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Flash Rust and Waterjetting Study

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Abstract: Certain areas of the primary wall in the AY-101 tank annulus are being cleaned with a remotely operated waterjet. There is some concern on how it will effect the surface of the tank wall after cleaning and how to prevent rust and corrosion from developing on the wall in the future. This study addresses the cause and effects of flash rust, which typically develops on steel surfaces after the waterjetting process.

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FLASH RUST AND WATERJETTING STUDY

September 21, 2001

Paul Dorsh
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1.0 INTRODUCTION

Ultrasonic examination of tank AY-101 was attempted in 1999, but could not be performed due to excessive corrosion located on the tank wall. Initial attempts to use a magnetic wheeled crawler to deliver ultrasonic sensors, failed due to the corrosion product building up on the vehicle wheels. In order to assess the condition of the tank, a video inspection of the primary tank and annulus was performed at several risers in early 2001. These inspections showed that the corrosion is greater than observed in other double-shell tanks (DST's) and appeared to be more prevalent in the upper regions of the tank than previously observed in 1992. Also, the depth of damage on the outside surface of the primary tank appeared to be more than that predicted by atmospheric corrosion models. Analysis of tank conditions and data suggests that the corrosion was the result of water intrusion into the annulus, coupled with the shutdown of the annulus ventilation system for an extended period (Anantatmula et. al., 2001). A more in-depth examination of the corrosion areas is needed to determine the effects of the corrosion on tank integrity.

Aptech Engineering Services was contracted by CH2M Hill to conduct a risk assessment of the tank (Aftanas, 2001). The objective of the project was to risk rank areas of the tank in order to prioritize inspection activities. The assessment was based on 13 inspection videos of the annulus and one inspection video of the interior of the tank. The tank circumference was divided into 64 segments, each segment being approximately 5.6 degrees of arc. The tank wall was then divided into 17 segments, two for the haunch, thirteen for the vertical shell, and two for the lower knuckle. The approximate size of each segment area is 3 ft by 4 ft. A spreadsheet was prepared modeling the outside primary wall of the tank as a flat surface. Each area segment was given a ranking of 1 through 4, 1 being no corrosion observed and 4 being heavy corrosion observed. Based on the recommendations of this examination, all locations of the tank with a high risk ranking will be tested, 20% of medium risk locations will be tested, and 5% of the low risk locations will be tested. In order to test these locations, the areas must be cleaned prior to the NDE examination.

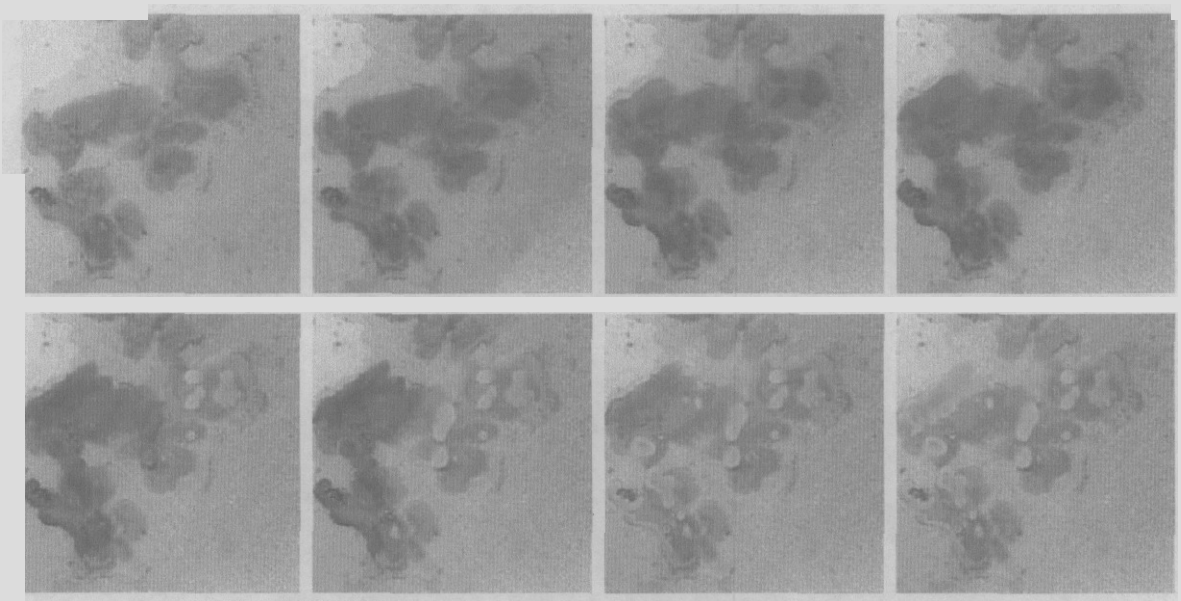
2.0 SCOPE

Waterjetting has been chosen to remove the rust and corrosion off of the primary tank wall in the annulus so that UT inspections can be completed. Oceaneering International, Inc. has been contracted to clean approximately 2000 ft^2 of the tank wall with a remotely operated Ultra High Pressure (UHP) Waterjet. It is known that the typical waterjet process leaves a layer of "flash rust" on the surface shortly after cleaning. There is a concern of how it will affect the surface of the tank wall and how to prevent rust and corrosion from developing on the wall in the future. This paper addresses this concern of flash rust on the tank wall.

3.0 FLASH RUST

Rust is defined as "A corrosion product consisting of hydrated oxides of iron. It is a porous red-brown oxide produced by action of oxygen, moisture, and electrolysis of metal". Flash rusting is the rapid onset of this condition. Flash rust is caused by chlorides and other soluble salts (such as sulfates and nitrates) located on the surface of steel. If these contaminants are present and

water is added, such as with waterjetting, a bloom of flash rust quickly appears (Johnson, et. al, 1991). Typically, the length of time needed for flash rusting to occur is dependent upon the relative humidity and the level of soluble salts upon the surface. High humidity and soluble salt levels will promote very fast flash rust (can occur in a matter of minutes), with the opposite being true of low relative humidity and soluble salt levels (could allow many days to pass before flash rusting occurred). Soluble salts initiate and accelerate corrosion of steel, and become deeply embedded within the corrosion product. The salts stimulate corrosion through an osmotic action by pulling moisture from the air and through any protective coatings. It is in this form that they achieve their highest level of chemical stability. Also, when the moisture is combined with chlorides, a mild hydrochloric acid is often formed, causing degradation of the substrate.



Development of Flash Rust on a Cleaned Steel Surface. About 10 min/frame

Figure 1

Salts left on a surface prior to the application of protective coatings can be the cause of several occurrences. All liquid coatings are permeable, thereby allowing the salt on a substrate to "pull" moisture through the coating, causing active corrosion of the substrate long before the protective coating fails. This is commonly seen on structures or objects with blistered paint, which when removed, rust is seen on the surface. In nearly all cases, the coating was applied over salts.

4.0 PREVENTION OF FLASH RUST

Virtually all rust on metallic surfaces is caused or induced by salt contamination. It is common belief that whenever there is bare steel and humidity that there will be rust. As stated by Dr. Gerald Soltz in his research work for the National Shipbuilding Research Program, in the executive summary, "Clean uncontaminated steel will not rust for thousands of hours, even in 100% humidity. Problems with surface re-rusting after blasting indicates that there is still undesirable contamination on the steel's surface" (Soltz, 1991). Thus, to prevent flash rust, the soluble salt contaminants must be removed from the steel.

It is nearly impossible to totally remove all contaminants from surfaces, there are usually some very low levels of salt contaminants remaining after decontamination. Ultra High Pressure (UHP) Waterjetting will usually, but not always, result in the desired level of cleanliness. Typically, cleaning by waterjetting would require blasting beyond the amount needed to simply remove any coatings or dense rust. However, there are several chemical soluble salt removers that may be added to the waterjet that will aid in the removal of soluble salts. They are typically a liquid, organic, non-hazardous and biodegradable and are designed to solubilize both chlorides and sulfates. The soluble salt remover must come in contact with salt ions in order to solubilize them, therefore, any barrier, such as rust, must be removed. This application is extremely easy when applied with UHP wetterjetting.

5.0 TANK WATERJETTING

In order to test the tank's primary wall thickness, cleaning of the rust and corrosion off of the surface of the tank wall is required. This will be accomplished with the use of Oceaneering's Cleaner Crawler. This device is a remotely operated four wheel drive vehicle, which utilizes vacuum to adhere to vertical surfaces through a cup located in the center of the crawler. The vacuum cup also contains an ultra-high pressure water spray wand that is used to clean rust and corrosion off of surfaces. Specific locations (approximately 2000 ft^2) will be cleaned off based on Aptech's evaluation and the Non-Destructive Examination and Inspection Plan (Staehr, 2001). Thus, the majority of the tank's wall surface will remain untouched and uncleaned from the waterjet. The areas that are cleaned by the crawler will be forced dry by the waterjet's powerful vacuum, leaving the surface warm and dry, thus minimizing flash rust due to water evaporation. Typical waterjetting leaves the surface wet allowing evaporation of the water to promote flash rust. It is believed that the cleaning action of the waterjet itself, removes a majority of the contaminants.

6.0 PROTECTIVE COATINGS

The real problem with flash rust concerns the life of a coating over surfaces due to the contaminants that caused the flash rusting. In the past, it was generally thought that good, industrial grade coatings could be applied over the flash rust without difficulty. However, now industry opinion regarding the wisdom of applying coatings over flash rust instead of washing it off is in a state of uncertainty.

There are numerous types of rust inhibitors used today. One example that has been designed to work with waterjet coating removal systems is solvent-free, water-displacing epoxies (such as TFT coatings). Some of these coatings can be applied to still wet or dripping, freshly waterjetted metal surfaces. The displaced water migrates through the uncured epoxy carrying away corrosion causing salt ions. When the steel surfaces are allowed to dry, these ions precipitate into micro crystals that have proven to be a leading cause of under coating corrosion. Water-displacing epoxies can be applied prior to the development of flash rust, even prior to having the surface water free. However, if a protective coating is used, a corrosion expert should specify the type of protective coating to be used on the tank wall.

7.0 CONCLUSIONS

All water-soluble salts not removed from steel during surface preparations, such as waterjetting, can quickly produce flash rusting and eventually osmotic blistering of any protective coatings that are applied to the steel surface. The salts can also react chemically with the steel and form corrosion cells that can cause accelerated degradation of the steel. However, it is known that when these contaminants are removed the cause of flash rust is removed. Waterjetting alone is a good remover of the soluble salt contamination but it is not guaranteed to remove all the salts. Proper salt removal may require blasting 3 to 4 times longer than just removing the corrosion on the surface. Since the integrity of the tank wall is unknown at the areas of cleaning, the effects of blasting the wall with an UHP waterjet for an extended period of time is unknown and should be avoided. A chemical additive to the blasting water can aid in the removal of these salts without slowing the cleaning rate of the waterjet.

The ultimate concern of flash rust is how it will impact protective coatings applied to the steel's surface after cleaning. Currently, there are no protective coatings on the DST's annulus primary tank walls. If some type of protective coating is to be applied to the tank wall, soluble salt contamination on the wall's surface should be a concern. Currently, Oceaneering is cleaning only 2000 ft^2 of the tank's wall surface. This is a small portion of the tank wall. Thus, the majority of the tank wall will be untouched and uncleaned by the Oceaneering crawler and it is believed that application of a coating now may be more detrimental than beneficial. The Annulus Ventilation Engineering Study (Anantatmula et. al., 2001) concludes that the excessive localized corrosion was likely due to water ingress and the shut down of the ventilation system. If water intrusion cannot be contained or eliminated, localized corrosion will likely return. Under these conditions, a protective coating may be desired. Cleaning of the entire tank wall should be completed and a coating applied based on the recommendations of a corrosion/coating expert.

8.0 RECOMMENDATIONS

It is seen in Aptech's evaluation (Aftanas, 2001) that the majority of the tank's wall surface was labeled as low corrosion observed / low risk areas. These areas of the tank wall have experienced acceptable, slight general corrosion due to atmospheric conditions, without the use of a protective coating. Thus, if the water intrusion can be effectively stopped and the ventilation system is operating properly, the cause of the excessive localized corrosion will be eliminated. The cleaning of the waterjet will likely be enough to remove soluble salts to prevent the quick onset of flash rust and no additional protection is required. Flash rust is a concern with typical waterjetting because it leaves the surface wet, allowing evaporation of the water to promote the rust and corrosion. If this were the case, it has been suggested to use water inhibited with 0.01M sodium hydroxide and 500ppm sodium nitrite. However, it has been stated by Oceaneering that the areas that are cleaned by the crawler will be forced dry by the waterjet's powerful vacuum, leaving the surface warm and dry, thus virtually eliminating the quick onset of flash rust due to water evaporation.

Therefore, provided that the ingress of water is contained, the ventilation system is operating properly, and the cleaner leaves the surface dry, no additions to the waterjet stream or protective coatings to the tank are recommended at this time.

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