Use of Internal Coatings in Oil Field Production Equipment

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Corrosion of oil field production equipment is a serious problem which is many times not given the consideration it deserves. Every year, the oil industry pays a corrosion bill running into millions of dollars.

In many cases, the fact that some of their costs can be eliminated is not realized, and others, the ravages of corrosion are not recognized. It is now possible in some cases to economically allay the reoccurring costs of maintenance of equipment, and in others to prevent the actual destruction of the equipment.

Some of the costs which can be charged to corrosion are product loss, damages to the land owner, maintenance costs, loss of production, loss of investment, and a number of intangible costs to which attaching a specific dollar value would be difficult. Every individual situation is different and must be satisfied separately.

Several methods of providing corrosion protection have proved satisfactory for use in oil field equipment. Each one has its special uses. No one plan or method is the most economical for all conditions.

One of the most important and most widely used is protective coatings. Use of these materials goes back to the early 1940's. Where the proper coating is properly applied, protective coatings have given excellent results.

MATERIALS

Basically, four resins are used in the formulation of coatings for the oil industry. These are epoxies, vinyls, chlorinated rubbers, and phenolics. Each of these has special properties which governs its use. All are air dry materials and can be applied in the field; however, the phenolics are more usually curved by baking which must be done in a plant. There are some environments where any one of the above materials will be satisfactory; in others, no more than one or two will be satisfactory.

The choice of material should be made only by someone familiar with the wide ranges of properties available or by persons responsible for the success of the coating work. Many times, this is difficult since the experts don't agree in all cases. However, adequate protection is assured if a resin is chosen which has given a satisfactory account of itself in the laboratory, as well as in preliminary field tests.

APPLICATION

Tremendous strides have been made in the last five years in the field application of protective coatings. These have encompassed both the refinement of practices that have long been in use and the development of new revolutionary techniques.

One of the more important new methods is the internal, in place, coating of pipe. This idea was first attempted in 1947, but the major developments have occurred since 1953. In the last four years, several million feet of pipe have been coated, varying in size from two inches to twenty inches, and in length from a few hundred feet to eighteen miles.

The in place coating of a pipe line requires three main steps - cleaning, application of the coating, and drying. Each of these presented major obstacles which had to be overcome to provide the quality of work offered today.

Cleaning

In cleaning, a combination of chemical cleaning and mechanical abrasion is required. The exact procedure varies from job to job, depending upon the types and quantities of contaminants in the pipe.

Abrasive action is obtained by sending tightly packed bundles of steel lathe cuttings through the pipe at high rates of speed. Lighter abrasion is obtained through the use of wire brush plugs.

Chemical action is obtained by use of petroleum solvents, detergents, and de-greasers, with under the most severe conditions, the additional use of specially formulated acid solution.

For most normal cleaning operations, the use of acid is not necessary. Where it is needed, the type and concentration depend upon the contaminants which are to be removed. It has been necessary to develop special techniques in the use of these chemicals to reduce the cost of this type cleaning and make it economically feasible.

Coating

Specially designed rubber plugs are used to apply the coating. Two of these plugs are placed in the loading joint at the upstream end of the line. The desired amount of coating material is then pumped between the two plugs, forcing the lead plug down the line. After all the coating is in the line, air pressure is applied to the line and a calculated back pressure is maintained. The construction of the plugs makes it possible to hold the coating material under compression, forcing it into any crevices or imperfections on the pipe wall.

When the coating train reaches the downstream end, the excess coating is removed from the line. This excess is measured and if the proper amount has been left in the line, the deposited film is ready to be dried.

Drying

Drying of the coating in the confined atmosphere found inside a pipe line has presented two major problems.

The most serious was preventing recondensation of the solvent vapors on the wet film and consequent redissolving of the coating. This phenomenon is called "solvent washing." To prevent solvent washing, it is necessary to carefully control the drying rate and the removal of solvent saturated air from the pipe.

The second major problem was preventing solvent bubbles in the dry film. This is caused by the surface of the coating filming over and trapping solvent underneath. To prevent this, a slightly positive pressure is maintained in the pipe.

To solve these problems, special coatings and drying procedures have been developed to allow for the unusual conditions; and, the necessity of drying in a confined atmosphere has been turned to advantage in making it possible to dry heavier films without solvent entrapment.

Other more minor problems involved include the prevention of contamination of the wet coating by condensed moisture, compressor oil, and dust. This is done by scrubbing and drying all air injected into the pipe during the final cleaning stages and during the coating and drying operations.

ADVANTAGES AND DISADVANTAGES OF IN PLACE COATING

Cleaning

In place cleaning of pipe is possible because of the tremendous forces which are available during mechanical cleaning. These forces and the speed with which the cleaning materials are propelled through the line provide a scouring of the pipe wall which is as severe as any other method of abrasion.

In addition, chemical cleaning of the pipe is possible without the need for additional expensive equipment.

The major disadvantage of in place cleaning was the limited means of visual inspection. This has been overcome by development of chemical means of checking the cleanliness of the surface where the highest degree of cleanliness must be assured.

Coating

In the pressure controlled method of in place application, the coating is laid down in a continuous film with no chance of inferior coverage in the joints. Since the material is not atomized as in spray coating, it does not have to depend on the wetting and flowing properties of the coating material to form a continuous "pinhole" free film. Being applied under pressure, there is no bridging over minute pits or other crevices or imperfections on the steel surface. Also in screw pipe, the coating will be forced back into the threads and give protection here.

The only disadvantage, as in the cleaning process, is the lack of complete inspection. However, the inherent properties of the application method make it extremely unlikely that any coating voids will be left. This was recently proved when a 3000-foot section of an 18-mile line, previously coated in place, had to be rerouted. The takeup operation on this 3000 feet permitted a minute internal inspection which failed to locate even one void in the coating. This foot-by-foot inspection also served to verify the assumptions regarding spot inspection that had been established and used in practice on these longer, more important lines.

Drying

Drying the coating from the inside out assures a pinhole free film by preventing solvent bubbles, which in turn, makes possible the use of high solids coatings and the application of heavier films.

PERFORMANCE

As previously stated, several million feet of pipe have been coated in the last four years. This has been accomplished with a success factor of 98.5 per cent. The percentages of pipe coated in various environments are shown in Table I.

TABLE I

Service	Percentage of Total Pipe Coated
Crude Oil Corrosion	57.0 per cent
Crude Oil Paraffin	8.8 per cent
Waterflood and Salt Water Disposal	10.0 per cent
Natural Gas	22.0 per cent
Natural Gasoline and LPG	2.2 per cent

In most instances, the savings have been dramatic. In others, although the payout has been longer, the benefits have been no less apparent. As an example, a pipeline gathering system in a certain Texas field had deteriorated to such an extent that the operating costs had risen to \$0.18 per barrel. By reconditioning the lines and applying an internal coating, this cost was reduced to \$0.037 per barrel. The cost of reconditioning was estimated at \$71,000 while the cost of coating was \$14,000. The company estimates that the total cost of rehabilitation of the system was paid out in approximately 300 days while the cost of coating alone paid out in fifty days!

The above is a most interesting case in point and the payout period is most remarkable. Even more striking would have been the savings if the decision to coat the lines had originally been made at a time previous, when a large percentage of the major repair bill of \$71,000 could also have been saved!

Admittedly, each study of the use of internal, in place, coatings would not show as remarkable a payout, but all such studies show that the most important and largest savings can be made if coatings are installed in systems known to be corrosive before losses to corrosion are allowed to occur. Every pound of steel lost to corrosion is a loss in the initial investment. The time to prevent corrosion is before the first loss occurs in metal.

OTHER USES OF INTERNAL PLASTIC COATINGS

Although the in place method of coating application was originally developed for corrosion control, it has found other important uses, one of the outstanding of which is the prevention of paraffin deposition in tubing and flow lines. As listed in Table I, 8.8 per cent of all pipe was coated for paraffin mitigation. As in corrosion control, some of the lines coated have shown dramatic payouts, while with others, the payout has been slower. But in all cases easily within the period established by the original economic studies justifying the work.

Two of many excellent examples of savings in paraffin mitigation can be found in the Panhandle of Texas. In one case at the time an automatic battery was installed, all the flow lines and headers were internally coated in place. This battery has been described in detail in several trade publications. It is the first which combines automatic well testing, automatic well operation, and automatic custody transfer.

Prior to installation of the new equipment, it was necessary to run a rubber ball every twenty-four hours. If one day were missed, it was necessary to steam the lines.

Since the automatic features of the battery depended upon pressure changes to operate, it was absolutely necessary that no pressure increases were caused by restrictions in the lines. Although the cost of coating the lines was only a small part of the cost of the installation, it made automatic operation possible. Without some means of assuring freedom from paraffin deposition, unusual pressure increases would have caused erratic operation of the automatic features.

In addition to assuring satisfactory operation of the installation, the company estimates the cost of coating the lines was paid for in oil savings and labor costs in three months.

In another case, before coating, it was necessary to run balls every day. If one was missed, it was necessary to break out the line and steam it joint by joint. It has not been necessary to touch this line since it was coated.

SUMMARY

It is possible for the oil industry to save millions of dollars a year by preventing the deterioration of field equipment. This can be best realized by setting up rigorous preventive maintenance programs.

This problem is similar to the safety problem which the industry faced in the past, and can be solved in much the same manner. If every man in the field would be in search of places where corrosion preventive measures were needed as they are continually searching for safety hazards, much could be done. The major problem is to convince the field superintendent of the terrific costs involved and show him that something can be done about it. The safety problem was solved in this way, and so can the corrosion problem.