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THE REVOLUTION IN SURFACE COATING PRACTICE.

C. P. W. BRYANT - TECHNICAL DIRECTOR - THE GIOVENCO GROUP
OF COMPANIES.

INTRODUCTION.

Surface coating for the protection of steel, in particular structural steel, had changed little for a hundred years prior to the 1940's and this change was largely promoted by the "discovery" that lead-based primers and paints were toxic.

There is come justification for this attitude, through my own experience during the period when lead paints were generally used, led me to believe that most lead-poisoning was the result of carelessness and poor practise in the handling of these materials, i.e., the greatest pro rate incidence of illness seemed to occur among signwriters, who used the least amount of paint, but such habits as scratching off small mistakes with their finger nails and wiping the excess onto waistcoats worn for that purpose. Whatever the accuracy of the above, the fumes from lead paints during welding operationswere objected to by welders in any case.

The zinc chromates, which largely replaced red lead in primers, did not, for a number of reasons, do nearly as good a job, but the resultant situation did have quite a lot of influence on the re-awakened interest in surface preparation, as this had not been so important with red leads. We have since learned that even poor primers and overcoatings will perform surprisingly well over clean steel surfaces free of mill scale, in other than the more aggressive environments. The higher cost of such surface preparation, however, brought a demand for coating performance to justify this coat and the cycle had commenced.

Other factors were beginning to emerge also, full employment and the consequent attitude to the heavier and dirtier types of manual work has now made the constant chipping and repair of conventional paint systems uneconomical. The steep increase in cost of replacement or repair of steel structures has further highlighted the need for coating systems of much greater durability.

HISTORY.

The term "paint" does not, any longer, accurately describe the materials being used in the preservation field. "Paints" were (and still are) made and used by primitive peoples, using the coloured mineral earths of their particular region to decorate or accentuate certain features of their dwellings or places of worship, the usual solvent being water.

The Egyptians used lime, ochres, lampblack etc and used waxes, eggwhites, linseed oil, gums and pitches to bind them, etc. Likewise the Chinese, Japanese and Inca peoples used lacquers and varnishes made with the resins of the trees native to their countries, and available local or "imported" minerals. Much of the same can be said of the Phoenicians and Greeks, though the Phoenicians were more maintenance minded because of the large numbers of trading vessels they operated, and varnished the bottoms of their vessels to facilitate the removal of fouling.

The beginning of this century however saw the emancipation of paint making from secret art, and the introduction of technological study to the production of coatings to meet the requirements of the new age, though at this late stage, Linseed Oil, developed as a paint medium by the artist painter Jan van Eyck in the late 14th century, was one of the principal raw materials in paint manufacture, in fact, at this time, the turn of the 20th century, the raw materials were still largely linseed oil, vegetable oil, turpentine, white lead, mineral earth and inorganic colours.

MODERN DEVELOPMENTS.

The early 1920's was notable for the introduction of nitcocellulose lacquer, "DUCO", developed to 'use up' the tremendous stocks of gun cotton left over from World War 1., it's happy marriage to the rapidly growing automotive industry soon reduced the stockpile pressure. Later, alkyd type finishes were introduced as a direct result of chemical industries using raw materials such as Phthalic Anhydride, Glycerine and vegetable oils. The production of synthetic resins, phenol formaldehyde and bakelite was now in full swing, and chlorinated rubbers and cellulose acetate lacquers first appeared in commercial quantities.

The period from the late twenties up to the outbreak of was (1939) was mainly notable for the development of a number of quick drying lacquers, based on poly yinyl acetate and other poly-vinyl resins, ethly cellulose and cellulose aceto=butyrate, the vinyl resins, mostly based on co-polymers of vinyl chloride and vinyl acetate (90/10) had been developed and used in the marine field in anti-fouling paints, and in civil engineering as tank linings and seal coatings for inorganic zincs. At this time Titanium di-Oxide showed up as a white pigment capable of ousting the old established trio, white lead, zinc oxide and lithopone, though experience proved a tendency to free chalking unless it was mixed with zinc oxide. It has however, with the development of non chalking rutile titanium di-oxide lived up to it's promise, and is the most widely used in white pigment in conventional paint formulations.

World Wat 11 produced such a variety of resins and such a ttemendous advance in paint technology, that the radical changes brought about can literally be described as a revolution, it would be impossible in the time available to describe them all, but I will attempt to discuss them in groups.

EPOXY RESINS.

The most important resins to emerge from the war years were from the maintenance or protective coating aspect, Epoxies. These resins are condensation products of epichlorhydrin and bisphenol and as a group have excellent alkali and solvent resistance and can be formulated to give good acid resistance.

Epoxy-amine, is cured by mixing with an amine catalyst immediately prior to application. The pot life can be to some extent regulated by the type of amine used. Adhesion to most metals is very good, but subject to embrittlement on aging. Chemical resistance generally good.

Epoxy-Amide, is polyamide cured. This gives generally better flexibility and weathering properties and longer pot life than the amine cured epoxy, but the chemical resistance suffers somewhat. Adhesion is similar to epoxy amine. Improved flexibility under alkali conditions makes it more suitable for use on concrete.

Epoxy-phenolic,mostly used as a baked coating, giving remarkable chemical resistance and good flexibility in thin coatings. This resin combination (Epoxy phenol-formaldehyde) or urea-formaldehyde or melamine-formaldehyde, all "baking" formulations, can also be used as a two pack amine or polyamide cured products; but either flexibility and/or chemical resistance suffers compared with the baked finishes.

Tar-epoxies, probably the most widely used in the marine field, are the result of cross linking the correct combinations of epoxy resins and particular tar coal tars with amine and more recently polyamide catalysts. These give high solids coatings with excellent resistance to water, bring, and hydrogen sulphide, qualities which make them useful for lining pipe lines and water cooling equipment and crude oil tanks. They are lower in cost than unmodified epoxies, nor do they demand quite the same standard of surface preparation to achieve good adhesion.

Epoxy-esters are not true epoxies, inasmuch as they are manufactured in a manner somewhat similar to varnishes by heating together in a kettle epoxy resin and a drying oil, the resultant resin being formulated with pigments, solvents etc., to produce a coating which dries by solvent evaporation and oxidation in the same manner as a conventional coating. The epoxy-esters have good weathering resistance, fairly good resistance to acid and alkali fumes and good solvent resistance. Their cost compares to the tar epoxies.

POLYESTER RESINS.

Polyester resins are cheaper than epoxies and are readily cured at room temperature, furthermore they have reasonably good solvent and acid resistance and are hard and wear resistant, they have poor resistance to alkaline conditions however, become brittle and shrink on curing. Polyesters can be plasticised but lose a lot in chemical resistance in the process.

SILICONE RESINS.

The introduction of Silicone resins enabled tremendous advances to be made in the production of heat resistant coatings, for although the chemical resistance of these resins is not high, their resistance to heat is remarkable, withstanding up to 600°F without trouble, over an inorganic zinc primer they will perform very well up to 1200°F even under the difficult conditions of periodic cooling down and reheating.
Silicones have for many years of course being used as a water repellant coatings for masonry, particularly in those countries where sub freezing temperatures are experienced.

POLYURETHANE RESINS.

Polyurethane resins are more usually made by reacting di-isocyanate with various polyester resins. A wide range of coating resins is produced, from sfot to very heard, at the same time all are very tough, and their weathering properties can be very good. They have been successfully used by coating manufacturers to upgrade polyesters to achieve a tough chemically resistent coating at a more competitive price than straight polyurethane. A one pot air-moisture cured coating is now available which could prove very popular in this country, where high humidity conditions are so often a aproblem with more exotic coating systems.

PHENOLIC RESINS.

Phenolic resins in their various forms are excellent can linings, they have very good acid resistance and are quite hard, however they are in the main specialised coatings requiring baking or curing by acid catalyst. The chief interest they have for structural or marine application is as a vehicle for red lead. Phenolic red-lead primers are extremely good quick drying primers which I am sure would have proved very popular had they not been overtaken by events, principally in the form of welded construction, however, even at this late stage, there is a real need for a quick drying primer for maintenance work, where only minimum of surface preparation is possible, phenolic red-lead is the best answer I have at this time.

VINYL RESINS.

I have dealt so far with the thermosetting resins, or those of them that have any real application, probably the most importance of the thermo-plastics are the vinyls, which I have already touched on briefly; Vinyls require plasticising to give satisfactory flexibility, have good acid and alkali resistance but very poor resistance to organic solvents, they are widely used over inorganic zincs, both on structural steel for appearance and in water tanks as a non-contaminant lining. The main disavantages of the material are high cost, difficult application at site due to the very low solids content (25-35% by volume), and inflammable nature of the high proportion of solvent used.

ACRYLIC RESINS.

The Acrylics, mainly the methacrylate resins, the better known form of which is probably Perspex, have become very popular as coach finishing lacquers, and a further development, the thermosetting acrylic enamel that promises to take over in the mass productions appliance field where clarity and colour retention are prime requirements. The acrylic modified latex coatings appear to have little application in the marine or structural fields at this time, even if they were free of the teething troubles if dirt retention at present bothering them.

ELASTOMERS.

The most practical elastomeric coatings are Chlorinated Rubbers, these are coatings with fairly good acid and alkali resistance and good adhesion, but very little resistance to solvent. A problem with chlorinated rubbers is age embrittlement, and other resins particularly alkyds are used to modify them, this does improve weathering but results in some loss of chemical resistance. These coatings are very useful on structure in the wake of cooling towers and funnel gases.

ZINC COATINGS.

Zinc coatings fall into two major types - inorganic and organic. Inorganic zincs employ silicates, generall sodium silicates as vehicles, though ethyl silicate is also used and has the advantage that it is moisture cured, so that the troubles than can be experienced with sodium silicates in humid conditions do not occur. Whatever the vehicles used, the result is similar a firmly adhering zinc coating of oneto five mils thickness, as required, generally speaking stoved coatings are considerably harder than self cured or chemically cured coatings. Over coating of inorganic zincs can be troublesome and the advice of the manufacturers should be sought and adhered to, almost invariably vinyl or epoxy top coatings will be recommended.

Organic zincs can be formulated with a number of vehicles, epoxies, polystyrenes and chlorinated rubbers being the most popular, in all cases a firmly adhering coat, rather underbound, results, and overcoating presents no difficulties, almost any type of topcoat can be employed. The argument doe inorganics as against organics is besed on the assumption that the life of an organic zinc coating is predetermined by the life of the organic vehicle binder, whilst the life of the inorganic zinc coating has no such limitation. Whatever the pro's and con's neither assertion has yet, in the experience of the writer been proved, premature failure having occurred with both systems.

METALLISING.

METALLISING covers a wide range of both metallic coatings and application methods. These coatings can be applied by flame spraying, electrodeposition, hot dipping and cladding to name a few of the more common techniques.

Zinc, aluminium and cadmium coatings are all less noble than steel under most conditions, and can be used to cathodically orgalvanically protect iron and steel. In the process the coatings are consumed preferentially and the base metal remains intact.

Nickel coatings, being more noble than steel do not provide sacrificial protection, so must provide an impervious, non porous barrier. They can be applied by cladding or electroplating up to 30 mils in thickness.

Chromium electroplates have useful tarnish and wear resistance, and a low coeffieient of friction, but in themselves are poor corrosion protection, due to the nature of the coating, which is laid down more like fish scales than a continuous film, and requires a coating such as nickel as a substratum.

Silver Elecroplates can be useful in many corrosive environments. They are immune to attack by most dry or moist atmospheres, and although attacked by ozone, they resist the effects of oxygen at high temperatures. Most halogen gases will attack silver (bromine is more corrosive than chlorine) but the initial film that is formed inhibits further attack. Moist ammonia is corrosive to the coatings but dry ammonia has no effect. Carbon monoxide, hydrogen, fluorine and nitrogen have no effect at ordinary temperatures. The coatings will of course tarnish when subjected to most sulphur bearing compounds.

Precious metal coatings such as gold, platinum and rhodium are used to prevent surface corrosion on instrument and electrical switch components but need no further comment here.

Various metal coatings such as aluminium, tin, lead, monel, stainless steel etc., are frequently used to protect iron and steel against corrosion. Hot dipped aluminium coatings or flame sprayed aluminium coatings are especially useful where a combination of heat and corrosion is encountered, and they have high resistance to corrosive condensates which form when a heated part cools down. Tin, of course, is widely known for its use on corrosion resistant food containers, it is however, being challenged by the epoxy resins in a number of cases now. Lead coatings are distinguished by their ability to form a film environmental reaction products, such as lead sulphate, which are highly resistant to corrosion.

The foregoing gives some idea of the range of metal coatings available, but not all are applicable to structural work, the most widely used being zinc, either as hot dipped galvanising or flame sprayed zinc; flame sprayed aluminium and electroplated cadmium. Electroplated zinc is being used, but does not perform well in any but the least aggressive environments, the plating thickness is normally of the order of one quarter to one half a mil, and it's usefullness is limited to metal furniture etc.

GALVANISING.

Galvanising is a useful method of zinc coating steel, but the size of the job is restricted to the bath sizes available, and samage incurred during erection must be patched up by some other means. The ever present danger of hydrogen embrittlement of high tensile steels would also restrict it's use in some bridgework and other structures where these steels are often used. The embrittlement of the steel can occur during the pickling process, and although it is usually relieved suring hot dipping, some risk still remains. Galvanising is a most useful method of protecting ornamental wrought iron work and other heavy steel items of intricate form.

METAL SPRAYING.

Flame spraying of metals is having more and more application to structural steelwork as it usefullness and real, rather than apparent, economy is recognised. The protective coating metal more generally used is zinc, though aluminium and zinc/aluminium systems are also used for particular requirements. Zinc sprayed coatings range in thickness from 3 mils to 8 mils, depending on the type of service for which they are designed, and may or may not be overcoated, though they are generally regarded as primer and base on which a full heavy duty protective system can be completed.

Surface preparation of steel for metal spraying is abrasive blast preferably using chilled steel grit to give a surface profile of approximately 2 mils, and a standard of cleanliness of S.A.3, in other words "white metal" as any residue of mill scale or rust left on the surface will destroy the adhesion of the sprayed metal coating.

Flame spray guns used to apply the coatings employ either acetylene or propane gas and oxygen to melt the metal, which may be in the form of wire or powder and compressed air to atomise the molten metal and drive the wire feed turbine in the case of the wire fed gun. Very precise control is essential of gas mixing and flow, and air metering must be absolutely correct to prevent overheating and backfiring of the gun. First class flame spraying can only be produced by trained and experienced operators under strict supervision.

The nature of the sprayed metal surface can be varied as required to suit the particular job, i.e., the internal surfaces of a water tank will not require to be sealed or overcoated if given a finely sprayed coating of approx. 7 mils of zinc or aluminium, but a bridge that is intended to be coated finally with micaceous iron oxide will be either sprayed with a slightly more porous coating to give maximum adhesion to the overcoating paint films.

Techniques being developed at present,,will, it is feltmake flame spraying in the near future the most economical surface preparation and basic coating system available for structural steel. Improving not only the corrosion protection of the steel, but also the performance of the overcoating paint systems.

CONCLUSION.

It will not have escaped the readers notice that almost all of the coatings developed since the zinc chromate fell short of the standard required of it on structural steel, have been lock out coatings or sacrificial coatings of one form or another, 'inhibitive' primers such as red lead have, it would seem, ceased to merit attention, and apart from some recent work on metaborate which promises a dual function as a corrosion inhibitor and fungicide, been discarded.

The reasons forthis changing outlook have been twofold:
Firstly - the heavy duty coatings required and developed all required descaled derusted steel for optimum performance.

Secondly - welded structures are the rule rather than the exception nowadays and first class welding also requires descaled and derusted steel. The high cost of steel replacement and demands of modern techniques therefore complement each other in the requirement for proper surface preparation, and having achieved this at considerable expense, it would seem a pity to waste it with an inadequate coating system, which is almost at the point where we came in.

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