THE DEVELOPMENT OF CONTAINER COATINGS

There are now in excess of 4 million TEU in the world – they predominate the world trades, and are frequently seen on the oceans, rivers, roads, rails and even airplanes today. World trade has become much more efficient, speedier, regular and more economical as a result. The major container owner/lessors have become in the process household names – CTI, Sea Containers, Evergreen, etc. One of the ways these companies have achieved this status is by the use of distinctive colour schemes and logos. But paint systems for containers do much more than that. So, what are the functions of container coatings?

Briefly they:-

1. Protect the container from rusting and corrosion in order to ensure prolonged service.
2. Help keeping the container clean to prevent damage or contamination of goods in transit.
3. Give the container an aesthetically pleasing appearance.
4. Make the container (and hence its owners) easily recognizable.
5. Allow the application of decals, sticky labels, transfers, marking inscriptions, etc.

In addition to point 1. containers face the following corrosive conditions like:

- varying temperature and humidity
- continuous exposure to salt-spray and UV radiation
- abrasion and impact by wind-borne sands and container handling.

In order to obtain the best of properties for the above mentioned service requirements, container paints must have certain characteristics both in the wet paint and in the dried film. The wet paint should be:

- easily applicable, with most types of application equipment but especially airless spray (bot manual and automatic)
- quick drying so as to rapidly assemble the painted unit into complete containers and apply labels, transfers, etc. in accordance with a time schedule.
- capable of good film formation – the applied paint must be free of surface defects, pinholes, orange peel, sags, etc. The solvents in the applied film should not persist for long periods after application.
- capable of storage for extended periods or being transported long distances without changes in the product viscosity or settling out of pigment, etc.

The dry film too must have certain characteristics:-

a. adhesion must be good to surfaces, which may have been prepared by a variety of techniques (e.g. grit blasting, shot blasting, pickled plates, phosphatised plates, etc.).

b. mechanical properties must be excellent – the surface must be hard yet the paint should be flexible to allow substrate deformity without detachment, the paint system must also resist the shocks and impact (from scrapes, rubs or blows) that container in service are often subjected to as well as an ability to resist thermal expansion and contraction of the substrate as the container travels through warmer regions.

c. Chemical resistance of the paint system should include resistance to weathering in environments ranging from urban/rural to polluted industrial and marine. In the latter, containers will often be sprayed with seawater and should be able to resist this.

d. Overcoatability especially by labels, transfers and inscriptions must be good and also the system should be easily retouched or repainted.
PAINT SYSTEMS

The ideal protective system will combine high performance, easy application and maintenance with low cost. If you consider the practical aspects of application and maintenance, this means that the most convenient system is that based on the use of a single product to be applied by a single pass at high film thickness (but this has considerable drawbacks imposed largely by the trapped solvents trying to escape from the applied film and solvent retention if often a problem) or even applied by multiple passes to achieve higher build. Two coat systems (primer and finish) involve more complex application plans and more labor and storage facilities – but they are preferable as they give better protective properties and allow more favorable technical solutions to be arranged and this results in a higher performance.

Two coat systems are routinely used for painting new containers; single coat systems applied by 2 passes are intended mainly for refurbishing operations.

So, much for generalities on type of paint that might be suitable and the technological qualities required of them.

Let us now consider briefly the types of formulations often used and then how Transocean set about evaluating products for the protection of containers.

PRODUCT TYPES

Much though is always given to the choice of resin used – the major ones used are :-

1. High molecular weight epoxy resins – these give excellent films of good hardness with very good chemical resistance – these formulations are however always two pack and rather expensive and therefore, the use of epoxies on containers tends to be limited to primers and the interiors of containers where a hygienic (and easily clearable) coating is desired for transport of edible materials. As primers they may be overcoated by chlorinated rubber of vinyl finishes.
2. Chlorinated Rubbers – are versatile materials that are formulated into a variety of one-pack materials, either as pure chlorinated rubber or as mixes with a variety of plasticizers and resins. These materials find use in both primers and finishes.
3. Vinyl Resins – of the vinyl chloride/vinyl acetate type are also employed with special modifications for primer and finish. However, the products tend to be low in volume solids as these high polymers need much solvent for dissolution – hence they can be rather expensive.
4. Alkyds, modified alkyds and epoxy esters – these are all materials that harden by means of a reaction. They are commonly used as binders in container coatings and often in the formulation of low-cost products. However, the drying and recoating times can be rather slow and mechanical properties, especially shock resistance, not of the highest quality.

The choice of binder, of course, largely stets the choice of solvent, which carries it. However, the pigments influence performance of the coating in rather profound ways. The two major pigment types are :-

Anticorrosive Pigments – these give the primers particularly, their high corrosion-inhibiting power. In particular zinc dust confers very high rust inhibiting power.

Decorative Pigments – these pigments give the paint its particular colour shade and they should therefore have good light-fast properties. In addition other extending pigments are included to improve adhesion, film impermeability or texture.
Using a combination of binders, solvents, pigments, extenders, thixotropic agents, etc. the paint chemist may now formulate products. But before they can be even considered for the market place they are subjected to a battery of tests. The nature of the tests reflects the product end use and it is perhaps instructive to consider the nature of these testing regimes. (Although, no test can fully duplicate the tremendous variation in surface preparation, application, handling conditions and weathers extremes that containers may be subject to).

**CORROSION RESISTANCE** – this is usually determined in a salt spray cabinet. A salt spray (content 3 – 5% is sprayed over the panels continuously and the aid the corrosive conditions, a break is introduced onto the coating surface by scribing with a knife (usually in the form of an X). Coating condition is evaluated after 500 and 100 hrs. And the degree of rust creepage from the scribe and blistering of the coating are assessed. This test then gives an indication of the resistance of coatings to the more or less constant presence of salt and spray in and around containers in transit and storage.

**ABRASION RESISTANCE** – measures the resistance of the paint to continuous wears induced by the rubbing of a weighted wheel on the coating. The amount of wear after 1000 cycles of abrasion is assessed. This test obviously tries to simulate to a degree the handling that the container experiences in service.

**ADHESION** – the coating is subjected to cross-hatching with appropriately designed knives. A tape is attached to these squares and the amount of coating adhering to the tape is noted. The test is repeated after accelerated weathering. It is a good indication of the adhesive tenacity of the system to the substrate.

**ACCELERATED WEATHERING** – where coated panels are exposed to intense UV under rather humid conditions. The panels are evaluated after a month's exposure for colour change and any decrease in gloss is also monitored. The test is geared to evaluating resistance of the coatings to the UV component of sunlight, which has a particularly destructive effect on the resin and pigment components of paints.

**HARDNESS** – the coating is also assessed for hardness. Subjecting the coating to scratches from increasing hardness grades of pencil – the grade that makes, does this and impression in the coating approximates to the coating hardness. In addition there are micro indentation hardness testers that can give a more precise evaluation of the hardness and elasticity of a coating surface.

**IMPACT RESISTANCE** – a one kilogram steel ball is dropped at increasing distances (unto 1 meter) onto the reverse side of the painted panel and the resistance is rated at the height which just causes loss of adhesion of the coating. This test is carried out on panels before and after the weathering process. The test is designed to simulate the shock that containers are subject to especially during loading and unloading operations.
**FLEXIBILITY** – the paint system on a panel is subjected to a 180° bend over a half-inch mandrel. The paint should not crack or delaminate. This test is repeated on a specimen panel exposed to the accelerated weathering cycle. This test attempts to simulate the flexing of the container walls in service caused either by mechanical or thermal means – the paint should obviously survive such flexing with adhesion unaffected. A combination of these tests therefore allows a close appreciation of the coating types that will satisfactorily survive container service.

So much for how paint companies select suitable paint systems. Now, let us look at the criteria on which the paint supplier and his systems are selected.

The paint manufacturer serves not only the container owner but also the container manufacturer or refurbisher and the successful coating and protection of a container requires full confidence, cooperation and understanding amongst these.

What does the paint manufacturer offer in order to satisfy the container owner, manufacturer and refurbisher?

Let us consider the 5 most important items:-

1. **Durability of system in marine and industrial environments.**
   Containers endure various atmospheric conditions. Besides temperature- and humidity fluctuations due to voyage patterns in some areas big differences in day/night temperatures can be expected too. Continuous exposure to UV radiation (sunlight) and seawater tend to cause deterioration of paint such as fading of colour. Since the containers’ colour is important to each company or owner, it is obviously desirable to preserve the original colour and appearance as long as possible.
   The durability of paint systems is very much a function of surface preparation and application. If a Sa 2½ surface preparation and service life of a given system is related to the coating chemistry and dry film thickness. Generally speaking exterior systems should have a total dry film thickness of not less than 100 µm and this should be applied in at least two coats to minimize the pinholing. Expected service life for the most common generic container coating types under these circumstances is:

   - **Alkyds**: 3 coats, 2 years
   - **Epoxy Ester**: 2 coats, 2 – 4 years
   - **Chlorinated Rubber**: 2 coats, 2 – 4 years
   - **Zinc rich Epoxy Primer /1 coat**
   - **Chlorinated/ acrylic Finish**: 1 –2 coats, 4 – 6 years
   - **Epoxy**: 2 coats, 4 – 6 years

   After 4 – 6 years, the containers have been subjected to so much mechanical damages that they will have to be refurbished anyway. An interesting point is the usage of inorganic zinc silicate primer on the steel frames of aluminium containers.

2. **Mechanical damage**
   Containers can be damaged during loading and discharging procedures. During transportation and handling container are exposed to vibration and rubbing. Cargo movement in the container created impact stresses on the coating systems too. Therefore, the coating system must be flexible and tough to cope with these conditions.
3. Application properties.
Container production lines are never identical. To suit a particular line, a paint manufacturer will have to adjust some characteristics of his products (e.g. application, drying, etc.) without affecting the protective properties or price. To do this, local laboratory know-how and practical experience is a must.

4. Easy of Maintenance
In general the finish coat will be a thermoplastic type such as acrylic or chlorinated rubber enabling easy recoating when required. When containers are repaired, abrasive blasting may not always be possible. Hence, refurbishment paints have to adhere well to power tool cleaned substrates. Also, compatibility with the old, existing paint system is important.

5. Economics.
Coating cost is dependent the choice of system. It will be obvious that when choosing a zinc epoxy primer instead of a Chlorinated Rubber primer, total cost is higher but the lifetime expectations too! Finally, it is perhaps worth comparing paint materials costs to the other costs involved in paint containers. It is evident that even for a good quality system, the major costs are with surface preparation and paint application. With this distribution in mind (and not forgetting the costs of container, lying idle in repair yards) it is clear that it is not in the owner’s interest to cut corners on paint quality.

Appendix - Process for 2-coat system application line.
Process for 3-coat system application line.

Process for 3-coat application line with phosphatising treatment.