

Use of Protective Coatings in Salt Mine and Plant

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ABSTRACT

The author's company has been studying the protection of equipment and structures in salt exposures for the past fifteen years. These studies have been conducted not only in the salt producing facilities of Morton Salt Company, but also in the producer and user operations of such companies as Food Machinery Corporation, Monsanto Chemical Company, and Permsalt Manufacturing Company.

Some of the more important results and findings from these studies are presented, with particular emphasis on that which, in the author's opinion, is the most important advance: the use of metallic sacrificial bases prior to protective coating.

Performances and economics are thoroughly developed.

INTRODUCTION

Paint and coatings can protect in salt exposures.

This has been amply proven in many salt-producing plants and salt-using operations. Coatings can prevent corrosion of steel in humid salt exposures; such corrosion being capable of destroying steel structures and equipment at the rate of 1/4 inch of steel in little more than four years.

Such protection is not going to be obtained however by the use of "magic" materials, or by gullible wishful thinking that the spreading of some highly touted material over the surface will, by itself, cure your corrosion problems.

Durable coating protection is obtained by exactly the same approach which you have found necessary in solving all of your other plant maintenance operating problems; by the use of intelligent engineering planning and attention, in the same manner that you engineer your use of corrosion resistant metals and your cathodic protection.

HOW DO COATINGS FAIL IN SALT EXPOSURES?

Let's follow through the various stages of paint failure in salt atmospheres; for only by studying the mechanism of coating failure can we learn how to intelligently prevent such failures.

Let's not make this study in the dry atmospheres of the mine, or even in your mill or packaging buildings where the humidity might be very carefully controlled. The active corrosion of steel in salt exposures proceeds to a serious degree only when the prevailing humidities are above 70%. So let's look for the various stages in the progression of paint failure and consequent corrosion of the underlying steel in your above-ground structures exposed for long periods to relatively high humidity. Let's look at your headframes, your salt conveyors and other bulk salt handling equipment, and any steel work immediately adjacent to these.

Coating failure will almost invariably start, assuming proper coating material selection and application, at small isolated points in the paint application. It will be noticed that these points of initial failure predominantly occur at prominences or projections, at plate or flange edges of the steel surface, or other irregularities in that surface (Figure 1).

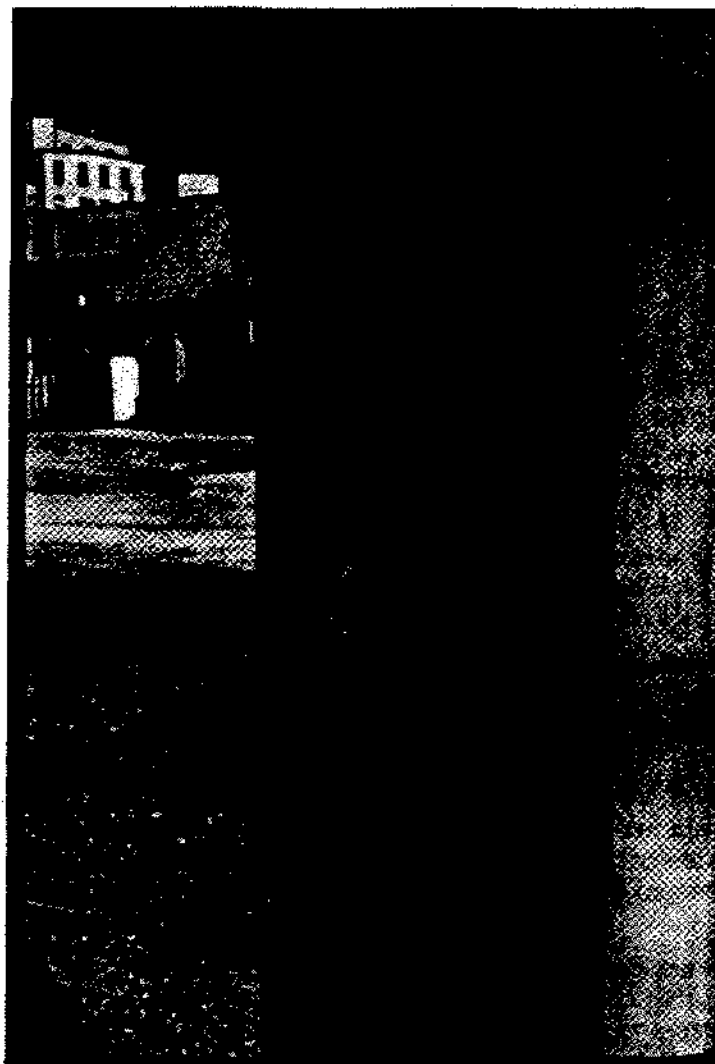


Figure 1.

Failures so starting at such point sources rapidly spread from these points of initiation to destroy, by undercutting the paint protection in the immediately surrounding areas (Figure 2). As long as this process of spreading from the points of initial failure is not detected and stopped by intelligent maintenance attention, this undercutting and spreading process will continue until paint protection is lost in large surrounding areas (Figure 3), until complete paint protection is lost (Figure 4).

Thus it may be seen that complete paint protection over equipment, or structure, originates from a few early pinpoint paint failures, which if detected and sealed in, in their early stages, would prevent such complete failure. It is again the old story of "for the lack of a nail the battle was lost."

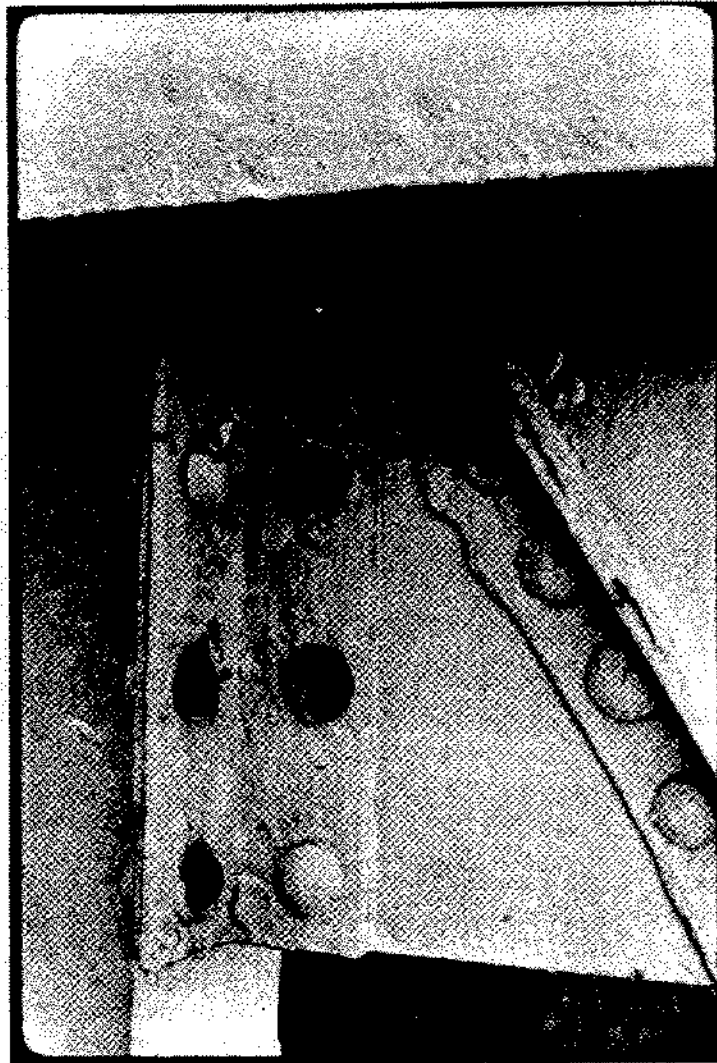


Figure 2.

These first few points of failure initiation are, of course, minute discontinuities in the coating application which allow exposure of the base steel to the humid salt environment. The environment causes corrosion at these points of metal exposure and the prying, undercutting action of the rust produced proceeds to destroy the adjacent sound paint protection, continuing at an increasing rate as long as any steel or its corrosion product is exposed to the environment. These initial discontinuities in the paint protection may be caused by inadvertent air bubbles, pinholes, or other holidays in the paint application itself, or by mechanical damage of scraping, impact or abrasion to the coating protection during its service life.

From this mechanism of premature failure of paint protection, it is easy to see that durable protection can only be obtained if the coating material is selected and applied to be a completely continuous and resistant barrier between the corrodible steel and the corrosive environment, and during its service life is maintained as such a continuous resistant barrier. This end is most practically accomplished by using only coating systems which have proven their durable resistance to the exposure, by either actual plant tests or successful long term usage; and the application of these to the surface by application procedures of good surface preparation and coating application, making sure that the paint protection is applied in a minimum of 5 mils (0.005") dry film thickness and this thickness is built up in a minimum of three coats.



Figure 3.

Three months after the applied coating system has been exposed to service, the surfaces should be examined for any traces of rust stains, which will disclose those minute discontinuities should be promptly sealed by spot repair. This three month inspection and spot repair interval will disclose any weaknesses inadvertently resulting in the application. However, during the entire service life of the paint application, such inspection and spot repair if indicated should be conducted at regular periods varying with frequencies from six months to a year depending upon severity of exposure, in order to detect mechanical injury occurring to the coating by usage.

"Oh, but that's a lot of trouble," I can hear some of you say, "that's an expensive procedure, and we don't have the money and personnel to carry out that type of application and spot repair, and we can't afford to set up to do it just for the sake of painting the plant." You can't afford not to do it! Figure 7 shows, in the step-curve, the cost of casual painting, which over a fourteen year period amounts to \$2.80 per square foot of surface protected. The diagonal showing a final cost of \$3.40 per square foot is the average cost of your fabricated and erected plant steel which will be lost and must be replaced if it is not protected from salt corrosion. The horizontal line at the top ending at this same cost is that cost to your plant if you over-design all steel members and equipment to provide a corrosion allowance, which can be corroded away during the design life of the structure or equipment without impairing the required load-bearing strengths. The lower curve showing the lowest cost of \$1.20 per square foot is the cost of doing what we recommend: properly applying a properly selected coating initially, and then placing it on regular inspection and spot repair during its entire service life. You will notice the initial cost of the paint application is over twice the cost of your present paint application, but this initial premium is returned after the first two years of service.

Still skeptical? Let me tell you a story. Many years ago when we first started working with the salt industry, we were told by the experienced old-timers in the industry that when steel was exposed to salt, the salt worked into the steel, and no matter how carefully this steel was subsequently cleaned, it would thereafter corrode rapidly and paint performance over it would be inferior to steel which had no prior exposure to salt. Of course we immediately recognized this as

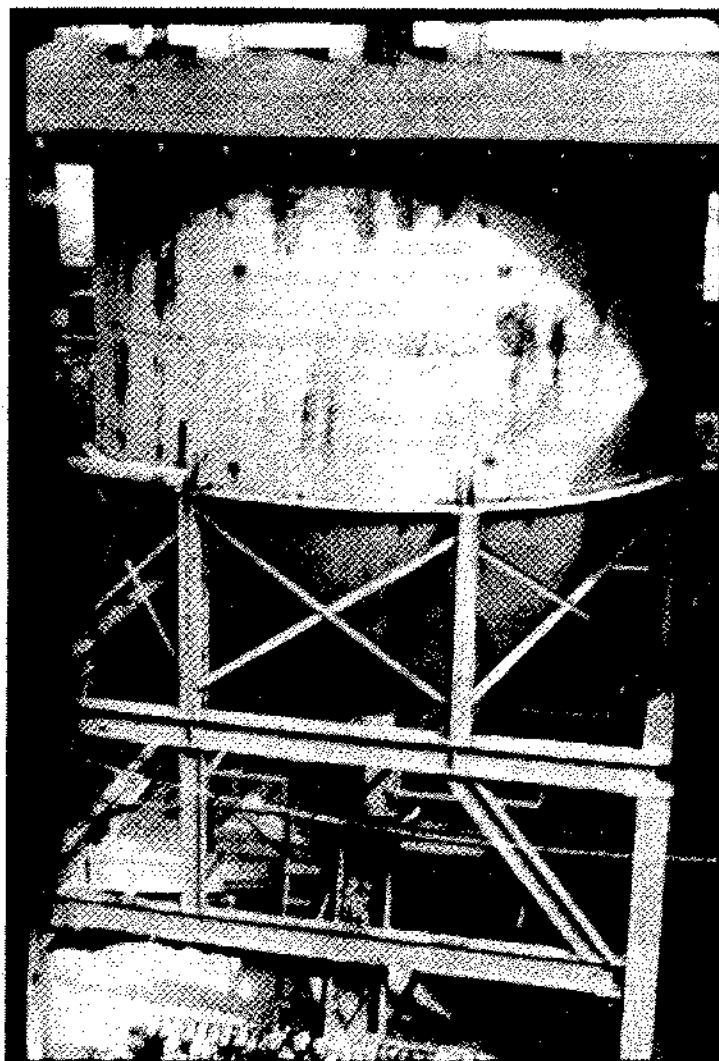


Figure 4.

an "old wives tale," which had been handed down in the industry and accepted; but which really had no foundation in fact. Rather than argue the point, we decided it would be much simpler to demonstrate the fallacy of this belief. So we put in a salt exposure, identical pieces of steel, coated with exactly the same paint system, one of which had been exposed to salt exposure for some months and which was coated after only wire-brushing; another which had been similarly previously exposed to salt but which had been then blasted to clean white metal before coating; and a third which had never been exposed to salt. On exposing these coated specimens in salt exposure, it was not surprising to find that the paint system applied over the wire-brushed rusty steel failed quite soon; but unfortunately the performance of the coating system over the blasted specimen previously exposed to salt, while good, was definitely inferior to the one which had never been exposed to salt. We knew of course that this was a "fluke" in testing and so set out replication of these tests. The replication gave the same results; and so have further replications made ever after. It is evident that this "old wives tale" does have a basis in fact, and our faces are slightly red!

However, what can we learn from this? If it is then true that steel which has been exposed to salt is more corrosion-susceptible than steel which has never been exposed to salt; it logically follows that we should never allow our steel to come in contact with salt! This comes right back to where we started. The steel should be initially coated with a continuous resistant barrier

which will prevent the salt from ever contacting the steel; and during the service life of this steel that resistant barrier must be maintained continuous by regular inspection and spot repair of that barrier film. It seems that we just cannot duck it!

We recently have a new assist which will make this job of regular inspection and prompt spot repair less onerous. This is the use of zinc as a sacrificial base under our coatings. I can hear you say, "zinc as galvanize certainly does not last very long in a salt plant"; but we did not suggest that you use zinc as the protective coating, we suggested that you use zinc as a sacrificial base for an organic protective coating. It is true that with this system, it is the zinc that protects the steel from corrosion, but the organic coating film over the zinc protects the zinc from useless dissipation, and preserves its full reservoir of protection until it is needed to protect the steel. Furthermore, the corrosion product of zinc is a fine powder with little prying action, and subsequent mechanical injury to the organic coating will not result in a rapid deterioration of the surrounding surfaces.

The additional cost of such a sacrificial base will increase the initial application cost by about 10%, but will prolong protection over three fold. Figure 5 shows two beams erected and



Figure 5.

Painted at the same time with the same paint system in a salt pan house. The vertical beam has zinc as a coating base, and the transverse beam is without such zinc.

As a word of caution, it must be pointed out that while all zincs are beneficial, there will be considerable variation in performances with the type and form of zinc selected. It is therefore suggested that the zinc used be chosen with intelligence, from the varieties of galvanize, metalize, and the various zinc-rich coatings available. Figure 6 shows the range of variation in performance of various zincs under the same organic coating.

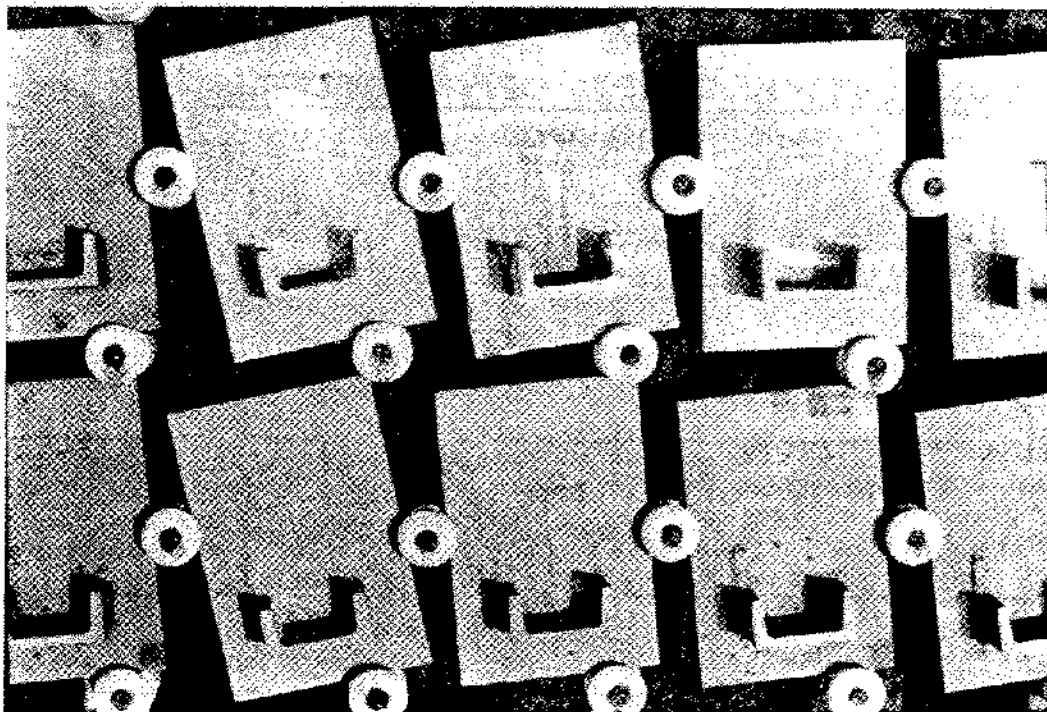


Figure 6.

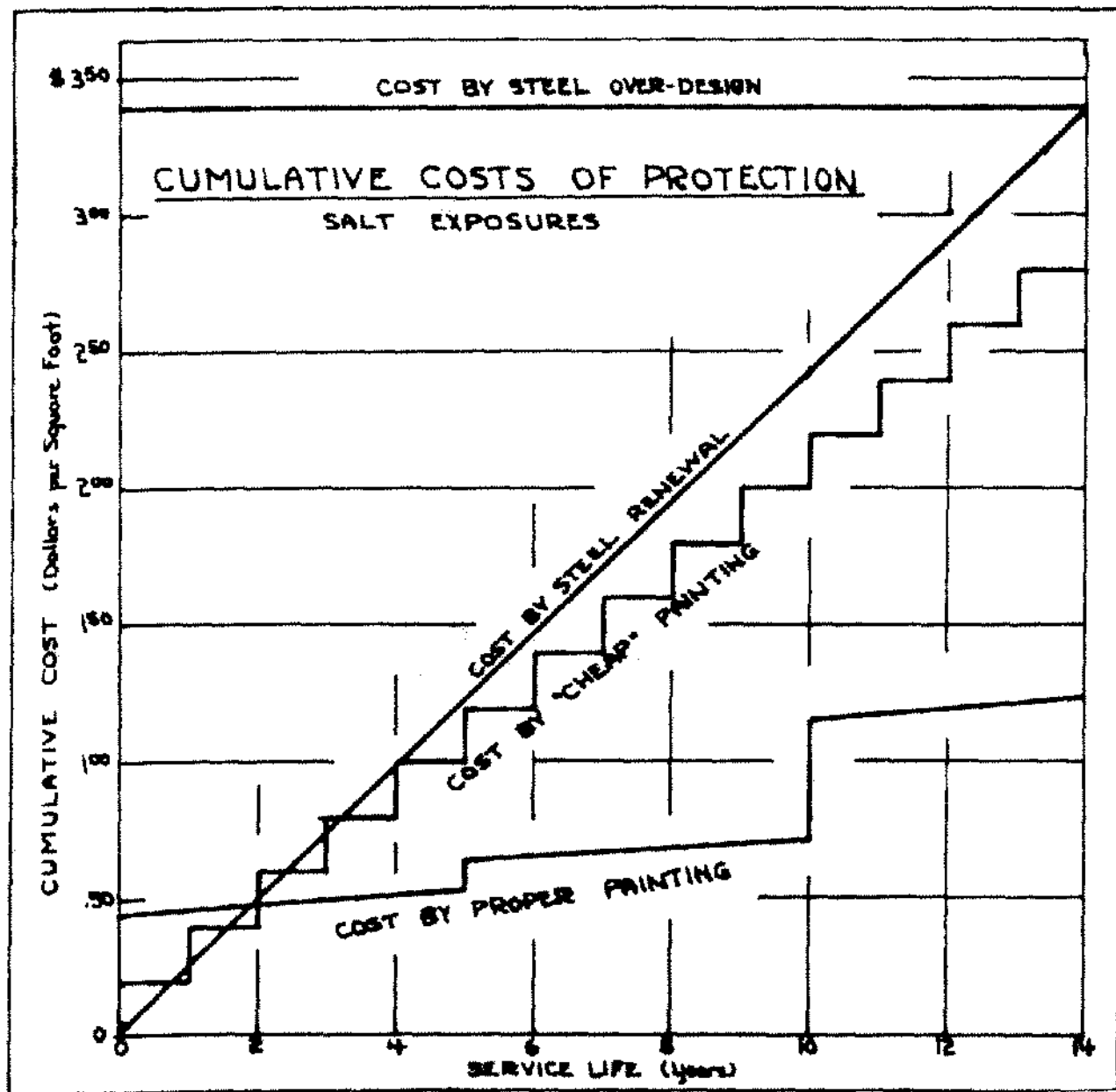


Figure 7.