. The EPA's annual deposition maps verify this fact. Furthermore, in marine service, alkaline environments are beneficial in passivating surfaces (keeping them from corroding). Salt water is slightly alkaline (with a pH up to 8.1). This alkalinity is very slightly beneficial to the marine industry in mitigating corrosion because it operates in a highly salinic environment which is alkaline. In contrast, environments further from the ocean are more acidic (acid rain fallout) which reverses surface passivation. In other words, in an acidic environment, subjecting steel to anion contamination will induce corrosion at a more rapid pace because the passivation process cannot occur. It is documented in SSPC 91-07, and referred to in SSPC's TU4 that the adhesive cell method extracts somewhere around 50% of chlorides with DI water. The adhesive cell method is the prevalent way of obtaining samples for testing used in conductivity.

Conductivity assumes either that all the conductive species are chlorides (or converted to chlorides) or some major percentage is chlorides. From independent work done by a KTA-Tator Laboratory some years ago, little or no correlation was found between the levels of chlorides and conductivity. The results demonstrated that one can have low chlorides, yet high conductivity and vice versa.

This, then, raises the concern about cost. In testing with conductivity, high results would infer high levels of chlorides which may not be valid. Excess expenditures may be incurred which are not necessary. For example, Swedish research concluded that it takes several times the level of sulfates to get the same corrosion inducing effect of chlorides. Yet, conductivity cannot discern this difference.

Also, it is not just the anions (chlorides, sulfates, and nitrates) that are important in the corrosion cycle. The cations play a very important role. Conductivity is not ion-specific so measures them both. Chemically speak-

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ing, in the corrosion cycle, when the sodium of sodium chloride dissociates in the presence of moisture, and the chloride serves as the electrolyte of the corrosion cell, the sodium — because of size and reactivity — moves out of the corrosion cell to the periphery to form a hydroxide. Other cations such as calcium will do the same thing, although much more slowly, impeding the pace at which the chloride operates as an electrolyte in the corrosion cell on the steel surface. If you measure everything that is conductive, how do you know how much of what species you are dealing with?

Conductivity seems to be a more engineer-oriented approach. Chemists will speak to ion-specific issues, most generally because one can test for ion-specific species in the laboratory. Conductivity measurements are actually the inverse of resistivity, which is what is actually being measured. When you get to the inferred level of chlorides, yet another set of mathematical calculations take place. Chemists are big on math, but engineers thrive on it.

In summary, if only around 50% of the actual salts are extracted, and you get an indication of an assumed conductive species on a surface through conductivity testing, you can't expect very exacting results. Since salt anions, such as chloride, impact a coating's lifecycle performance so dramatically, accuracy in surface preparation becomes a matter of paramount importance. It is surface cleanliness prior to a coatings system's application that will help provide the desired lifecycle performance. CP

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Removing Soluble Salts

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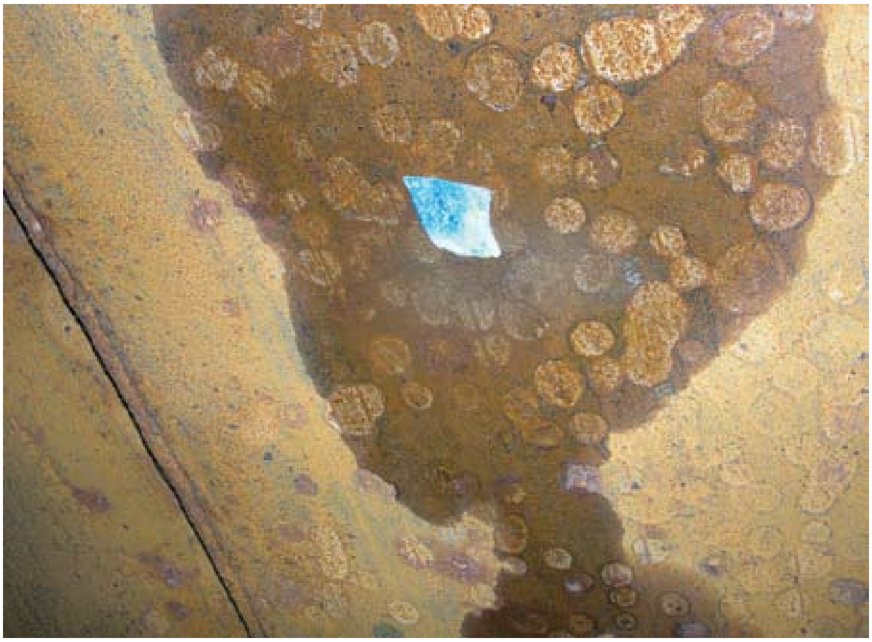

ABOVE ▲ Often a coatings specification for a steel substrate will call for surface prep using Ultra High Pressure Water Jetting (UHP-WJ). However, salts that have attached to and reacted with a metal substrate sometimes cannot be removed even with 40,000 psi UHP-WJ. Once these chloride ions form an attachment to the metal substrate, a very high level of energy is necessary to break that electro-chemical bond.

How Do You Remove Salts?

Removal of soluble salts can range from very easy to extremely difficult, depending on actual conditions which can vary greatly. Consider just one very common salt — sodium chloride. The chloride ion is never found by itself. As it is commonly encountered in the coatings industry, the chloride ion is always coupled with something else. For chemical stability, the chloride ion (this also applies to sulfate and nitrate ions) seeks to attach to something, forming compounds such as sodium chloride, zinc chloride, lead chloride, ferrous chloride, or any of several other combinations.

When a coated surface becomes contaminated with sodium chloride, the salt lies on the surface. Due to the chloride ion's strong affinity for metals and its extremely small size (1 µg of FeCl3 = ~ 3,686,600,000,000,000 molecules), even very small imperfections — such as nicks, scratches or micro cracks — in the coating allow the ion to migrate to the metal surface. At the metal surface, with the chloride ion having its affinity for metals, it leaves the sodium and bonds with the metal surface for greater stability. The chloride ion forms an electro-chemical bond to the metal and that bond becomes extremely strong. That is why it cannot be simply washed off with a garden hose. Where the sodium chloride would have been relatively easy to remove from the surface of the coating, the chloride ion now has bonded with the metal surface and is far harder to remove. For example, most of the salts on the surface of a coating can be removed with low-pressure water blasting, but salts that have attached and reacted with the metal substrate sometimes cannot be removed with 40,000 psi Ultra High Pressure Water jetting (UHP-WJ).

Once these chloride ions form an attachment to the metal substrate, a very high level of energy is necessary to break that electro-chemical bond. That energy can be in the form of mechanical energy, chemical energy, or both. The properties of mechanical energy are widely known, but many coating professionals

> **The coating manufacturers should be asked not only what the allowable level of salts is, but they should be asked what the allowable level is to attain an intended or targeted lifespan.**

are unaware of the ability or chemical requirements of a salt remover. Since it was a series of reactions that resulted in the bonding of the salt anion to the steel substrate, chemical disbondment is the most effective method and has the highest probability of success of removal if the proper product is used.

Chemical salt removal is not new to portions of the coating industry. Pipe coating operations have been utilizing a phosphoric acid bath for several decades for salt removal. For maximum effectiveness, a salt remover should have several distinct properties:

1) The pH of the remover should be below 7 to facilitate disbonding, as supported by both chemistry textbooks and history. Products with a pH above 7 accelerate the formation of a barrier layer which can mask salts remaining on a surface.
2) The remover should be capable of being used with water that contains a fairly high level of salts, such as 600 ppm of chlorides, as is common with many water sources.
3) It should not leave any type of residue that will interfere with adhesion of coatings.
4) It should not leave any film that will interfere with the adhesion of a coating.

As has been stated, the mechanical energy of pressurized water alone sometimes cannot do the work, but when combined with the chemical energy of a salt remover the work can be accomplished successfully. One form of energy assists the other, thereby providing the needed energy to complete the task.

On an abrasive-blast-cleaned surface, chlorides can usually be adequately removed with the mechanical energy of a 3,000 psi pressure washer with a salt remover added, providing the chemical energy needed to perform the task. The water pressure is important for penetrating the crevices of the surface profile that exists on abrasive blasted metal surfaces — in joints and connections and similar locations and for flushing the disbonded salts from the surface. The action of a chemically balanced salt remover will take on the challenge of disbonding the chloride ion from the metal while the water flushes it off.

RIGHT ▶ When confronting the problem of soluble salts, it is important to remember that soluble salts are not only found in marine environments or in areas where de-icing salts are used. Industrial emissions transform to acids, which can in turn convert to surface salts.

When discussing water on bare steel, the subject of flash rust invariably arises. Reviewing what was stated in an earlier article (“Notes From The Field,” May 08), contaminants, including minerals, cause flash rust, so when the contaminants are removed the cause of flash rust is removed.

Note: Since it is uncommon to totally remove all contaminants from all surfaces, there usually are some very low levels of salt contaminants remaining after decontamination. This is because of the irregular structure of a metal surface after abrasive blasting. When an abrasive blasted surface is viewed under magnification, it can be seen that the abrasive has impinged onto the surface, forming the valleys and peaks of the profile. Also visible at the same time is that succeeding abrasive grit has burred over the peaks and even created cave-like formations where one peak burrs over and meets another. To remove 100 percent of these incredibly small ions from such locations can be almost impossible. Even a very small amount of contamination can cause some flash rust, but it is typically very minimal and in many cases reblasting is not necessary. Some manufacturers of coatings, primarily for immersion service, do require a full white metal surface with no flash rust. In this case, it is usually necessary to perform a light sweep blast to remove any small amount of flash rust or use an approved inhibitor, or passivator product.

Dry and Wet Blasts: Which To Use And When?

There are several methods available to remove salts; only one is a dry method; the others all include the use of water. The dry method involves repeated abrasive blasting. A fine grit abrasive blast media is more effective at removing salts than coarse grit, so an engineered abrasive mix is sometimes specified (coarse abrasive to provide the necessary profile and fine abrasive for cleaning). But seldom can an effective job of removal be accomplished in a single abrasive blast. Typically, a surface has to be abrasive blasted, allowed to rust back and then reblasted. It is not unusual to reblast a highly contaminated surface multiple times to reach an acceptable level of cleanliness, particularly on highly contaminated surfaces such as those found in marine environments, pump bodies, and water inlets. The rust-back process can be activated by atmospheric humidity or hastened by a water wash; simply add moisture and the salts will do the rest. The costs associated with such an operation make this an economically questionable process.

Of the wet methods, there are several choices, such as UHP-WJ, wet abrasive, or slurry blasting, and dry blasting in conjunction with a water wash with a salt remover added, which sometimes requires a reblast as stated above. Other less common methods exist, such as specialty abrasives, but a particular type of abrasive alone will probably not remove all salts, though some abrasives

LEFT ◀ All liquid-applied coatings are moisture-vapor permeable and will allow the salt on a substrate to "draw" moisture through the coating, causing the active corrosion of the substrate long before the coating fails.

do "scrub" the surface better than others. Reviewing the various options available, it can be determined which method will work best for a particular job.

UHP-WJ can, but not always, result in the desired level of cleanliness. If you want to be assured of attaining the desired cleanliness levels on a first time basis, add a suitable chemical salt remover to the water. This combines both mechanical and chemical energies, each assisting the other. This also allows the operator to proceed as fast as the visual work can be performed while being assured the non-visible contaminants will be removed. Maximum production can be achieved in this manner.

Wet abrasive blasting, or slurry blasting, can reduce chlorides, but may not attain the desired result in a single blast. A suitable chemical salt remover can be added to the water, thereby combining chemical energy with mechanical energy. In every reported case using a low pH chemical salt remover, this method has resulted in chlorides being reduced to a non-detectable level with a single blast. A brush blast may be required to remove light flash rust, usually quickly and easily accomplished, or an inhibitor may be used in the rinse down water.

Wet abrasive blasting is not used frequently because "old habits die hard" and contractors are accustomed to dry abrasive blasting. Many contractors say that they do not want to make major equipment investments, not knowing the task can be accomplished with something as simple as a water ring, usually costing under $100.00, or an injector type nozzle, costing just slightly more, installed on their existing blast equipment. Wet abrasive does not sweep easily, but it can be vacuumed or shoveled much the same as dry. This method does offer greatly increased visibility, which is a major consideration. Because wet abrasive blasting is almost dust free, environmental compliance is far less an issue. Since operators have better visibility, additional blast nozzles can be operated to complete a job more quickly. Because dust is not generated, time and labor savings result with a cleaner surface for coating adhesion.

The technique most commonly used is a dry abrasive blast of any rusted areas, sufficient to remove rust to an exposed bare steel substrate, such as would be provided by an Industrial Blast Standard. Depending on the extent of rusting, this could be either a spot blast or a complete blast over the entire surface. This blast is

RIGHT ▶ It all hinges on information. For information regarding the requirements of a coating system it is traditional to go to the coating manufacturer. Since they know their product best, they are the most able to provide guidance on allowable salt levels. To gain meaningful information, the coating manufacturer should be asked not only what the allowable level of salts is, but they should be asked what the allowable level is to attain an intended or targeted lifespan. Tying the lifespan requirement into the equation will result in much more meaningful input — and fewer premature coating failures due to soluble salts.

merely to remove any barrier materials, such as rust or damaged coating, and to provide access to the salts so they may be removed. A pressure wash is then performed, usually a minimum of 3,000 psi, with a salt remover added to the water, again providing a combination of mechanical and chemical energy for removal. A final blast is then performed to the standard required by the specification. This same technique can also be performed by first dry abrasive blasting to the standard required, and then performing the pressure wash with the salt remover, followed by a brush blast to remove any excessive flash rust or a rinse with an approved inhibitor. Either method works well and can be relied on to achieve the desired result if performed correctly. These methods are very cost effective and do not cause problems to cleanup, workers, or the environment. Each of the above is uniquely different and as each job is different, the option may be chosen that will provide the best result for each specific project.

Allowable Levels Are The Question

The entire coating industry is asking for guidance on allowable levels of salt contamination. Though many have voiced their opinions — some very loudly — almost all are people who will not bear the cost of a premature failure. The old adage seems to apply here — “Advice is cheap.” If advice is not correct, the advisor seldom is held responsible for the results. For information regarding the requirements of a coating system it is traditional to go to the coating manufacturer. Manufacturers provide requirements for profile, mil thickness, recoat windows, etc. Since they know their product best, they are the most able to provide guidance on allowable salt levels. In order for them to do this effectively, they need to be informed of the intended project lifespan. To gain meaningful information, the coating manufacturer should be asked not only what the allowable level of salts is, but they should be asked what the allowable level is to attain an intended or targeted lifespan. Tying the lifespan requirement into the equation will result in much more meaningful input. Proceeding in this manner should provide the best answer to the question.

Our industry is changing. We, as a group and as individuals, are faced with change and challenge in order to keep up with technology. While we have relied on visible standards for surface preparation, we need to recognize that we must also be concerned about non-visible contaminants. This requires specific testing. To avoid premature failure of coatings, excessive soluble salt contaminants need to be removed. CP

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*The information provided in the series is a synopsis of materials presented at CHLOR*RID International, Inc.’s Soluble Salt Training Sessions. Additional educational and informational materials are available online at www.chlor-rid.com. For more information, call (800) 422-3217 or e-mail info@chlor-rid.com.*