Corrosion and Plant Maintenance[1]

JOE RENCH, Napko Paint and Varnish Works, Houston, Texas

THERE is no such thing as a miracle coating. And, of course, preventive maintenance has to do with coatings. We have looked everywhere, and it seems that everything we find has some little drawback along the way that prevents it from being a perfect coating. They have good properties one way and bad another. Each of the raw materials that is used in the paint industry is such that we have to engineer our paints. We end up always with a compromise. I believe you end up with a compromise in the things that you engineer. I am going to begin this presentation with an explanation of what paint is and/or the raw materials that go into it.

J. E. Rench

Paint is a big subject, and it will be virtually impossible to cover the entire field. In general, the broad components of paint are the pigments or the solid powders, and the vehicles or the carriers that carry the pigment onto the surface. Thinners are used to reduce the viscosity of the paint so that it can be applied to a surface. Last of all, there are the driers, which are used to hasten the drying of the vegetable oils.

Four broad general pigment classifications are: white, colored, black, and metallic. The white ones are represented by such pigments as zinc oxide, white lead carbonate, lithopone, titanium dioxide, magnesium silicate, calcium carbonate, and so on. The colored ones are completely in the field of chemistry, iron oxide and those made from organics. The blacks are made from carbon, bone, and other materials. The metallics are stainless steel, aluminum, and zinc.

White pigments are either active or inert. The paint industry, a long way back, developed a misnomer. When we refer to a white pigment as being active, we do not mean active chemically. We mean that it is active with respect to hiding power, that it has the property of obscuring the surface below it. The inerts, on the other hand, have no hiding power when dispersed in a vehicle. Such pigments as basic carbonate of white lead, leaded zinc, zinc oxide, and titanium dioxide are active because they possess hiding power when dispersed in a vehicle. Inerts like magnesium silicate, barium sulphate, and calcium carbonate have no hiding power when dispersed in a vehicle. It was a contention for many years that the inert pigments were adulterants in paint, that they were merely there to occupy volume so that instead of selling quality the manufacturers were selling the cheapest pigment they could find. Actually that has been proved untrue. Inerts definitely contribute to the durability of paint.

[1] Transcribed report, including discussion period.

Vehicles can be made up of any material that will form a film when it dries. This covers oil, varnishes, alkyd resins, ester gums, cellulose compounds, chlorinated rubber, and the like. Thinners are very important. Whether you have direct control over paint or not, whether you use it at home or not, this advice will be sound. Always look on the label and use the thinner that is recommended by the manufacturer, whoever he may be. We have had situations time and again where two storage tanks or some other equipment were being painted with two different kind of paints. If one painter ran out of thinner, he would invariably go over and borrow some of the other's thinner. When he added it to his paint, it thickened it so that it not only could not be put on with a brush, it could not be put on with a gun. It would have to be shovelled out of the can and put on the surface with a trowel. The solvent was incompatible with the paint. Always use the thinner that is recommended by the manufacturer.

The driers are best represented by three: lead, cobalt, and manganese. These are usually in the form of resinates, linoleates, oleates, acetates, or oxides. Lead has the property in oil paints to cause the film to dry, more or less, from the bottom up. Cobalt dries from the top down. Manganese gives you an all-over dry. Driers are calculated and used in oil-based paints in the quantities required to catalyze their dry. Any excess that is added actually causes brittleness, loss of durability, and, many times, wrinkling. The latter is particularly noticeable if too much cobalt is used since it is a top drier.

There is a magic word that has captured the public's imagination, plastics. I average four telephone calls a week wanting to know if we make a plastic paint. Well, in one sense, yes, we do. Almost all of the enamels manufactured today are from what we call synthetic material. Many are the same as the plastics that go into dice, piano keys, telephones, phonograph records, and brushes. These articles are made from the same thing that we use in paint. We call them either plastics or synthetics.

SO far I have tried to show the different components in paint, pigment, vehicle, and driers. Each component of paint will contribute different properties. However the effect will not always be the same but will depend in a measure upon the other components in the paint. As previously indicated, there are different kinds of pigments. These will contribute some or all to the following: color, hiding power or the lack of it, color permanence or lack of it, and chemical resistance. It is very important that the various components have the same effect. For example, if the pigment has no caustic resistance and it is dispersed in a vehicle which does, the film is still not a sound film. It will break down unless a chemical-resistant pigment is used. Pigments contribute to durability in certain quantities but can be detrimental in larger amounts. For instance, zinc oxide, if used in excessive quantities, will make a brittle film.

In regard to viscosity the oil absorption of the pigment will vary the viscosity of the paint. Some pigments, used in primers, can contribute greatly to the adherence of the films to metal surfaces. Some inert pigments contribute suspension and prevent hard packing in the can. They also contribute to the film strength. Magnesium silicate, for instance, is fibrous. It is used very much like re-enforcing rods in concrete in that it strengthens the paint film. The inert pigments, too, must be chemical-resistant if the paint is to be used in a corrosive atmosphere. It would be foolish to use calcium carbonate in an acid area where it would react. Pigments also contribute to the sag resistance and consequently the film thickness. The more paint that is put on, the greater the film thickness. If the paint sags easily, it is impossible to build up a thick film.

Vehicle solids are today probably the most important part of a paint. From them comes durability, viscosity and film thickness, adhesion, hardness and flexibility. In our modern day vehicles, as the polymers become bigger and bigger, adhesion becomes less and less although chemical resistance becomes greater. In any one application such properties as solvent resistance, the speed of dry, water resistance, and chemical resistance must all be considered. All of these factors are compounded together to come up with a compromise coating.

The alkyd coatings are probably those most generally used for general maintenance purposes. Like every type of vehicle, the alkyd has plus and minus properties. On the plus side it has exterior durability. I would say that on dollars per gallon or, better, the cost per sq. ft. per year in average conditions, it is probably the cheapest coating you could buy, that is, the most economical. It contributes great film thickness and chemical resistance and, with longer oil, good flexibility. Its drying characteristics are very good, and it has the finest color retention for the type of vehicles that can be used in home enamels and industry. On the negative side, its caustic and acid resistance is quite low; and the moisture resistance is poor. The area where the alkyd is most useful is where it is exposed only to the elements with no chemical exposure, that is, in areas in plants which are not continually wet or damp or exposed to caustic or acid.

The phenolic coatings are made from phenolic resins. The phenolic resin itself is a hard, brittle resin, which flakes very easily. It has poor film-forming properties but, when cooked with linseed tung or dehydrated castor oil, it forms a film that has a higher degree of chemical resistance than that of an alkyd. A phenolic coating has on its plus side, when well cured, fairly good solvent resistance. Its moisture resistance is much better than that of an alkyd. Its film thickness is good, it has fine salt spray resistance, and the film dries well. It is a very hard coating but has a negative side also.

Although at one time it was probably the most chemical-resistant coating available to all industries, it is now taking a back seat. Other coatings are much better. Its durability on exterior exposure is such that it chalks, and as it ages, it tends to become brittle. It is unsuited for use in white or pastel colors because on exposure it yellows badly. Its most useful application is with mild chemical attack where a brush coating is required and in areas which are perpetually damp.

Vinyl coatings are made from vinyl chloride, vinyl acetate copolymers. They are probably the most chemical-resistant materials available in the field of coatings today. They have a very good durability, their solvent resistance is quite good. They will swell in the aromatics but usually will return to their original shape and form. They are not easily dissolved in any type of aliphatic solvent. They dry very rapidly for re-coat, and their water resistance is unexcelled mil for mil of film thickness. On their negative side their film thickness is quite poor, and their spraying properties are somewhat questionable. It takes a fairly good applicator to come out with a good job. It requires rigid inspection on jobs to be sure of proper application.

Vinyls are not satisfactory over conventional primers because they require ketones to dissolve the resin. Consequently, if used over a linseed oil, red lead primer, the primer would wrinkle or alligator. Finally, the coatings have poor heat resistance. They are satisfactory at temperatures up to around 140°F., but above that temperature they are not too satisfactory unless modified with heat stabilizers. They can be used in strong chemical exposure. Incidentally they have good resistance to linseed oil, the kind of thing that would be of interest to vegetable oil chemists. Their caustic resistance is excellent. A vinyl type of coating should fit well into your industry, but it is only economical on exposures where it is wet or the chemical exposure is strong.

Chlorinated rubber has really been a boon to us in solving many problems because it has good durability and good film thickness. Incidentally all general comments are made on the assumption that the coatings have been plasticized correctly. Many of these new coatings must be plasticized. For instance, the chlorinated rubber itself is a hard, dry, brittle powder, and without a plasticizer the material is worthless as a coating. When plasticized with chemical-resistant plasticizers which will contribute flexibility, it is an excellent coating.

It is possible to get much better film thickness with chlorinated rubber than with vinyl. Coat for coat, the vinyl will average approximately one mil. Chlorinated rubber will run from one and a half to one and three quarters mils per coat. It has very fast dry for re-coat and uses such solvents as xylol or toluene. It usually has non-lifting properties because of its weaker solvents. Its chemical resistance is of the same order as vinyl. Its heat stability is better than that of vinyl, and its moisture resistance is very good. On the negative side, one of its weaknesses for your industry is that vegetable oil will easily dissolve it. Since weak solvents are used with chlorinated rubber, its solvent resistance is very poor. It is used in strong chemical exposure which is free from vegetable oil spillage.

IN any coating system it is necessary to have a primer to do one or all of these: prevent rusting, provide a good surface for re-coat, provide film thickness, provide a moisture barrier, and in the case of use over heavy oxidation, have good wetting for the penetration of rust. Red lead is a pigment. It is not a paint, but red lead combined with vegetable oils generally have the following properties. They are very alkaline in nature, and as the linseed oils or vegetable oils decompose, forming acids, they are neutralized, thus preventing an acid condition at the metal interface.

A red lead-pigmented primer provides good adhesion. It has good water resistance, remains flexible, and contributes film thickness. On the negative side, with vegetable oil, the dry is quite slow. Zinc chromate has on its plus side the fact that it passivates metal. It is basic in nature. In addition, it has soluble chromates that are carried to the metal surface, making it very useful in under-water applications or for marine uses. It contributes to the film thickness. On the negative side, because of its solubility in water, it is quite an unsatisfactory product for a material to be used in shop coatings if they are to be exposed without finished coats. Zinc chromate is not used too successfully with raw oils.

For the most part our industry is a good one, and it is an honest one. We have a few miracle product companies that will misrepresent themselves. Don't hold us all at fault for them. We make paint, and we can make it as well as anyone. I speak of all manufacturers. We can make a good paint, but we have to go beyond that point. We can give you the best paint in the world, but if it is put on the wrong kind of a surface or an ill-prepared surface, there is nothing we can do about it. The coating will fail. An example of what proper surface preparation and proper application can do for the durability of an item happens to concern meters for a gas company, which was trying to get five years durability out of their system. Two years ago we put five meters on exposure. Three meters were wire-brushed and painted with one primer and one finish coat. Two meters were sand-blasted and had the same two coats of paint put on. The difference was in preparation. The same person applied the material. Now one meter shows rusting and scaling badly all over, even on the regulator. The meters that were wire-brushed show signs of serious pitting. The meters that were sand-blasted look almost freshly painted. They were all put on exposure at exactly the same time, the same day, and in the same area. The only difference was the surface preparation.

Incidentally, while on the subject of primers, if any of you are writing specifications for new equipment coming into your plant, consider the shop coat. No doubt you have watched many, many items come in painted and never thought about it. A fabricator, for the most part, uses the cheapest product in the world to shop-coat the materials which you are going to spend the rest of that apparatus' life trying to protect. So, for goodness sakes, specify a real quality primer for a shop coat. Most shop coats are made from iron oxide. As far as iron oxide having any rust-inhibitive properties, no one has proven it to me. It is cheap, it has no rust-inhibitive properties, and usually the vehicle of shop coatings is made out of a cheap rosin modified varnish. The fabricator wants something that is quick to dry and something that will last until it gets to your plant. Unless you insist on quality, you are not going to get it.

For another example, some steel test panels have had different surface preparation and then have been allowed to rust. One has had no treatment, and the top is just weathered. It has had surface preparation. Another has been wire-brushed. The next has been given what is called a brush-off. It is a quick shot of sand out of a nozzle, just to knock off the loose rust. The last is what would be called a commercial sand blast. It takes off all rust and all of the mill scale except the gray millscale binder. These are the types of surface preparations that are used. The least desirable treatment is no surface preparation. It leaves all of the loose rust, chemicals, salts, and moisture that have collected. Wire-brushing just takes off the loose material. If it is impossible to sand-blast, wire-brushing is the best thing to do. In regard to the brrsh-off, we frequently wonder if it is not more economical to finish the job properly with a commercial sand blast.

Starting with bright, shiny metal, it is possible to build a sound, protective coating system. Starting with a poor preparation is much like building a house without a good foundation. The result is poor durability no matter how well the coatings are formulated. Many of you will say, "In our industry we can't sand blast. We can't prepare the surface that way because we have machinery that dust will affect." There are a million excuses. However you can probably find a way to tent off or trap off an area so that you can sand-blast the equipment in order to give us a decent surface to begin with. Then we can give you a protective coating system that will be sound and will last.

There is an old story in our industry that you may have heard, about leaving the mill scale on the metal. Let me describe the top part of a steel panel, which has been sand-blasted to white metal. The mill scale has been left on the lower half of the panel. The same coating systems were put on the panel. They were identical, top and bottom. One year later after exposure in this area, the result may be seen, showing what happens to the durability of a system if a coating system is applied to a poor surface. The paint is failing somewhat on the top because it is a poor coating for outside exposure in this particular area. Other tests have shown that. However it is much worse on the bottom. It is a total failure from one end to the other. Prepare the surface, extend the durability. You will find it is cheaper in the long pull.

SOME companies have gone to a tremendous amount of expense to test paints as you know. Thousands of dollars are being spent to expose various coating materials. Quite a bit has been learned about paints by using outdoor test racks. It is simple to distinguish between those coatings which have no possibilities and those which have. The final decision in regard to the practical durability of a coating however is on operating equipment itself. That is the only true test. Many people will send in panels for testing in a salt fog, in a weatherometer, or one of a dozen other accelerated testers. Experts have told me they believe that a test in a weatherometer tells whether or not the paint can stand up in a weatherometer or in a salt fog cabinet, and so on. The only way you can test a coating practically is in the area where it is to be exposed, where you have the problem to be solved.

There is a bit of engineering which we can not solve. If you, as engineers, can design equipment so that it doesn't have small diameters or such small angles, we can do more to protect the surface. We have no coating that can be applied practically to a piece of equipment that is less than one inch in diameter. More paint will be lost by spraying around it than goes on it. If you do have areas with very fine, small pipes, then the best we can suggest is to use something like vinyl tape, which can be wrapped around small pipes. It has an adhesive and will adhere well. It is possible to build up 20 mils of film thickness in one wrap. On that kind of a surface it is the cheapest and most economical way to obtain a good coating.

In emphasizing sand-blasting, if I can get one of you to sand blast one tank or one vessel, I shall feel that I have spent my time well. If there is another bit of advice that I can leave with you, it will be to use a proper primer. I would suggest that you use a vinyl-butyral wash primer on any sand-blasted surface. It is the best method of pretreatment that I know. In respect to the rust-inhibiting properties of the vinyl-butyral wash primer, let me describe a specimen panel. One half was treated, the other half of the panel was not. One coat of zinc chromate primer was then put on the whole panel and a finish coat of a white alkyd applied. After exposure on a 45-degree rack, for four years, the difference was easily noted. The panel had rusted underneath the film, and rust had actually crept completely across the panel on the top half. The vinyl-butyral wash primer stopped it on the bottom. Another panel tells exactly the same story. The lower half of the panel was treated with a vinyl-butyral wash primer, but the top half was not. Creepage from the edges came in and went clear across. On the bottom half there was little or no creepage.

YOU may be interested in the problem of high temperature exhaust stacks. We have to paint them. The Houston Paint, Varnish, and Production Club has a technical committee which conducts research on various phases of paint technology. This committee has developed a piece of equipment for testing high temperature paint. It is made up of a Fisher burner with a manometer to regulate the gas and a section of pipe, baffled, to even out the temperature. Once the coating has been applied to the pipe, it is placed on a stand and the burner heats it for seven hours. The maximum temperature is about 1,000°F. at the bottom and something like 300°F. at the top. This covers a fairly wide range of temperatures. The pipe is sprayed periodically with cold water during heating to duplicate a driving rain. Something like 500 cc. of water are used to shock the coating. After this treatment the pipe is placed on a rack for exterior exposure for six days. In all the testing work we have done, we have found no organic coating that would successfully withstand temperatures above about 500 or 550°F. for any length of time. We have found that a silicone, a semi-organic material, was the most durable. This is especially so when pigmented very highly with zinc dust. It is not a very decorative coating, but it has excellent durability. It can be recoated with aluminum for a decorative effect. The most important thing to a paint manufacturer, in helping to solve a customer's temperature problems, is to know the temperatures. Many times we have been told, "I have got 1,800°F.," or some such exaggerated figure. We find he has only 350°. It may not be hot enough to cure a silicone. We have had considerable difficulty in determining their exact temperature. It is wise to use either a contact pyrometer or tempil stiks. These little wax crayons melt at steps of 50°F. Exact temperatures can be measured with them. If you have a high temperature problem, first find out the exact temperature and prepare the surface properly. Then it can be protected and be decorative, too!

I hope that I have helped you to understand some of the problems with coatings. One of the biggest is to represent adequately the paint industry to another industry. In the old days a salesman may have been a glad-hander and a know-nothing, but that is not so true today. In our business, and I think throughout the paint industry, we have switched from that type of salesman to young engineers. We have people who are experienced in your own industry—people who have had technical training. Be wise and use these free, trained personnel as consultants for your coating problems.

Question Period

Q. Did you mention a minimum temperature at which silicones could be used? A. Yes, that's right. Silicones will not cure satisfactorily below 400°F. unless an extended curing cycle is used. However a more or less recent development uses an alkyd resin modified with a silicone which will air-dry at lower temperatures. It can be made to cure even at room temperatures if desired.

Q. With regard to tests that were made on the stack, you said that the silicone paint was not too decorative and that it could be covered with aluminum paint. What kind of aluminum paint was used? A. A silicone-aluminum.

Q. I wondered whether the aluminum paint could be brushed off. I didn't hear "silicone." A. Silicone will adhere quite well. We have stacks that are two or three years old which have been coated with two coats of silicone-aluminum. Silicone however does not give great film thickness. Any interior stack in continuous operation does not need a silicone because actually there is little moisture for corrosion. The aluminum seems to adhere to the surface well. It stays there and looks grand while in operation. However if it is shut down for a time, rusting will begin. We can use a material that is very highly pigmented with zinc dust. It is flat in appearance, but it builds up to something like three or four mils with one coat. Aluminum is put over it. You get the inhibitive property of zinc metal on the surface. Silicone coatings costs between $17 and $20 a gallon. Aluminum is much cheaper. Therefore if you have an area that is not an exterior exposure or if you have constant operation, then it is cheaper to use what we call a normal heat-resistant aluminum.

Q. You were mentioning chemical-resistant paint. What paint was it that you recommended for caustic resistance? A. Both chlorinated rubber and vinyl are very excellent for caustic. Vegetable oil will destroy chlorinated rubber.

Q. How about application? A. Our problem in the industry is not so much the ability of the painters to apply paint but their desire to apply it in proper film thickness. For good durability it is necessary to get sufficient film thickness to protect the metal. A painter, without good inspection, will apply paint for decoration only. I have had the experience of going into plants to supervise application. The painter would apply one section, and I would apply another. His sole idea was to get that panel decorated and keep moving. He will thin the paint too much. There is very little leeway with vinyl. It has to be put on properly in order to get sufficient film thickness. Other coatings are more easily applied. It means that a painter can do a more sloppy job and still have greater film thickness.

Q. It can be put on with conventional type guns, can't it? A. That's right, but some equipment is recommended as more suitable than others. Vinyl can be applied with a brush, by the way, but it is quite tricky because the solvent evaporates so rapidly. When vinyl is brushed on, the film is so fast drying that it tends to drag the brush. It is possible to spray vinyl in many areas where other coatings can't be sprayed because it dries so fast that the over-spray doesn't stick to nearby equipment. If the local area is protected reasonably well, it is possible to spray inside of a plant without contaminating the whole area. Are there any other questions?

Q. What is the life of this vinyl tape? A. It should be a great deal more than a paint if it is applied properly to a clean surface. It will have probably two or three times the film thickness. One disadvantage of vinyl paint is that on certain surfaces it has poor adhesion. Tape has an adhesive on the back of the tape which helps it to adhere. Durability should be very good if wrapped properly. There is a technique in wrapping tape. If you should get into a serious application of it, it might be well to contact the tape people and have them demonstrate it for you. They have equipment that automatically wraps it on pipe. They also have putty to be used at joints so that there will be no cracks or pin holes.