Field Experience in the Protection of Lease Surface Equipment

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INTRODUCTION

During the past 10 years, methods have been developed to adequately and economically protect lease surface vessels fabricated from mild steel and subject to corrosion. In general, these methods have fallen into 2 categories — coatings and cathodic protection. Where these 2 methods are impractical, or uneconomical, a variety of corrosion resistant materials and metals are available and can frequently be used.

Corrosion encountered in the oil field is caused by acidic compounds in the produced well fluids and ordinary galvanic (or electrolytic) corrosion caused by two dissimilar coupled metals immersed in an electrolyte.

PROTECTIVE PLASTIC COATINGS

Protective coatings are normally defined as those organic barriers which are applied to provide a finished thickness of no more than 10 mils (0.010 inch). (When the thickness is between 10 mils and 1/16 inch, the barrier is normally defined as a "mastic", and when above 1/16 inch, the barrier usually is applied in sheet form and is referred to as a "lining".)

For lease surface vessels, economics usually eliminates consideration of linings and mastics; thin film coatings are considered most seriously. Experience has shown some of these coatings to be far superior to others. This is particularly true in the Permian Basin area, and may be attributed to the aromatic components in most of the crude produced there. These aromatic compounds will attack coatings which have been quite successful in other areas. The following is a resume of coatings more frequently used in the Permian Basin area:

1. Baked-on phenolics: This material offers excellent protection for mild steel vessels and has a record of many years service without failure, both in salt water and crude oil immersion. However, due to the high cost of application ($1.50 - $2.00 per square foot), it frequently cannot be justified for protecting large lease vessels. It is applied in 4 to 6 multi-pass coats with a bake between coats, to provide a final thickness of approximately 6 mils.
2. Air cured epoxies: Straight epoxy coatings have records of more than 5 years service in the Permian Basin with no failures. They are applied in 3 to 4 coats to a final thickness of approximately 6 mils, and furnish a tough coating that has excellent adhesion. They may be applied for approximately 40 cents to 60 cents per square foot to new lease vessels, and can be justified for almost all applications.
3. Coal Tar-epoxies: This is a unique material, in that it is applied in the manner of a thin film coating; but its thickness after two coats is 15 mils, which places it in the mastic category. Coal Tar-epoxy coatings have a record of over 3 years service in all areas of the Permian Basin with no failures. They can be applied for approximately 40 cents to 60 cents per square foot, and offer the same general qualities as the straight epoxies, plus greater thickness to provide additional abrasion resistance.
4. Vinyls: Vinyl coatings and vinyl mastics have been used for at least 10 years in the Permian Basin; in general, their service has been good. There have been a few known failures, most of which could be attributed to improper surface preparation. Solvent vinyl and vinyl wash coatings may be applied very reasonably, but the application of some of the mastics and hot spray vinyls may be quite expensive.
5. Furans: These coatings have seen very limited application in protecting lease surface vessels, since approximately 10 coats are required to provide a 5 mil coating, which makes the cost of the coating too high for most applications. Laboratory immersion tests indicated that this coating will blister, and in the few field tests recorded, blisters were noted on the tank bottom.
6. Chlorinated rubbers: These coatings usually are considered only for water tanks. There have been some known serious failures with this type of coating in field service in the Permian Basin, and therefore it is not recommended for general use.
7. Coal tar base coatings: This class of coating material has been in use for many years in all oil fields. With specific reference to the Permian Basin area, it has been only mediocre in success; in other areas, it has been very successful. It is believed that these failures in the Permian Basin may be attributed to the fact that the crude in this area is highly aromatic, and aromatic compounds will attack and soften coal tar coatings.

Perhaps more important than the selection of the proper coating material is the surface preparation and application. All of the above coatings can, and have been known to fail badly because of the application. The following general rules should be followed for the best coating application:

1. Surface preparation: In general, a sandblast is required. For a new vessel, a "brush-off" or "commercial" blast may be satisfactory for some coatings; for used vessels, and for other coatings, last traces of oil in the steel, and to remove all mill scale and gray oxide binder.
2. No coating application should be made during cold or inclement weather. This is particularly true for air-cured coatings.
3. Each coat should be allowed to cure and/or dry completely before the application of the next coat.
4. After the final coat has been applied, the coating should be spot-checked for thickness, and all

weld seams, corners, nozzles, couplings, etc. should be checked for holidays.

5. The coating material manufacturer's recommendations should be followed closely.

CATHODIC PROTECTION

Cathodic protection of lease vessels is of limited value, since it may be used only to protect those parts of the vessel immersed in salt water. However, design of a cathodic protection system in salt water is quite simple. The following represents the basic design considerations:

1. With Sacrificial (Magnesium) Anodes:

   a. The system should be designed to provide 5 milliamps current per square foot of metal exposed to salt water in the vessel. This current will provide approximately 90 - 95 per cent of total protection; systems are normally designed with current densities no more than 5 ma./square foot, since anode replacement would be too expensive.

   b. For design purposes, only those surfaces which can be "seen" by the anode will be protected. In actual practice, an anode will protect to some degree all surfaces in the vessel, whether shielded or not.

   c. The life of a magnesium anode may be estimated by the formula:

   $$\text{Life in Months} = \frac{\text{Weight in Pounds}}{1.5 \times \text{current in amps}}$$

   For convenience, a system should be designed with the anode life to be from 18 to 36 months. In actual practice, it is difficult to draw more than 2 to 3 amps per anode.

2. With Graphite Anodes and Impressed Current:

   a. To obtain maximum protection, the system should be designed based on a current density of 10 milliamps per square foot. If bacterial corrosion is anticipated, this should be increased to 15 - 20 ma./square foot.

   b. No more than 4 amps should be drawn from each anode. This will provide an estimated anode life of 5 years. (In actual operations, considerably more than a 5 year life is obtainable.)

Cathodic protection will provide good vessel protection as long as it is checked regularly and frequently and maintained properly. Often, a cathodic protection system is neglected, resulting in untimely vessel failure.

If a vessel fails and cathodic protection is applied after repair, it is seldom successful. If a vessel fails in one spot, there are probably several more thin spots near failure. Since cathodic protection provides only 90 - 95 per cent total protection, one can expect one or more of these thin spots to fail, in spite of cathodic protection.

In installing impressed current systems, one should be extremely careful to connect the rectifier properly. If it is connected in reverse, a vessel failure may be expected within 30 days, in addition to extensive internal vessel damage.

CORROSION RESISTANT MATERIALS AND METALS

In many cases neither cathodic protection nor coatings may be desirable or practical. For these situations, there are a number of corrosion resistant materials which may be used. Perhaps two of those more frequently used are aluminum sheet for tank decks, and cast iron coils for heating service. These applications for these two materials have proved to be successful in almost all locations. (As a word of caution, one should be very careful about using aluminum in immersion service. Contact of aluminum with aqueous chlorides, even in small percentages, will frequently cause failure.)

Other materials are less frequently used, but equally reliable. These include plastic pipe for internal vessel piping when the temperature will never be above 150°; transite pipe spreaders, downcomers, etc.; cement lined flumes and boots; and stainless steel and Monel trimmed valves, controls, etc.

There has been one report published of a nickel plated tank bottom which has remained in excellent condition after several years service in an extremely corrosive area. However, the cost of application ($7.50 per square foot) has made this protective material unacceptable.

Miscellaneous

One excellent corrosion prevention tool which is seldom utilized in lease vessels is stress relieving. Refinery and chemical plant engineers have long recognized the value of stress relieving for corrosion protection.

The mechanics of corrosion prevention by stress relieving are as follows: when a vessel is fabricated by welding, the weld seams are always anodic with respect to the rest of the vessel; when immersed in an electrolyte, they will corrode rapidly by galvanic action, In stress relieving, the temperature of the metal is raised above the transition point, and when the vessel is cooled, the metal and weld seams both will form the same crystalline structure, and become homogenous; the weld seam will no longer be anodic.

Stress relieving does not provide complete protection of a vessel; however, for only mild to moderate corrosiveness, stress relieving will extend the life of the vessel 100 per cent or more. One of the most advantageous places to use stress relieving is on fireboxes.

Another peculiar way to protect a firebox in a vessel is by coating the vessel shell. This phenomenon has been noted several times in field service; it may be attributed to the coating insulating the shell, thus preventing a flow of current from firebox (anode) to the shell (cathode) through the electrolyte. This flow of current is induced by the difference in metal temperatures in the shell and firebox, and is referred to as the "Thompson effect". If not prevented, it can cause considerable current flow, and therefore considerable electrolytic corrosion to the firebox.

CONCLUSIONS AND RECOMMENDATIONS

As a summary to the information presented, the following represents a general guide for protecting lease surface vessels in the West Texas — New Mexico area:

1. In general, coatings are recommended over cathodic protection, because of the lack of any regular attendance on maintenance on a coating.
2. Cathodic protection is recommended for large water tanks, and for vessels for which coating may not be practical.
3. If a coating is to be used in the Permian Basin, the epoxy base coatings are preferred, particularly the coal tar-epoxy coatings. This group provides the most general, universally satisfactory service. When used in the form of the

coal tar-epoxy coating, the advantages of a heavier coating are also obtained.

4. When designing a corrosion resistant system, one should use corrosion resistant materials and metals liberally for those items which cannot be protected otherwise.
5. All fireboxes, for any service, should be stress-relieved.

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