

CORROSION CONTROL IN DRY KILNS

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In the United States there is over \$200 Billion spent annually on the control of corrosion. This corrosion occurs everywhere - from factories, refineries, and power plants to tanks and bridges to automobiles and architectural structures. And, as you are well aware, corrosion is a real concern in dry kilns. Corrosion not only shortens the life of a kiln, but can seriously affect its operating efficiency as well.

Corrosion is defined as deterioration of a substance (usually metal, but also wood, concrete, plastic, etc...) or its properties as a result of a reaction with its environment.

Corrosion is an electrochemical reaction and can be controlled when one or more elements of this reaction are eliminated. Paints and coatings are used as barriers to eliminate or prohibit this reaction by separating the elements - oxygen and moisture from the substrate, usually steel and its impurities - carbon, etc. If the surface is dry nothing happens. If a little water and some air, particularly salt air, are exposed to the steel all the components necessary for the formation of a minute galvanic cell are present. It is this galvanic cell which causes the electrochemical reaction which results in corrosion. However, as stated earlier, if one or more of the elements of the reaction are eliminated, corrosion cannot occur. In order for a paint to perform as a barrier and successfully eliminate or separate the elements, thus prohibiting the reaction and the resulting corrosion, it must be properly formulated, specified and applied.

Corrosion is worse if moist air is present rather than dry air; polluted air rather than clean; high oxygen content rather than low; hot water rather than cold; salt water rather than fresh; acid environment rather than alkaline. Corrosion under any of these conditions will not occur if the proper paint is specified and applied.

The following five characteristics are necessary in order for a protective coating to perform as a "barrier" and separate the substrate from the elements:

1. Adhere tightly to the substrate
2. Impermeability
3. Chemical and abrasion resistance
4. Produce Pinhole free surface
5. Retard (inhibit) corrosion

These five characteristics are dependent on formulation (film density, resin, and pigment usage), proper specification (generic type), and proper application (dry film thickness). The importance of each of these factors should be readily apparent. However, the use of the proper coating for a specific exposure is basic to the performance of the coating system. If the wrong type of paint is chosen, then its formulation and application really do not matter.

The type of environment to which the painted surface will be exposed, the condition of the substrate, and the degree of surface preparation that can be practically attained are the major determining factors in the selection of a coating system. Of these, exposure conditions are the most important. In dry kiln applications, this is an especially important consideration in the selection of a corrosion control system.

Different generic type paints will perform better in one environment than another. A coating is composed of three basic elements: vehicle (resin), pigments, and solvents. It is the vehicle or resin which determines the basic performance properties of a specific paint type. Pigments contribute to the corrosion inhibition, stabilization, hiding, and color of a paint. Solvents are used to aid in the application of the paint. The combination of these components determine the specific performance characteristics of a paint which, in turn determines the selection and use of the appropriate coating for particular exposure conditions and applications.

Therefore, the first requirement in choosing the proper coating for a particular environment is a thorough knowledge of the conditions it must withstand. Specific compounds (acids, etc...), pH's, temperatures, and conditions (interior, exterior, immersion, etc...) all directly relate to proper paint selection.

The second requirement for proper paint selection is a knowledge of the type and existing condition of the substrate. Certain paints are formulated for application to carbon steel or weathered galvanized steel, while others for concrete or wood surfaces. Also, different paints are designed for abrasive blasted substrates or moderately rusty or previously painted surfaces, etc. Serious problems, such as poor adhesion resulting in coating delamination, may occur if the incorrect paint type is applied to a particular substrate.

The third requirement in choosing a protective coating system is an awareness of the degree of surface preparation that is practically attainable. It is not always possible to clean the surface as well as we might prefer - logistical problems may disallow blasting. This information must be known prior to paint selection as certain coatings require absolutely clean surfaces (i.e. inorganic zinc primers, high temperature paints) while others do not (i.e. long oil alkyds). As surface preparation is crucial to a coating system's performance, it is imperative that coatings be selected that are compatible with available preparation methods.

Though these should be the determining factors in the choice of a protective coating system, more often than not COST becomes the deciding factor. But cost does not always mean the least expensive product.

There are plenty of cheap paints on the market which will lower the initial material cost if used. But emphasis should be to choose coatings which provide the "Lowest Cost per Square Foot per Year" of protection while still meeting the requirements of the application. This is accomplished by choosing paints that are formulated with high volume solids. High volume solids means reduced volatile content (that portion of the applied paint which will "flash" or evaporate). This, in turn, increases the square foot per gallon coverage of the paint which translates into increased coating thickness and, ultimately, increased life expectancy. Increased coverage also leads to savings in labor costs, which can be from 3 to 30 times the material cost, by reducing the number of coats required to achieve the specified Dry Film Thickness.

Generally, coatings with high volume solids are somewhat more expensive than those with lower solids, but when the cost per square foot per year is calculated, it is obvious which product is more cost effective, both initially in labor costs and over the life of the coating in material and labor costs.

It is apparent that for a painting project to be successful, many factors must be considered. As previously discussed, paint formulation, selection and application are the keys to proper coating system performance. Assuming that the formulation and application of the coating is correct, a dry kiln operator must be thoroughly familiar with the exposure conditions at his specific kiln to properly select a protective coating system. The unconventional nature of kiln drying wood make

this an especially important consideration.

"The subject of dry kiln corrosion and its prevention is directly linked to the composition of the wood itself. Extractives, or those substances which can be removed from wood with water or neutral solvents and may be present in the humid vapors of a dry kiln, can be entirely different depending on the wood species being dried. Although extractives are only a small fraction of the wood, they are responsible for at least 90% of the corrosion problems encountered in dry kilns."¹ However, this is not always the case as certain types of wood may contain extractives which actually might help protect kilns rather than deteriorate them. Wood species such as pine and Douglas-fir contain resinous compounds that provide a coating action which increases corrosion resistance.²

Therefore, corrosion control in dry kilns is not as "simple" as in most other types of structures, as conditions can vary widely depending on the area of the country where the kiln is located, the type of wood being dried, the preservatives used in that wood and the design of the kiln itself. Corrosion control systems must be tailor-made to reflect the conditions at a particular kiln.

Certain basic conditions are common to all kilns (high temperatures and humidity, acidic atmospheres), and these will determine the general type of paint to be used. Also, paints available today are very versatile and may be used in a variety of similar exposures. A single type of paint may offer protection in a range of pH's, temperatures, and chemicals. In any case, the key to the successful performance of a protective coating system is a knowledge of the exposure conditions unique to the specific kiln and an understanding of the performance of different paint types under those conditions.

We have exposed and tested many different coating systems in the test kiln located at the University of Tennessee, under the direction of Dr. Robert Little. We have applied various Keeler & Long products to carbon steel and aluminum components as well as high temperature surfaces (steel heating coils) of this kiln, testing for overall coating system performance while searching for the most cost effective protection system. Interior conditions in this kiln, when drying oak, were temperatures up to 200° F, relative humidities to 97% and pH's of 3.0-3.5. These conditions may remain in effect for several weeks at a time.

Based on this work with Dr. Little, we have determined the best coating system for the aluminum components of his kiln is one comprising Chlorinated Rubber paints (primer and topcoat). The Chlorinated Rubber resin is formulated by treating natural rubber with chlorine. Plasticizers and stabilizers are then added for flexibility and exposure resistance. Chlorinated Rubber paints exhibit excellent moisture and chemical resistance, demonstrate superior adhesion properties, and are fire and mildew resistant. Though aluminum itself does not readily corrode, it does deteriorate when exposed to certain extractives (i.e. white fir wetwood)³ and protective coatings should be applied to control and eliminate this deterioration. This Chlorinated Rubber paint system has provided excellent corrosion control on aluminum surfaces exposed to the conditions in the University of Tennessee kiln.

A coating system composed of our Epoxy-mastic paint has exhibited excellent performance on carbon steel surfaces in the University of Tennessee kiln. This product is a combination of aluminum and stainless steel pigments dispersed in a polyamine epoxy resin and utilizes a high volume solids formulation which lends itself to applications on steel surfaces which have been blast cleaned, previously painted, or have been prepared by Hand or Power Tool Cleaning. The metallic pigmentation affords corrosion inhibition and produces a barrier which prevents the movement of air and moisture through the paint film. This "vapor barrier" action is especially necessary for proper protection in kilns, as the highly

corrosive moist air must be completely sealed out from contact with the steel substrate. The polyamine epoxy resin utilized in this product also affords excellent resistance to alkalis and acids. As each of these conditions may be encountered in a dry kiln, a single coating that is able to withstand them should find wide-spread applications.

High temperature surfaces (steel heating coils) present one of the most difficult applications in a kiln, as temperature resistance is not the only consideration. Thermal shock, or the expansion and contraction of the steel as temperatures rise and fall, is one of the toughest conditions a coating system will encounter. To withstand this exposure a paint must be formulated to resist high temperatures, as well as be applied in thin films to remain flexible and be applied to very clean surfaces for proper adhesion. In addition to these requirements, high temperature surfaces in dry kilns may be subject to high relative humidity and an acidic atmosphere which results in an even more severe environment.

Through our testing at the University of Tennessee kiln, we have determined that a coating system consisting of our silicone zinc aluminum paint performs very well under these conditions. All high temperature paints contain varying amounts of silicone to provide heat resistant qualities, but the addition of zinc and aluminum affords corrosion inhibition as well as a certain amount of exposure resistance. This coating system has proven the best of those tested thus far, but as this application is so severe we feel further testing under specific kiln conditions is required.

Though at the present time the aforementioned coating systems provide some of the best and most cost effective protection available for dry kiln applications, current technology is leading toward products which will offer superior performance while further reducing maintenance costs and increasing kiln efficiency. Our goal is to develop paints that will withstand increasingly severe environments (including those encountered in dry kiln exposures) while providing the lowest cost per square foot per year of protection. We must accomplish this while facing new challenges, including tough environmental (VOC) and health regulations, as well as spiraling raw material costs. Bob Little's research at the University of Tennessee, as well as our own testing and field experience, have demonstrated that we are well on the way to achieving this goal.

REFERENCES

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