

Case Study Based on Coating Failure Analysis of Cargo Container

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ABSTRACT

Coating system of a cargo container belonging to a high-profile cargo company failed terribly during service at the humid south gulf coastline. The failure occurred during the summer of 2020 after only 8 months of service. The container had an acknowledged life expectancy of 20 years. An investigation commission was appointed to investigate the root causes of the coating failure. Visual inspection revealed checking and cracking all over the container surfaces including surface rust and rust stains at damaged/cracked locations. Holiday testing revealed multiple holidays/voids for the coating examined at various locations of the container. Dry film coating thickness was also carried out and it showed several locations which were undercoated or excessively over coated. Pencil hardness test was carried out on several locations and it should surface roughness/hardness. A section of coating removed from the container surfaces was randomly taken and analyzed using SEM/EDS technique to see the different layers of the coating and to check the constituents at the base of the coating where the base metal layer was also visible. Pull off adhesion testing carried out on the limited sampling showed at least two out of five readings which did not meet the specification limits for adhesion compliance. Tests conducted below the failed coating system showed evidence of high levels of salt. Flexibility test was performed to check the flexibility of the coating. The failure mechanisms were discussed and good engineering practices were put forward to combat and mitigate poor adhesion and inhomogeneous coating application.

Key words: Coating Failure, Coating analysis, Epoxy coatings

INTRODUCTION

Coatings are a composite blend of raw ingredients that are mixed, applied to a prepared substrate, and dried and cured correctly to perform to their maximum capability. Failures and defects can appear themselves at numerous times in the life of a coating. Prior to application, they can take the shape of settlement and skinning, during application as runs and sags, shortly after application as solvent popping and orange peel, and during service as blistering and rust spotting. Therefore, it is not unexpected that those coatings can suffer from premature failure and/or exhibit defects that may or may not result in failure. Coatings nowadays are the most efficient method to shield metals and thus has been widely

engaged among various protective techniques ^{1, 2}. There are mainly three protective mechanisms involved, namely resistance barrier, inhibitive pigments and adhesion ³, however, it is quite inevitable that the deterioration of coatings, arising from processes such as corrosion of substrates, blisters, and cathodic disbondment etc., may occur during its period of service. Once this happens, the adhesion between the coating and the substrate will be decreased, which will subsequently induce the occurrence of peeling. As a result, coatings will no longer provide protection for the underlying metals. Therefore, the study of failure mechanism of organic coatings is of great importance and has so far attracted much attention in the coatings industry.

Coatings are a composition of raw ingredients that are engineered to protect various assets. Any sort of coating mixture is prepared by mixing proper composition followed by the application of that mixture on a primed substrate, and allowing those coating mixtures to cure in order to get proper adhesion between the surfaces. Catastrophes and imperfections can unveil themselves at different times in a coating's lifecycle. Orange peel appearances could occur on the coating surfaces as a result of various coating defects such as checking, cracking, delamination, peeling, wrinkling, blistering, rust stains etc. Surface preparation is a critical step in applying a coating system to any substrate. Adequate surface preparation plays a vital role in achieving adhesion between the substrate and subsequent coating layers. Environmental parameters like temperature factor, relative humidity levels, and dew points measurements during the coating application should be monitored regularly. These values should be within the manufacturers' specifications. Meaningful coating application techniques, which could include the use of stripe coats will save the time and money that a re-application would require, if a coating failure would occur. Premature coating failures could only be evaded by ensuring proper application techniques. An experienced applicator who possesses great expertise will do a thorough coating integrity check for various coatings defects, if any ⁴.

Steel shipping containers are comprised of a few crucial parts that make them 100% reliable. These parts generally includes steel corrugated walls, cargo doors, cross members, corner castings, twist locks, bamboo flooring, and the CSC plate. One of the most intimidating parts of a shipping container has to be the steel it's made from, also known as corrugated steel or weathering steel. The corrugated pattern means that it's far stronger and more durable than wood or any other type of metal. Major benefits of using steel containers are long lasting durability, dent and warp resistant, very low maintenance, and marine grades having plywood flooring. In this paper, a case study related to failure of coating system applied to a cargo container is given where paint cracking was observed just after one month of coating application.

EXPERIMENTAL PROCEDURE

Coating failure of a steel cargo container (having dimensions of Length: 10', Width: 8', and Height 8.5') was observed in the form of cracks, and rust stains were also seen on the surfaces of the container. Container coating was noted to be very rigid and showed evidence of almost no flexibility which was not in compliance with the claims in technical data sheet of the paint manufacture. Evidence of failure of coating flexibility test even with a minor bending supports this conclusion Rust stains were noted below coating at few locations which implies that the surface finish requirements for coating were not fully complied to during the coating application. Below photos are self-explanatory in terms of visual appearance.

