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Improve Equipment Performance against Pitting Corrosion Degradation by Utilizing Corrosion Control Methods at Petrochemical Facilities

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ABSTRACT

Pitting corrosion degradation has been observed on RVCM (Recovered Vinyl Chloride Monomer) tanks at petrochemical facilities. Generally, these pits are repaired by weld build up in order to stop further degradation. However, a more permanent solution is required to resolve these chronic pitting corrosion issues in RVCM tanks. The most efficient method to mitigate the pitting corrosion degradation is application of a protective coating or strip lining as the coating will isolate the material from the environment, and thereby prevent pitting corrosion degradation as well as stop the initiation of SCC (Stress Corrosion Cracking). The type of coating that should be used depends on the temperature, pressure and fluid composition of the system. This paper evaluates the feasibility of providing the strip lining method or coating method to stop the degradation of equipment due to pitting corrosion. Based on a further technical study, successful implementation of the coating application has been carried out on one of the RVCM Tanks, and subsequent inspections confirm satisfactory results of the coating application.

Keywords: Pitting Corrosion; Coatings; Strip Lining; Degradation; Dye Penetrant Testing (DPT), Holiday Test.

INTRODUCTION

Recovered vinyl chloride is that monomer which remains unreacted in the polymerizer and is recovered from the process. During the previous and recent inspections on RVCM (Recovered Vinyl Chloride Monomer) tanks, pitting corrosion has been observed at different locations and weld build up repair has been carried out on these locations. DPT (Dye Penetrant Testing) result shows the satisfactory result of weld repairs. It is worth to note that thickness readings of these equipment are well within the limit and during the weld repair, no incidences of SCC (Stress Corrosion Cracking) have been reported. Further technical study has been conducted to mitigate the pitting corrosion damage mechanism utilizing corrosion control techniques. Feasibility of installing a lining has also been considered. PFA (Perfluoroalkoxy) lining using the fix point lining method has been evaluated considering the design/operating parameters and service. The "Fix Point lining method" requires a transparent fully fluorinated liner (e.g. PFA), steel washer, absorbing fixing cap (e.g. PFA), and steel bolt with fine pitch threading to secure the liner to the metal substrate. This was not found to be feasible in this specific case.

For the PFA Lining Method, the tank will have to be completely cleaned to ensure that the bolts, which will be welded on the inside of the tank, will not be contaminated. However, the bolting arrangement required for the PFA Lining method has been assessed and concluded that it is not feasible for the present case. Hence a protective coating method has been selected as the corrosion control technique to stop the degradation of equipment due to pitting corrosion. Metallic coatings isolate the metal from the environment, and can, thereby, prevent SCC / pitting corrosion. However, the possibility of the coating being penetrated by improper application, or by mechanical damage in service, must be taken into account.

Figure 1 is a schematic of the RVCM tank and Figure 2 shows the prevailing pitting corrosion damage in the RVCM Tank. Figure 2 also represents the view of pitting at the shell before and after weld repair.

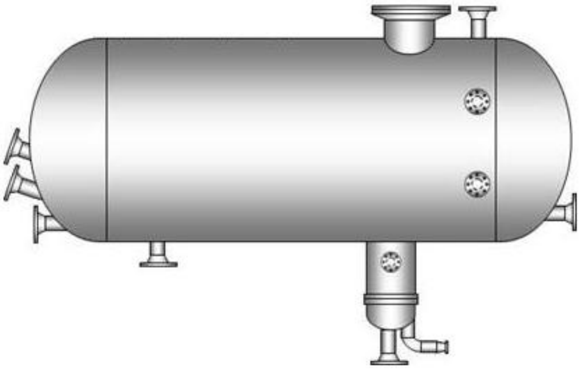

Figure 1: Schematic Diagram of the RVCM tank

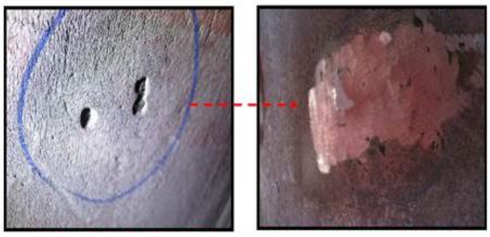

Figure 2: View of pitting at shell before and after weld repair.

EXPERIMENTAL PROCEDURE

This section provides the details of tank shell/head materials, design/ operating parameters, service composition etc. It also includes activities that have been carried out for implementation of new coating method to enhance equipment performance against pitting corrosion degradation:

DESIGN PARAMETERS

Shell / Head Material: Carbon steel (19 mm) + Stainless steel Clad (3 mm)

Design pressure: 8~10.3 Bar

Design temperature: 120~160 Degree C

Operating pressure: 3.5~6 bar

Operating temperature: 20~40 Degree C

Service: VCM+ Water (Acidic) + PVC slurry (Traces)

Composition: VCM + Water: VCM 98%, Water 2%, pH: 2-4

Considering the design/ operating parameters, service and prevailing damage mechanism, different coating systems have been evaluated. A 100% solids epoxy coating has been selected which is designed for continuous immersion in aqueous and hydrocarbon systems at operating temperature up to 160 C. This coating provides excellent corrosion resistance at elevated temperatures and withstands a wide range of chemicals including hydrocarbon and amines. This brush applied material with a 24 hour overcoat window allows application to be effectively and quickly completed, reducing downtime dramatically. After ambient temperature cure, its unique post-curing mechanism is activated at normal service temperatures, eliminating the need for separate post-curing processes and allowing a more rapid turnaround and return to service. Key benefits of this coating system are - excellent resistance to corrosion and chemicals, high temperature operation under immersion conditions, minimized downtime, simple and safe to use and excellent adhesion to all rigid metallic substrates.

Surface Preparation

No coating system will give optimum performance if applied over a poorly prepared surface. Coating over rust, grease or contaminated surfaces can be wasteful in terms of time and material. All coating systems fail prematurely unless applied over a suitably prepared surface. The purpose of this section is to provide a guideline on how to achieve an effective preparation of substrate surface prior to the coating application. In all methods of preparation, the aim is to remove contamination and corrosion as far as practically possible to provide a sound and clean substrate for coating [1].

Monitor and record environmental conditions during the entire application at regular intervals. This shall include relative humidity, surface and ambient temperatures as mentioned in the Table 1. Following are the activities carried out for achieving the required surface finish. Abrasive blast the inner surface to near white metal finish (Swedish Standard SA 2 ½), to produce the required anchor profile of 75 microns (minimum) as mentioned in the Table 2 [2]. Brush away the loose contamination. Check the surface for salt contamination and if found above 2 ppm, pressure wash the surface with sweet or de-ionized water, blow with compressed air to dry, then brush blast. This process is repeated until salt contamination level is within the above criteria as mentioned in the Table 3. Before the coating application, all pitted/corroded areas should be repaired using a suitable filler material through welding.

Table 1: Climatic Conditions							
Period	TIME	Air temp °C	Surface temp' ºC	%RH	Dew point ºC	Any Weather changes	Location of test
Shift start, Day 1	10:00	19.6	22.2	31.5	2.2	NO	Inside the Tank
Shift end Day 2	13:05	23.0	23.4	32.4	5.7	NO	Inside the Tank

Table 2 : Surface Preparation							
Oil/ moisture free air	**Yes** ☒ No	Abrasive type	GARNET-30/60	Avg surface profile in µm (Grit blast only)	81	Surface preparation	Grit blast ☒ Mechanical ☐ Hand prep ☐
Substrate cleanliness standard = ISO 8501-1 Sa 2.5	**Yes** ☒ No	Degreasing carried out prior to grit blast. (If required)	**Yes** ☒ No	Sufficient access provided to work area.	**Yes** ☒ No		

Table 3 : Non-visible Salt Contamination			
Test kit used.	ELCOMETER-134S	Serial No	NA
Test result recorded. (mg/m²) max.	2 ppm		

Coating Application

The goal in applying a coating is to provide a film which will give protection to the surface being coated. The success of any coating application will be governed by a number of parameters, including, surface preparation, film thickness, climatic conditions prior to, during and after application, and methods of application.

Following are the activities carried out for implementation of the new coating method, Table 4. All areas that are not to be coated shall be masked off to terminate on straight edges to ensure an aesthetic finish. Prior to beginning the coating application, environmental conditions must be checked to verify suitability in accordance with NACE guidelines [1]. 100% solids, epoxy coating is applied as a two coat system at a total DFT (Dry Film Thickness) of approximately 800 microns.

<table>
<tr><th colspan="6">Table 4: Coating Application</th></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="3" rowspan="2">Visible dust contamination level acceptable.
(No worse than rating “2” on clear tape)</td><td>Yes ☒</td></tr>
<tr><td>No</td></tr>
<tr><td>Product</td><td>Time</td><td>Area</td><td>Wet film µm</td><td>Full/ part pack mixed</td><td>Mixing ratio (part pack only)</td></tr>
<tr><td>100% solids, epoxy coating (1st Coat)</td><td>Day 1 13:30</td><td>Bottom Section</td><td>450-550</td><td>Full</td><td>NA</td></tr>
<tr><td>100% solids, epoxy coating (2nd Coat)</td><td>Day 2 11:00</td><td>Bottom Section</td><td>450-550</td><td>Full</td><td>NA</td></tr>
</table>

Allow the coating to cure for at least 16-hours, then conduct testing as mentioned in the Inspection activities below.

Inspection

Following are the activities carried out for inspection of a new coating in order to ensure the successful application of the coating. The coating must be checked for WFT (wet film thickness) @ 4 – 6 points per square meter using a comb gauge. DFT gauge (FNF type) has been used to measure the DFT (dry film thickness) readings preferably in accordance with SSPC PA 2 [3]. The presence of holidays / pin-holes must be checked using a high voltage spark tester with voltage set in accordance with NACE SP 0188 [4]. Any detected faults or defects in the coating application shall be rectified; by emery papering small areas or brush-blasting big areas followed by cleaning, solvent wiping and then then touch-up coating. All inspection activities must be carried out by NACE CIP Level 2 Certified personnel.

RESULTS

Table 5: DFT / Holiday Test Report							
Coating System	100% Solid Epoxy Coating		Finishing Colour	L. Green		SPEC REQ'MENT (Record below In µm) 800-1000	
	DFT READINGS In accordance with SSPC PA 2 (TYPE 2 Electromagnetic DFT gauge)						
AREA	Point 1	Point 2	Point 3	Point 4	Point 5	Average (µm)	
1	860	1150	921	995	1005	985	
2	950	1063	870	1100	920	980	Total Average DFT (Record below in µm) 942
3	785	910	873	1188	820	915	
4	1100	890	900	980	840	942	
5	800	980	1004	845	818	889	
DFT Instrument Make:	Elcometer 456	Serial No:	NG33898	Calibration valid up to:	24 Oct 2017		

HOLIDAY TEST		
Integrity test method	High Voltage Spark Test	Voltage setting : 4.2 KV DC
Equipment model and serial #	Elcometer-236 / SD 15965	No of defects : None
Calibration valid up to	19th June 2017	

All quality checks were carried out per the approved scope of work. Surface preparation was completed to the desired standard. The specified minimum dry film thickness was achieved and recorded in accordance with SSPC- PA2 [3]. Full coverage and uniformity was achieved on all coats. After holiday testing, corrective action was undertaken for any visual defects that were observed, repaired and re-inspected.

Results of DFT and Holiday Tests are mentioned in Table 5, which shows satisfactory results and within the limits of SSPC PA 2 and NACE SP0188.

Figures 3 and 4 shows the resultant coating application on the inside bottom section of the tank and on the circumference weld of the dome. Figure 5 provides the measurement of dry film thickness and Figure 6 is a view of holiday test conducted after the coating application.

Figure 3: View of Protective Coating application on the inside of the Tank [5].

Figure 4: View of Coating Application on the circumferential weld of dome side [5].

Figure 5: View of DFT Test readings taken in accordance with NACE SP 0188 [5]

Figure 6: View of Holiday Test in accordance with SSPC PA 2 [5].

CONCLUSIONS

The goal of this study was to evaluate the feasibility of providing the strip lining method coating method to stop the degradation of equipment due to pitting corrosion. It was concluded that the most efficient method to mitigate or improve equipment performance against pitting corrosion degradation was to utilize a protective coating method. The new coating method has been implemented successfully and inspection reports of the coating application shows a satisfactory result.

ACKNOWLEDGMENT

The authors gratefully acknowledge the support provided by all the associated departments for the implementation of the protective coating application on RVCM Tank.

REFERENCES

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2. SSPC-SP10 (RP0594), Near-White metal Blast Cleaning (blast cleaning abrasive to achieve a defined degree of cleaning of steel surface prior to the application of a protective coating or lining system)

3. SSPC PA-2, Procedure for Determining Conformance to Dry Coating Thickness Requirements.

4. NACE SP0188 (formerly RP0188), Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates, 2006.

5. Petrokemya Inspection report 2015 / 2017.