Coating The Reactivator Tank: A Step Into The Future

BY JOHN BRODAR P.E., OWNER REPRESENTATIVE, AND RANDY CARLISLE, SUPERINTENDENT KEENE COATING
PHOTOS COURTESY OF THE AUTHOR

The Navajo Generating Station (NGS) is a jointly owned, coal-fired generating facility with three 750 megawatt (MW) units located in Page, Arizona. Operated by the Salt River Project (SRP), the Page facility sits at the southern end of Lake Powell, straddling the Arizona-Utah border. In terms of transportation and industrial support, this is one of the most physically remote areas in the continental United States. It is two hours by road to Flagstaff, Arizona, and to the nearest rail transportation. Normally, any type of major maintenance work needs to be planned well in advance.

The assignment to repaint the NGS Reactivator 2 (Clarifier) during the scheduled 2010 outage came as a last-minute surprise. It was only considered after the midpoint of the outage when it became clear that not all allocated funds were going to be needed for the scheduled work. Management began looking for other required but unscheduled maintenance work that could be completed during the outage. I was asked if Keene Coating, the painting contractor performing the coating work in the circulating water lines, had the manpower and time to abrasive blast clean and coat the walls in the open top, 135' (41.15m) diameter 24' (7.32m) tall Reactivator 2 tank. I replied that I would develop a coating procedure and get an estimate.

From the beginning, there were complications for this coatings project. It was late February. The jobsite is at a 4,199' (1,279.86m) elevation. It can rain, snow, or sleet at any time at that time of year, and we would be painting an open top tank. The cool-to-freezing nighttime temperatures would seriously retard coating cure. Also, the corrosion rate in this tank had changed dramatically a few years earlier when we switched to ferric chloride as a more economical additive to the water treatment process: chloride ion contamination was now a known problem. To add to the problems, this would be a maintenance painting project.

MAINTENANCE PAINTING VS. NEW COATINGS

Maintenance painting for equipment in immersion service has long been recognized as a specialized field with its unique set of problems. Maintenance painting is generally more severe than new construction painting, especially for immersion service. In

LEFT When NGS management began looking for unscheduled maintenance projects during a scheduled outage, their attention turned to the pitted and rusted carbon steel Reactivator 2 tank.

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ABOVE ▲ Navajo Generating Station (NGS) serves electric customers in Arizona, Nevada and California. The coal-fired generating station also supplies energy to pump water through the Central Arizona Project.

recent years, there has been a growing amount of evidence indicating that a major cause for coating failure in maintenance painting is due to the presence of water-soluble ions left on the prepared surface. Hand and power tool cleaning removes virtually none of these water-soluble ions. Blast cleaning to white metal removes some of these contaminants, but doing so embeds many into the surface of the steel. This surface contamination of even white metal blast cleaned steel is responsible for many of the premature coating failures experienced during maintenance painting operations.

The painting adage, "Apply primer within eight hours of blast cleaning or before flash rusting occurs," is a warning flag. If flash rusting occurs during dry blasting operations, it is almost certain that water-soluble ion contamination is present on the blast-cleaned surface. Flash rust is a red warning flag signaling the probability of water-soluble ion contamination.

Uncontaminated blast-cleaned steel does not experience flash rusting from high humidity alone. Direct contact with water from rain, snow, dew, or condensation is necessary to cause flash rusting of clean or uncontaminated blast-cleaned surfaces. A blast-cleaned but soluble-ion-contaminated surface will flash rust, even though there is no direct contact with liquid water. These soluble salts are hygroscopic—they absorb moisture out of the air. Higher levels of contamination and/or higher levels of humidity will accelerate the flash-rusting process. In extreme cases, a color change can be noted in five minutes or less—under some conditions the color change from flash rusting can be observed while it is occurring.

DEVELOPMENT OF THE COATING PLAN

With this in mind, a coating plan for the reactivator tank was coming together in my head. I reviewed the data sheet for the Carboguard 235, which was already approved and in use on site in the circulating water lines. Carboguard 235 is a surface-tolerant, high solids coating described by its manufacturer as a ballast tank coating. Available in a low temperature cure version, this coating would be ideal for the intended work in the winter environment.

The open top tank itself, however, presented a significant problem. NGS is in an environmentally sensitive area—near the Grand Canyon and other national parks. Personnel at NGS have worked for decades to establish and maintain its status as a low volume hazardous waste generator. Nevertheless, as a coal-fired generating plant, the site is subject to intense scrutiny. A continuous dust cloud from open air blast cleaning would not be acceptable to my clients, the NGS Management.

The traditional solution for surface preparation for an immersion coating would be to tent the tank for dust containment and require a white metal blast-cleaned surface. Neither time nor funds would permit this approach. A wet abrasive blast would control the dust and was permitted by the regulations. A wet blast, using a water ring on the blast nozzle, with Chlor-Rid in the dust suppres-

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RIGHT Although the steel surface of the reactivator tank was covered with flash rust, the specifying engineer was certain that it could be coated—because it was decontaminated of chlorides and sulfates.

sion water, would be an acceptable solution. From past experience, I knew that a one-step abrasive blast-cleaning operation with Chlor-Rid in the dust suppression water would:

- Eliminate all visible air-borne dust,
- Allow complete decontamination of the surface from all water-soluble salts of chloride, sulfate, and nitrate,
- Leave the steel surface in a mixed condition (on a small scale) of near white metal and tightly adhering rust.

This coating plan was only slightly different than the work already in progress in the circulating water lines, which included:

- Ultra High Pressure Water Jetting (UHP WJ) to remove old coating and decontamination (with Chlor-Rid in the wash water),
- Removing spent water and old coating,
- Allowing the surface to dry,
- Performing a traditional white metal blast,
- Applying two coats of Carboguard 235 epoxy at 6-8 mils (0.15mm-0.20mm) DFT per coat for a total DFT of 12-16 mils (0.30mm-0.41mm).

Keene Coating of Salt Lake City, Utah, was already on site, decontaminating the steel circulating water lines of chlorides prior to repainting with Carboguard 235. And this was not the first job that Keene had performed for SRP. In fact, by the time of this project in 2010, there had been a 10+ year relationship established among the personnel involved; there was mutual respect and trust. As the owner's representative, I knew that I could expect an outstanding performance from the contractor at his quoted price. The contractor knew that the owner would not expect him to perform more than the specified work; if unforeseen conditions prevailed, the work scope and pricing would be fairly adjusted.

I had the contractor I needed in Superintendent Randy Carlisle. I had the paint material. I had a dust control method. I had a decontamination method. I had the tank. Keene Coating quoted a price that was acceptable for the work involved. We had a coating plan. We, a team consisting of the owner representative (me) performing the specification work and a competent, able, professional coatings contractor in Keene Coatings, in addition to Carboline, a coatings manufacturer able to meet our demanding schedule, and Chlor-Rid, a manufacturer of chemical soluble salt remover, all came together to make this project happen. The clock was ticking.

WHAT LEVEL OF SURFACE PREPARATION IS THIS?

It should be noted that the surface preparation standards simply do not describe the intended finished surface of this tank. While the tank would ultimately be cleaned to NACE No. 2/SSPC SP10, "Near White Metal Blast Cleaning," it would also experience flash rusting due to the direct application of water. It should be pointed out that even in the flash-rusted condition, the tank would exceed the requirements for NACE No. 4/SSPC SP-7 "Brush-Off Blast Cleaning":

"A brush-off blast-cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, loose mill scale, loose rust, and loose paint. Tightly adherent mill scale, rust, and paint may remain on the surface. Mill scale, rust, and paint are considered tightly adherent if they cannot be removed by lifting with a dull putty knife."

Yet, the finished condition would not meet the requirements of NACE No. 3/SSPC SP-6 "Commercial Blast Cleaning" because of the uniformly distributed flash rust:

"A commercial blast-cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dust, dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter, except for staining as noted in Section 2.2."

However, it was my strong belief and conviction that this intended surface, *fully decontaminated of chlorides and sulfates*, would provide a better substrate for subsequent painting than even a white metal finish. I believed that the use of a surface-tolerant coating over this soluble salt decontaminated surface would provide decades of maintenance-free service. This would be possible by the qualified application of an excellent coating over a surface that had a suitable anchor pattern, and was free of water-soluble salt contamination even though it was showing flash rust.

THE PAINTING

Carlisle and his five-man crew had 10 days to clean, prep, and coat the carbon steel walls of the 135' (41.15m) diameter 24' (7.32m) high reactivator tank. "Fortunately, the weather was actually good during the project, but we had to be prepared for snow or rain," Carlisle remembers. "The carbon steel itself has considerable pitting from chlorides."

This was not his first encounter with chlorides. As Carlisle tells it:

"I met John Brodar in 1999 at NGS where we were removing old coating from the circulating water lines using a 1300 Ingersoll Rand air compressor with a 6 ton Clemco blast pot to abrasive blast in preparation of recoating. At the very first inspection of our abrasive blast, Brodar said we had a serious problem. I couldn't see any problem, but he kept pointing to these slight discolorations and muttering 'chlorides.' Then he got some yellow paper and a spray

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bottle. Every place he sprayed with distilled water and applied the paper changed color from yellow to blue. He explained that it was an indicator of chloride contamination on the steel. I could see that some of the steel did not rust even with the sprayed-on distilled water.

Next was the really scary part. He said that we would have to wash the entire blast-cleaned area with water and a chemical, Chlor-Rid, and then re-blast. While I was worrying about costs, he assured me that it was not my fault, that we were not to blame; the problem belonged to SRP and they would pay to correct it. We continued blast cleaning while we waited for the 3,500 psi Clemco water washing equipment and Chlor-Rid delivery. During that time, my nice white metal blast-cleaned surface began to rust in very specific locations. I was beginning to think that there might be something to this chloride contamination issue.

After we decontaminated the circulating water line and re-blasted to white metal, it simply did not re-rust. We had continuous ventilation of outside air, with no heat or dehumidification, yet there was no further rust. Since then, we have used Chlor-Rid on every single one of Brodar's specified jobs. The really cool thing is to come back and see work that we performed three, six, or nine years earlier that is still in outstanding condition. The best results are still with white metal cleaning, but even the hand tool cleaned surfaces decontaminated with a 3,500 psi power wash with Chlor-Rid are unbelievable.

We have developed several methods of applying the Chlor-Rid for decontamination, depending upon the condition of the steel, type of structure, and degree of cleaning required. In 2010, we were using Chlor-Rid mixed with the water in our power washers and hydro blast units to remove the chlorides in the carbon steel of the circulating water lines. For that work, we decontaminated the exposed steel and then blast cleaned to white metal before doing a total re-coat.

When Brodar asked about painting the reactivator tank and

BELOW ▼ The crew blasted the surface to NACE No.2/SSPC SP-10 "Near White Metal Blast" using a water ring on a blast nozzle and adding a mixture of 100:1 Chlor-Rid to the water to create a surface profile and remove chlorides from the carbon steel.

JOB AT A GLANCE

PROJECT:

Sandblasting and coating interior of reactivator tank at NGS

COATINGS CONTRACTOR:

Keene Coatings
4170 West 2100 South
Salt Lake City, UT 84120
(801) 972-3822
Keenecoatings@aol.com

SIZE OF CONTRACTOR:

50 employees; a 5-man crew worked on this project

PRIME CLIENT:

Salt River Project (SRP)

SUBSTRATE:

Carbon steel

SUBSTRATE CONDITION:

Considerable pitting from chlorides

SIZE:

Approximately 10,000 sq. ft. (929.03m^2)

DURATION:

10 Days

UNUSUAL FACTORS:

- Open top tank, with environmental restrictions on dust control
- SRP needed project completed ASAP, which made dust control difficult due to the large diameter of the tank and the center rake structure
- Weather was a concern—had to be prepared for rain, sleet, snow at any moment

MATERIALS/PROCESS:

- Crew prepped tank walls using a water ring on a blast nozzle and adding a mixture of 100:1 Chlor-Rid to the water to control dust while creating a surface profile and removing chlorides from the pits in the carbon steel
- Using a 4000 psi power washer, crew rinsed and cleaned carbon steel walls of spent abrasive, allowed to dry
- Using a Graco 74:1 spray pump, applied two coats of Carboline 235 onto the tank walls at a DFT of 6-8 mils (0.15mm-0.20mm) per coat

SAFETY CONSIDERATIONS:

- Crew wore Tyvek suits, cartridge respirator masks, safety glasses, gloves, and fall protection when working on scissor lifts

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POTASSIUM FERRICYANIDE

From 6G186

Appendix A

Potassium Ferricyanide Test for Soluble Iron Salts

Preparation of Test Papers:

Prepare a fresh solution of 4 parts by weight of potassium ferricyanide in 96 parts of distilled water. Prepare test papers by soaking a medium grade of filter paper (No. 1, 9 CM)[1] in the potassium ferricyanide solution and hang to dry in air. When dry, store in a black envelope or dark bottle to exclude light.

Test Procedure:

Select an area of the blast-cleaned surface that has previously shown heavy corrosion or pitting. Apply a thin film of distilled water using a clean impregnated pad about 20 to 30mm in diameter. When the distilled water has nearly evaporated, apply the test paper to the slightly damp surface and press for 15 seconds with the thumb or forefinger to obtain a good contact. Examine the underside of the test paper. The presence of blue spots indicates that soluble ferrous salts remain on the blast-cleaned surface, which should then be re-blasted.

For those needing a more formal reference, see ASTM A380, "Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment and Systems", 7.3.4 Ferroxyl Test for Free Iron, which is similar but includes nitric acid for use with stainless steel.

1 *An acceptable substitute is a filter paper of sufficient size for home coffee makers.*

the need for dust control, I immediately thought of tenting the structure. Then he asked me if I had ever used a water ring for dust control. Of course I had, but not while adding Chlor-Rid to the suppressing water. He explained that clean surfaces would look like white metal even though wet while contaminated surfaces would stay rusty or have dark brown or black spots in the bottom of pits. Continued blasting and application of the Chlor-Rid through the water ring would quickly decontaminate the problem area.

Once we started, it was amazing to see wet white metal. The pits did show dark brown and black spots, which we quickly removed. It took a little while for my guys to get used to what we were doing, but they caught on. They would find a re-appearing dark spot and simply blast it a little longer, then move on. If any dark spot re-appeared, they would hit it again. Deep pits were harder to clean than broad shallow ones. On top of everything else, even if it rained or snowed, it would not slow this rush job down! Typical decontaminated pitted areas showed the same light brown rust as non-pitted areas. We had to brush dry wet sand from some locations, because when abrasive blasting wet, some of the sand will stick to the surface, even after it dries. This loose sand has to be brushed, blown, or vacuumed off of the surface. Then we were ready to paint.

"Using a 74:1 Graco spray pump, we spray-applied two coats of Carboline's Carboguard 235 epoxy in a beige prime coat (6-8 mils/0.15mm-0.20mm DFT) and a light gray second coat (6-8 mils/0.15mm-0.20mm DFT)," says Carlisle.

In 10 days from start to finish, they had the tank coated…with not a moment to spare. As a final complication to this painting job, Reactivator 1 had a mechanical failure and Reactivator 2, with a brand new paint job, had to be put back into service with only a 3 ½ day cure, with nighttime temperatures in the low 40s to mid 30s (4°C to 1°C) and daytime highs in the low 60s (15°C). Would the new coatings hold up? Would my theory prove to be true? I had to wait for one year with bated breath to find out.

ABOVE ▲ "Then he [Brodar] got some yellow paper and a spray bottle. Every place he sprayed with distilled water and applied the paper changed color from yellow to blue. He explained that it was an indicator of chloride contamination on the steel," says Carlisle.

THE PROOF

The 2011 inspection of the NGS Reactivator 2 interior surfaces after one year of continuous immersion service is the crowning jewel of my coatings career (to date). Close inspection of more than 10,000 square feet (929.03m²) of surface area has revealed not one speck of rust. Even the 8" (20.32cm) threaded pipe nipple was free of rust. In fact, the only rust observed on the 2010 work was found on a single pipe.

Anyone can show a nice clean photo of a newly completed paint job. These show the coating results with soluble salt decontamination after one year in immersion service.

Carlisle agrees: "Coming back to Navajo in February 2011 for the next outage allowed me to inspect Reactivator 2, which we had painted the previous year. It had been in continuous immersion service for a year. One year later, it was literally identical to when we finished it. No rust spots!"

My first exposure to chlorides as a painting problem occurred in 1969 aboard the SS Delta Paraguay of Lykes Lines. It was early fall in the Gulf; we were heading to the east coast of South America from New Orleans. My task at the time was to use a sandblaster to remove the rust and old paint from the aft end of the forward house. The instructions were to clean the steel and paint it "before it rusted." The only problem was that 10 minutes after I had cleaned

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ABOVE ▲ The crew used a Graco 74:1 spray pump to spray-apply the specified two coats of Carboline 235 at 6-8 mils (0.15mm-0.20mm) DFT per coat.

an area, it was rusted again. After blasting several times, we painted anyway, over the rust.

The second exposure was in 1974 at the Agua Fria Generating Station, located in Phoenix, Arizona. Phoenix is in the Sonora Desert—it normally does not have the high humidity associated with an ocean passage. Nonetheless, here I was again, abrasive blast cleaning. It was the interior of a small 5' (1.52m) diameter chemical cleaning tank. Within minutes of cleaning any specific area, it rusted again. I clearly recall thinking that there must be something on the surface that I could not see. Something was causing some of the steel to rust almost instantly.

In 1983, I was watching a crew blast failed coatings from the wall of a Flue Gas Desulfurization Unit (FGD). They were blasting from the top down, with a work zone about 3' (0.19m) wide. By the time they were about 18" (45.72cm) lower on the wall, the upper portion began to rust. Since they were using copper slag and the dust was at a minimum, I was able to watch the freshly cleaned

BELOW ▼ After one year of hard service, even the 8" (20.32cm) threaded pipe nipple was rust-free.

TIPS FOR USING NACE 6G186

"SURFACE PREPARATION OF CONTAMINATED STEEL SURFACES"

POTASSIUM FERRICYANIDE TEST FOR SOLUBLE IRON SALTS

The negative ion (frequently chlorides or sulfides) is electrochemically driven to the steel/rust interface. If there is a substantial buildup of corrosion products and the potassium ferricyanide test paper is used, there is a very real likelihood of getting a false negative result. The rule of thumb is that the surface must be cleaned well enough to show some white metal. White metal may be exposed by abrasive blast cleaning, sanding, grinding, or wire brushing. In cases of extreme contamination, the detectable salts may permeate the corrosion products; this is most likely to be true if there is extensive pitting or extreme metal wastage.

This test will also work on copper and copper alloys contaminated with chlorides and sulfides.

In spite of the footnote in Appendix A, coffee filters make a very poor substitute for medium grade filter paper.

It is almost impossible to decontaminate cast iron. Effectiveness of decontaminating ductile iron is unconfirmed, but expected to be similar to cast iron. Apparently the ferrous salts deeply penetrate the porosity of the cast iron.

It is possible to paint on or spray on a liquid solution of potassium ferricyanide and get results ... not recommended if only slight levels are expected.

Potassium ferricyanide test paper and solution is photo-reactive. Test paper should be a bright yellow (smiley face yellow) prior to use. If soluble iron salts are present, the paper will turn blue. Fully reacted paper will be a deep dark blue. Partially decontaminated surfaces with deep pits will show pinpoint blue, indicating contaminants at the bottom of the pits but clean upper surface. It is almost futile to believe such a surface is clean enough to paint.

When following the instructions in 6G186, the idea is to get a light, uniform layer of water on the surface to put the salts into solution; waiting until just before the water evaporates allows these ions to concentrate prior to testing. Consider using an atomizing spray bottle to apply the distilled water.

Potassium ferricyanide test paper will change colors in storage. Storage has been attempted in white envelopes, yellow envelopes, and inside plastic bags. I suspect that a reaction is taking place with chlorides from the paper bleaching process or from a PVC compound of bag. Useful life appears to be about one year when stored in a cool dry place out of direct light.

When potassium ferricyanide is heated to decomposition or comes in contact with acid or acid fumes, potassium ferricyanide will emit toxic fumes of cyanides.

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ABOVE ▲ At the year-anniversary inspection, the only rust observed on the carbon steel substrate was observed on this pipe.

ABOVE ▲ Even at the steel/concrete interface there were no signs of corrosion upon inspection after one year in immersion service.

surface rust. I was sure that the something I had seen at Agua Fria was also present in the FGD.

Time and time again, I witnessed SRP or contractor crews doing everything right, but the coatings kept failing. And they failed at all of our facilities. I observed that the failures seemed to occur at the same spots. Once an area began to rust, it would likely be rusted during the next outage.

I first came across NACE Publication 6G186, "Surface Preparation of Contaminated Steel Surfaces," in the March 1987 issue of *Materials Performance,* page 49-54. Getting this document changed my painting career. Learning about "Water Soluble Contaminants" was an eye-opening experience. I now had a name for that mysterious something. The final key was reading about the "Test For Presence Of Contaminants" and in particular the "Potassium Ferricyanide Test for Soluble Ferrous Iron Salts (Fe++)."

Typically, this test only indicates ferrous salts. However, in our raw water, the water in the reactivator tank, the primary ions result in ferrous chloride salts. In our circulating water system where we add sulfuric acid for pH control, we also get sulfates. So, using potassium ferricyanide test paper and getting a positive indication requires the user to determine what the contaminant is in fact. In a marine environment you can safely expect chlorides. Around sulfuric acid it is sulfates. Rusted steel exposed to only fresh water or rain water typically doesn't pit and won't have these contaminants on the surface.

For three years after I made my first batch of test paper, I tested every coating failure I encountered. Every single coating failure tested positive—the bright smiley face yellow paper turned a deep dark blue. Except one. Then I learned that if the rust film was thick enough, if you did not have at least some bright shiny metal exposed, you could get a false negative. At this point it dawned on me that SOLUBLE ION CONTAMINATION—CHLORIDES, SULFATES, AND NITRATES— were the single largest problem plaguing the rest of my coatings career. Once I figured that out, I have never looked back. CP

VENDOR TEAM

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