Oil Field Plastics

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INTRODUCTION

The advent of synthetic plastics, as they are known today, may primarily mark their humble beginning in 1909. At that time an American scientist, Dr. L. K. Baekeland, successfully synthesized phenol and formaldehyde into a resin used for molding and varnish laminate. From this basis Dr. K. Albert, in 1927-28, produced the phenol-formaldehyde resin which was suitable for a coating (1). From the beginning has expanded a total market which, in 1961, saw the production of some 6,300,000 tons of plastics (2).

While "oilfield plastics" includes a broad spectrum, it is intended that this presentation be limited to those plastics which are primarily used for coating production tubing, rods and accessory items. After a limited discussion of the most prevalent of those used, it is proposed to briefly outline a typical recommended application procedure, some quality control measures and then to elaborate upon usages, or, in some cases, misapplication.

FIRST USES OF PLASTICS

The first of these materials used were air-drying vinyls. This material, as is almost all others, is an applied multiple-cost application requiring, between successive coats, suitable curing time which permits the solvents to escape. This material was used in the 1947-1955 era for coating tubing and storage tanks. Most success was enjoyed in liquid phase service, and some of the more serious failures -- omitting applicator errors -- were found in gas or vapor phase service.

However, as the demands of deepening wells became known, the need for a more exotic material became evident. Such a material was originally introduced as early as late 1945 and was the phenol-formaldehyde, a non-oil soluble, thermosetting resin. This material served the strenuous requirements of the then highly corrosive wells of the day. It might be added that highly demanding wells of that day are the toys of today's high-pressure, high-temperature, 10,000 ft plus wells. Finally, after several test years, this coating was accepted as a suitable lining for tubular goods and well items. However, cost, requirement for relatively expensive application equipment, and other factors did not make it as readily acceptable as were other linings for tanks.

Phenolic plastic enjoyed almost complete dominance as a tubing coating until about 1953 when new thermoplastic coatings based on the epoxy resins began to appear. The most successful of these coatings was based on this resin and was produced as the reaction product of epichlorohydrogen and bisphenol ether; and this coating, in combination with a methylated phenol-formaldehyde resin, has now become widely accepted because of good performance data. Many modifications have been made so that today, this plastic is used with a high degree of success with chemically cured epoxy and fiberglass used for lining tank bottoms and sides and as a blast joint protective covering. Also, chemically cured epoxies are used for some tubing coating, tank lining, and flow-line work. However, in the latter cases the pressure and temperature limitations are lower than are those of the phenol-formaldehyde and/or epoxy based heat curing coating.

In the case of air drying and chemically cured coatings, forced or accelerated curing may be obtained by subjecting them to heat at 150-250 F for periods of 10-30 min. However, they must not be confused with the phenol-formaldehyde resin coating nor the epoxy-phenolic coating which requires a heat of some 400 F for periods in excess of one hour to effect cure. One rule-of-thumb used to indicate the type of coating required should be based on cost. The true baking coatings of phenols and epoxies will cost $0.65-$0.75 per sq ft for a 0.005 in.-0.007 in. film thickness. The air drying and/or chemically cured plastics, even with forced curing, should probably not be quoted at more than $0.50 per sq ft at the above thicknesses.

Certainly, one should not, in this discussion, omit the coal-tar epoxies which have enjoyed much success as a tank lining and some degree of success as a tubing - line pipe - or casing-coating. This coating is a mixture of coal tar and epoxy. It is normally catalyzed to effect a cure, but the curing may be accelerated by the application of heat. Application techniques have hindered its successful application to the inside of tubing but at least one applicator is enjoying some success.

These are probably the most widely used generic classifications of coatings which are being used in the oilfield. However, this should not be construed to mean that they are the only ones.

APPLICATION PROCEDURES

For T & C tubular goods the first recommended operation would be removal of the couplings.

Next, the item to be coated should be cleaned with a solvent wash, hot caustic solution, or flame cleaning. This cleanser removes oils, greases, paints, etc. Following this process, the items should be pickled in a suitable acid bath to remove most metal oxides and assist in the loosening of mil scale. Flame cleaning may also be successfully employed. The next procedure would be blasting with selected grit, silica, flint, or other suitable abrasives. For air drying or chemically curing materials, a commercial blast is sometimes utilized but adhesion of the coating would not be a maximum. For the baking type materials, satisfactory service will be contingent upon a perfectly clean surface. This process is referred to as a "white blast," and this condition is described (in Steel Structures Painting Council's Surface Preparation Specifications, Reference number SSPC-SP-5-52T and in NACE Publication 53-1 "Report on Surface Preparations of Steels for Organic and Other Protective Coatings") as Condition No. 1.

After cleaning, one coat of the predetermined generic-type coating is applied, and the applicator determines the solvent removing time and temperature cycle. Then, successive coats are applied until the ultimate thickness is achieved, and there follows a final bake cycle or drying time that is effected to produce a coating which will be satisfactory for use.

Ultimate success of the coating performance will be greatly influenced by:

(1) Degree of cleanliness of the surface to which the coating is applied.

(2) The degree of success in reaching a desirable

metal surface anchor pattern to insure maximum adhesion. (This is, at this time, generally conceded to be a maximum of 1/3 of the applied thickness of the thin film plastic and will normally be advertised as a one mil pattern.)

(3) Uniformity of the film thickness. This factor is especially important, for it concerns the generic classes of coatings, in higher temperature, higher pressure wells.

(4) Insurance that final baking time-temperature cycle is properly executed so cross-linkage of the polymerizing plastics are attained. Films without a full cure are doomed due to discouraging performance.

(5) Consistant quality of coating materials which will help insure constant performance results if the above details are insured during application.

Currently many companies are conducting laboratory tests to determine the most desirable coatings to be used in specific well conditions. This unbiased, competitive evaluation is recommended and endorsed by the applicators. Subject to approval and purchase of the coating job, many companies rely upon a non-destructive thickness gage to determine proper film thickness and on the so called "low-voltage holiday testing" as an evaluation of the coating condition inside the pipe bore. Currently these tests combined with laboratory results and field experiences are the criteria upon which the finished product is bought and accepted.

USES OF PLASTICS IN OILFIELDS

First, the air drying and chemically cured coatings, even with forced drying, are generally conceded to have maximum operating temperature ranges of 150-175 F when used in oil and water service. Gas handling service, at these temperatures and pressures above some 1000 psi, is not too conducive for use of these coatings because of permeation and resultant loss of coating adhesion.

Of the baking-type coatings, the phenol-formaldehyde based types offer the maximum in termperature and pressure resistances in oil - gas-condensate - gas - and water-handling service. Of the coatings normally available, service temperatures of 300 F are the maximum recommended and pressures of about 11,000 psi are advocated. Flow rates, chemical composition of produced fluid or gas, wire-line work necessary, handling procedures will all effect recommended usage and service life, and the applicator should be consulted concerning his specific product.

The other baking type coating, generally composed of varying ratios of epoxy and methylated phenolics, may again be used in oil, gas, gas-condensate and water service. However, service temperatures are limited to about 250 F and pressure ranges of 6,000-8,000 psi, depending upon suppliers' recommendations. These materials are, to some degree, more flexible than are the phenol-formaldehyde types and will offer greater resistance in alkaline service. On the other hand, their acid resistance is somewhat less than is that of the phenolics.

Certainly at this time it should be noted that several applicators offer organic coatings which are recommended for pressures and temperatures above those referred to earlier. These coatings, almost without exception, are based upon phenol-formaldehyde resins which have been modified with other resins, pigments, fillers, etc. Recommendations about the intended usage will again be made by each supplier.

MISUSES OF PLASTICS

Yes, coatings of the type described have and probably will contine to be misused. While this condition is not intentional it may result from several things:

(1) Improper selection of coating as influenced by economics of original cost. Correction--See the applicator representative and have him made a recommendation. He should be better qualified, in what his product will do, than is the operator.

(2) Improper selection of coating because of unknowns of service conditions. Correction--Insure that, as far as possible, the well conditions are made known.

(3) Improper or poor knowledge of coating performance by applicator representative. Correction--Invite the company to have competent representatives and omit purchasing from that company until product performance knowledge is forthcoming.

It goes without saying that these are only some of the more important factors which result in coatings being used in the wrong place. The conscientious applicator is doing his best to correct this condition and with help he expects to minimize the number of poor performances.

Because of time limitations several important points have been omitted. Especially has the application techniques been summarized.

However, the paper has reviewed the most generally used coatings, has hastily reviewed the process of application, has discussed the probable causes for poor performance, has noted quality control standards for the coatings, and has listed general environmental service limitations. The intent was to give a broad working knowledge so that the reader may be better able to critically judge a plastic coating and the job that it will do for him.

References

(1) Encyclopedia Britannica, Vol. 19, p. 210C.

(2) Modern Plastics, Feb. 1962, p. 123

(3) A more complete and detailed study of the recommended service conditions for these and other coatings may be found in NACE T6E Technical Practices Committee Report on "Protective Coatings in Petroleum Production".