Quality Assurance As Related to Field Performance of Plastic Coated Oil Country Tubular Goods

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Ability to predict satisfactory field performance of any product is directly related to the degree of quality assurance that can be built into the product during fabrication. This is particularly true in the case of plastic-coated tubular goods. Quality assurance must be "built-in" the product during manufacture and application of the coating. It is unrealistic and impractical to presume that routine "checking" for quality at the completion of the coating application process will produce a consistently high quality end product.

It, therefore, becomes necessary to continuously maintain, monitor and upgrade quality control procedures during all phases of the coating application process. This concept is of primary importance in processing plastic-coated tubular goods since inadequate or poor procedures at any stage in the application process will almost invariably result in a premature failure of the coating once the coated tubing is placed in service.

It is the intent of this paper to generally define the various stages of the plastic coating process and to discuss the techniques and methods used to determine whether certain specified parameters are being satisfied at each processing stage. Further discussion as to what happens when these specified parameters are not met and the product placed in service will also be presented.

SELECTION OF COATING MATERIAL

Selection of uniformly pure compounds used in the manufacture, compounding, packaging and shipping of finished coating materials is of primary importance in the ultimate performance of plastic coatings. Some of the parameters which must be constantly checked and maintained within specified tolerances are:

(1) Per cent solids
(2) Water content
(3) Solvent balance
(4) Storage life
(5) Weight per gallon
(6) Presence of foreign matter

Checking of the above parameters is routinely carried on in the laboratory utilizing such techniques as gas chromatography, titration,, distillation, specialized filtering, etc. All coating materials are checked at the coating plants to be certain that they are used within a specified time after manufacture.

Selection of the generic type of coating to be applied is usually determined after consultation between the engineer responsible and the technical representative of the coating company. Factors to be considered in selection of coating material are temperature, pressure, gas or liquid environment, and corrosive agent (acid, alkali, water, etc.). Improper selection of coating material, which is rare, will usually manifest itself in the form of chemical attack on the coating. This situation does not often develop probably because the qualtiy of the coating material is generally very good and the overall chemical resistance of the coating is generally adequate to handle the environment into which it is placed.

COATING APPLICATION PROCESS

The application of the coating is accomplished in a series of critical and demanding steps. These include cleaning and surface preparation, coating application, intermediate baking, final curing and preparation for shipment. Because of the critical nature of these various steps in the application process it has been said that even the best quality coating material can be rendered practically ineffective because of poor or improper application. Conversely, a coating material of even mediocre quality will in many cases give satisfactory service performance if it is applied properly. Thus, the coating application process in toto, is extremely critical and, in effect, actually determines what the ultimate performance of the coating will be.

Cleaning and Surface Preparation

The primary objective of this phase of the application process is to assure that all greases, oils, scale, paraffin, and other foreign matter is completely removed and further, to develop an adequate anchor pattern on the metal surface to be coated. Failure to achieve these objectives during the cleaning and surface preparation phase will almost invariably result in premature failure of the coating system. Coating failure, due to improper cleaning and surface preparation, usually manifests itself as loss of adhesion and ultimately complete disbonding of the coating from the metal substrate.

It is beyond the scope of this paper to discuss in detail the various techniques currently used in the cleaning and surface preparation of pipe. Generally, the cleaning procedure consists of prebaking the pipe at temperatures of 750° - 800°F for a sufficient period of time to remove oils, greases, paraffins, and other organic substances that are combustible. Prebaking also loosens tightly-adhered mill scale and other deposits which will adversely affect the ultimate adhesion of the coating.

Prebaking can be, and often is, supplemented by acid pickling to effect complete removal of scale, rust, and other deposits. Acid baths must be maintained at constant temperature and acid concentration in order to assure desired results.

Degreasing can also be achieved by immersion in hot caustic baths. Again it is necessary to control temperature and caustic concentration within specified parameters in order to achieve desired cleaning results. It is pointed out that only new OCTG can be adequately degreased using hot caustic baths. Used tubular goods must be prebaked to achieve satisfactory degreasing. Prebaking and/or degreasing and acid pickling is followed by sandblasting. Sandblasting effects final removal of all foreign mater from the metal surface and develops anchor pattern which is vital to ultimate adhesion of the coating to follow.

It becomes evident that selection of the proper blasting media and maintaining constant blasting pressure at the blasting nozzle are critical factors in carrying out the sandblast procedure. Various grades of "flintabrasive" and blasting sand are used dependent on type and grade of pipe being blasted and depth of anchor pattern desired. Maintaining proper air pressure is necessary in order to achieve effective sandblasting. It is, therefore, imperative that regular checking of pressure gauges be carried on throughout the operating day. Blasting nozzle orifice size has a critical effect on air pressure maintenance since the air volume required to maintain constant pressure increases as a function of the orifice diameter squared. Therefore, blast nozzle orifice size must be maintained within satisfactory limits if adequate sandblasting is to be achieved.

A continuous program of monitoring and properly maintaining prebake oven controls, acid and degrease bath temperatures and concentration, air pressure, and blast nozzle orifice size is absolutely vital in order to assure proper cleaning and surface preparation. A final optical inspection performed on each length of pipe determines whether proper cleaning and surface preparation has been achieved. This phase of the coating application process is considered the most critical since the large majority of premature failures can be traced to improper cleaning.

Coating Application and Curing

Internal coating of OCTG is accomplished by applying a series of coats (multiple coats) with intermediate baking between each coat until the desired final film thickness is achieved. It is vitally important that the initial coat be applied within a very short time after final cleaning of the pipe. Too long a delay will result in the formation of a thin film of oxidation on cleaned metal surface and is, therefore, detrimental to ultimate adhesion.

Coating temperature should be maintained constant during application in order that spray viscosity does not vary. Variations in spray viscosity as well as inconsistent lance speed and volume displacement of coating material through the spray head can result in non-uniform thicknesses of coating applied per pass. Failure to maintain constant the desired thickness per pass will result in foaming, sagging and running, and blistering during intermediate and final baking. Failure to eliminate and control these potentially detrimental factors results in premature failure due to blistering and film deterioration because of porosity.

Maintaining all coating equipment in clean condition and good operating order is necessary to assure that variations in the critical factors do not occur. Final checking is achieved by visual inspection and Wet Film Thickness Gauge.

Intermediate baking is performed after each coat is applied in order to remove solvents. Maintaining ovens in efficient operating condition is critical since improperly balanced ovens or inoperable oven controls can result in failure to completely remove solvents. Failure to remove solvents results in blistering of subsequent coats thus requiring complete re-processing of the pipe.

Final baking, or curing, is done after the desired coating film thickness is achieved. This procedure actually cures, or sets, the coating which in effect is the cross-linkage of the thermosetting polymers in order to give them their ultimate chemical and physical properties and adequate adhesion to the metal substrate. Failure to properly cure the coating results in an undercured film which will manifest itself in early failure. Properly operating oven controls and even oven balance are vital in order to achieve uniform cure of the coating. Proper cure is checked utilizing the conventional MEK rub test. Visual inspection for color uniformity is also a good indicator for proper curing, but color alone is not considered as an adequate check for proper cure.

FINAL QUALITY ASSURANCE INSPECTION

As stated earlier quality assurance must be built into the product during the manufacturing process. Good uniform quality doesn't just happen and performing a few quality control "checks" at the end of the coating process doesn't necessarily assure a high quality end product. Final inspection is, none the less, very important because it does provide the operator with the necessary information to determine whether an acceptable coating job has been done.

Final inspection consists of visual inspection, holiday inspection and thickness measurement.

Visual inspection is performed to check color uniformity, presence of any runs, sags or blisters, and general appearance of the applied coating.

Coating thickness is checked with a Mikro-Test Gauge and variations in the thickness which exceed the specification for the type coating being checked is sufficient reason to reject the joint.

Holiday inspection is performed utilizing either the 67.5 volt 80,000 ohm wet sponge technique or the high voltage dry spark test dependent upon the thickness of the final cured coating film. As a general practice in the industry the wet sponge technique is used on coating systems less than 8 mils' thickness when final cured film thickness exceeds 15 mils. There is no generally accepted technique for holiday checking coating systems of intermediate film thickness (9-15 mils); however, in the opinion of the authors the dry spark technique is the better choice because of the variables inherent in the wet sponge technique. It is pointed out that interpretation of "holiday" results can sometimes be confusing and inconsistent. The simple fact that a signal by the holiday detection device indicates the presence of a discontinuity in the coating film does not necessarily mean that the coating will fail to perform satisfactorily in service. Conversely, the fact that no holidays are detected does not completely assure satisfactory performance in field service. It is, therefore, very important for persons responsible for conducting and interpreting holiday inspection checks to be completely familiar with the variables that can affect holiday detection.

This is particularly important in the case of field holiday inspection, since results of this type inspection are highly inconsistent and, for the most part, inconclusive.

SUMMARY

A broad range of factors affect the quality of internal plastic coatings for OCTG. In an effort to maintain quality assurance at the highest practical level the industry has developed some rather sophisticated procedures and plant controls that enable it to maintain a comparatively high level of performance. Since we recognize that complacency almost always leads to deterioration, a continuous program of upgrading quality assurance controls and techniques is maintained. The continuing upward trend in demand for plastic coated OCTG and the infrequent reports of coating failures would indicate that progress is being made.