



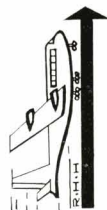
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JOURNAL OF THE  
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To open  
Autumn 1977

Test methods used for the evaluation of powder coatings based on epoxy resins

*C. H. J. Klaren*

The effect of oxidative coordination drier systems on film properties

*D. J. Love*

The integration of the protection function when building a ship

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Steel cleaning standards—a case for their reappraisal

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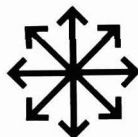
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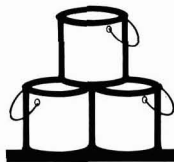
dispersion



color development



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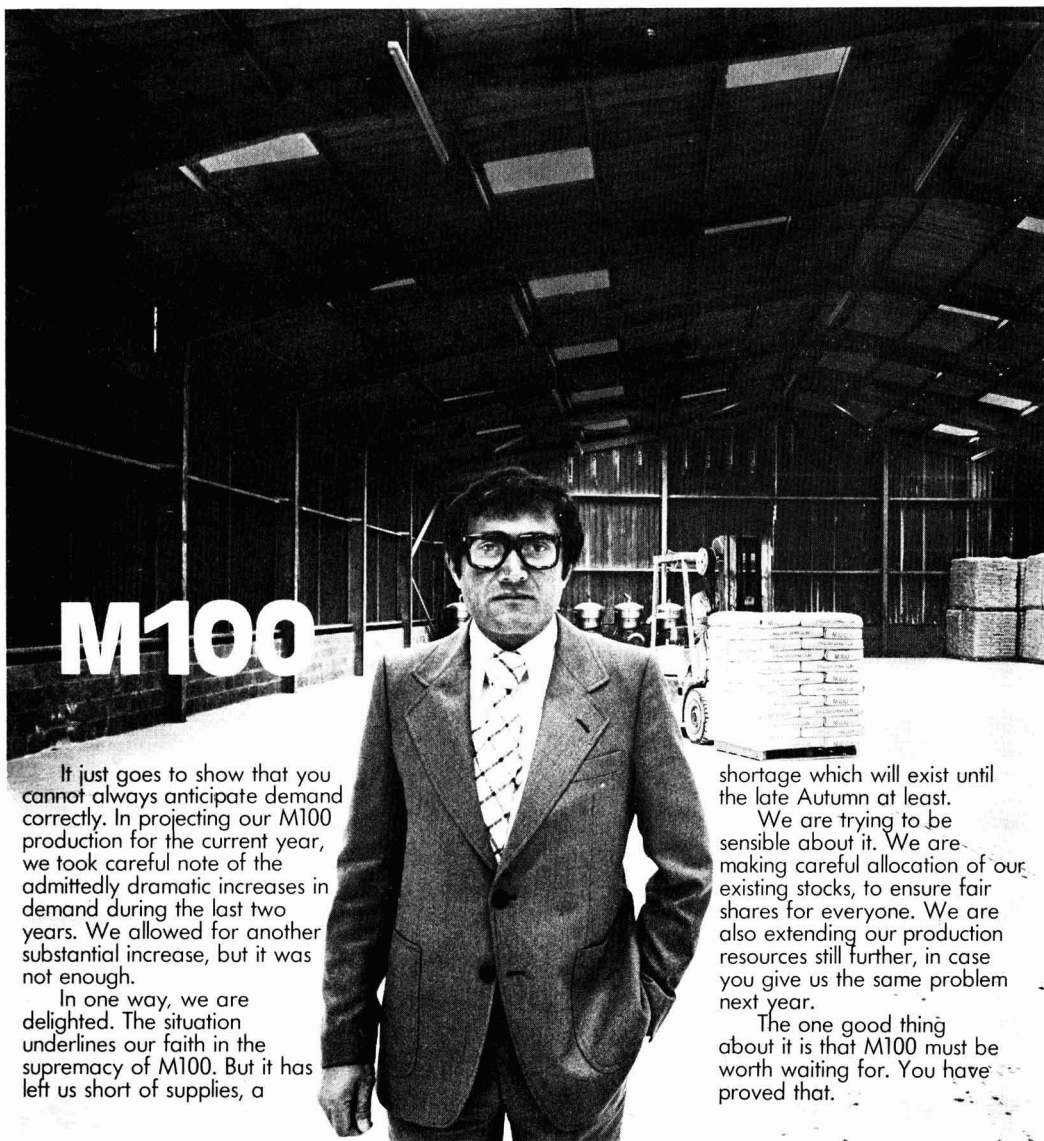
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## Transactions and Communications

# Test methods used for the evaluation of powder coatings based on epoxy resins\*

By C. H. J. Klaren

Koninklijke/Shell Laboratorium, Badhuisweg 3, P.O. Box 3003, Amsterdam, Netherlands

### Summary

This paper describes various test methods used for the evaluation of epoxy-resin-based powder coatings.

The first part deals with various production control methods. The tests for powders discussed here concern specific gravity, particle size distribution, reactivity and stability.

In the second part an attempt is made to correlate thermal behaviour of powder coating systems with the ultimate film properties. In this study Differential Scanning Calorimetry was used. The influence of type of resin and curing agent is discussed.

### Keywords

*Types and classes of coatings and allied products*

powder coating

*Properties, characteristics and conditions primarily associated with:*

*materials in general*

particle size

melting point

*bulk coatings and allied products*

can stability

*coatings during application*

curing rate

curing temperature

*bulk coatings and allied products*

volatile content

*dried or cured films*

gloss

hardness

*Processes and methods primarily associated with analysis, measurement or testing*

differential thermal analysis

*Specifications, standards and regulations*

standard procedure

## Les méthodes d'essai utilisées dans l'évaluation des revêtements en poudre à base de résines époxydes.

### Résumé

Cet article décrit les diverses méthodes d'essai utilisées dans l'évaluation des revêtements en poudre à base de résines époxydes.

La première partie traite des diverses méthodes pour contrôler les procédés de fabrication. Les essais sur les poudres elles-mêmes que l'on discute ici comprennent la densité, la répartition de la grandeur particulaire, la réactivité, et la stabilité.

Dans la deuxième partie on tente d'établir une corrélation entre le comportement des systèmes de revêtements en poudre et les caractéristiques ultimes du film.

Au cours de cette étude on a utilisé la technique de la calorimétrie différentielle par balayage. On discute l'influence exercée à la fois par le type de la résine et de l'agent de durcissement.

## Prüfmethoden zur Bewertung von Pulverlacken auf Epoxyharzbasis.

### Zusammenfassung:

In dieser Abhandlung werden verschiedene Prüfmethoden beschrieben, welche zur Bewertung von Pulverlacken auf Epoxyharzbasis angewandt werden.

Der erste Teil behandelt verschiedene Methoden zur Kontrolle der Produktion. Die hier besprochenen Prüfungen für Pulver betreffen spezifisches Gewicht, Teilchengrossenverteilung, Reaktivität und Stabilität.

Reaktivität und Stabilität.

Im zweiten Teil wird versucht das thermale Verhalten von Pulverlackensystemen mit denen der resultierenden Filmeigenschaften in Beziehung zu bringen. Bei diesen Versuchen wurde die Differential Scanning Kalorimetrie benutzt. Der Einfluss von Harzsorte und Härter wird besprochen.

### Introduction

In the evaluation of powder coating formulations a proper selection of test methods and a correct interpretation of the data obtained are of paramount importance for the user. This paper has the aim of suggesting a standardisation of powder coating evaluation methods.

methods, which will be referred to only by their test method number.

The paper is divided into two parts. The first part is devoted to routine work and subdivided into two subsections:

—tests on the powder, itself

—tests on the powder coating.

Some of the tests described are simple standard paint test

\*Paper presented at the 6th National Symposium held jointly of the South African Division of OCCA and CSIR in Port Elizabeth on 8 and 9 October 1976.

The second part concerns the thermal behaviour of the systems under practical conditions, for instance, the effect of the heating rate of an oven used for stoving the powder coating film.

## Tests on the powder

### Density or specific gravity

There is no doubt that when dealing with the quality and behaviour of the raw materials that together form a powder coating, attention should also be paid to the economics. In this connection it is important to know the density or specific gravity of a powder.

In the paint industry it is normal practice for a paint user to know how many square metres can be painted with one litre of paint. However, in the powder coating industry sales are always on a weight basis. Measurement of the specific gravity or density offers a means of calculating the cost per square metre of a powder coating. A practical formula is given by which it can be determined how many square metres can be coated with a powder of a given density at a predetermined layer thickness.

$$X = \frac{1}{d} \cdot \frac{1000}{\mu m}$$

$X$  = number of square metres which can theoretically be coated with 1 kg powder coating

$d$  = density of the powder

$\mu m$  = film thickness

Two methods may be used to determine the density:

#### a. Pycnometer ASTM D 762-66B

The principle of this method is based on the displacement of a liquid by a solid, in this case the powder.

#### b. Helium pycnometer

Since a hundred per cent wetting of the powder by water is very difficult, measurement of the volume of powder by the displacement of liquid can easily lead to erroneous results. Using an inert gas, such as helium, as the displaced fluid the absolute volume of materials in powder form can be determined much more accurately. The apparatus is of very simple design and easy to operate and it enables a rapid calculation to be made for the routine checking of the density of an epoxy powder.

Fig. 1 gives a scheme of the operation of this type of pycnometer. A weighed quantity of powder is placed in the sample holder. An indicator connected to the piston moves from an initial position until the pressure of the gas in the chamber remains constant. The displacement of the piston, that is the change in reading of the indicator, expresses the volume occupied by the powder sample under test. A simple calculation converts this figure into the absolute volume of the material tested. The precision with which the density is obtained will depend on the accuracy in weighing the sample; an accuracy to 0.001 g, gives an accuracy of the calculated density of 0.01 g/cm<sup>3</sup>.

### Particle size distribution (PSD)

In view of the tendency to reduce the film thickness of powder coatings, the PSD is becoming more and more im-

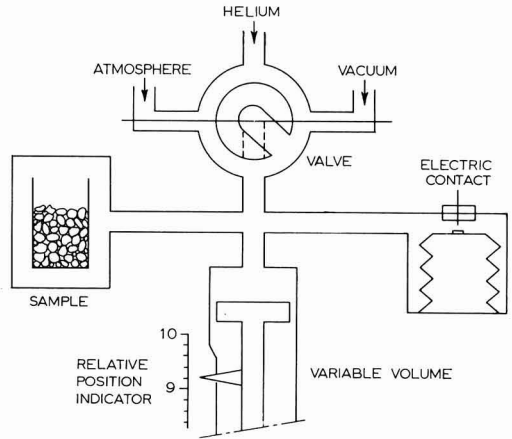


Fig. 1. Scheme of helium pycnometer

portant. This means that the user of powder needs a relatively easy and rapid method to measure the coarse particles in a powder and thus to predict results. This, of course, holds also for the powder producer. For the user the simple method of sieving is recommended, *i.e.* using sieves of various finenesses or, more completely, sieving with suction, as described in ASTM D 1921. This method refers especially to coarse particles. It is suggested that powder manufacturers (by no means excluding the users) use a particle counter, for instance the Coulter counter.

The principle of a Coulter counter is shown in Fig. 2. A powder suspension in an electrolyte flows through a small orifice having an electrode on either side. As a particle passes through the orifice, it displaces part of the electrolyte and for a moment changes the resistance between the electrodes. This change in resistance produces an electrical pulse proportional to the volume of the particle, which is measured and counted electronically.

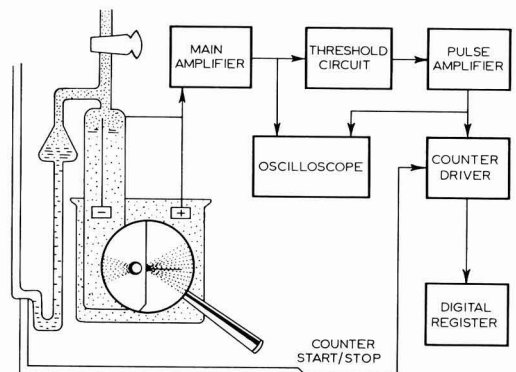
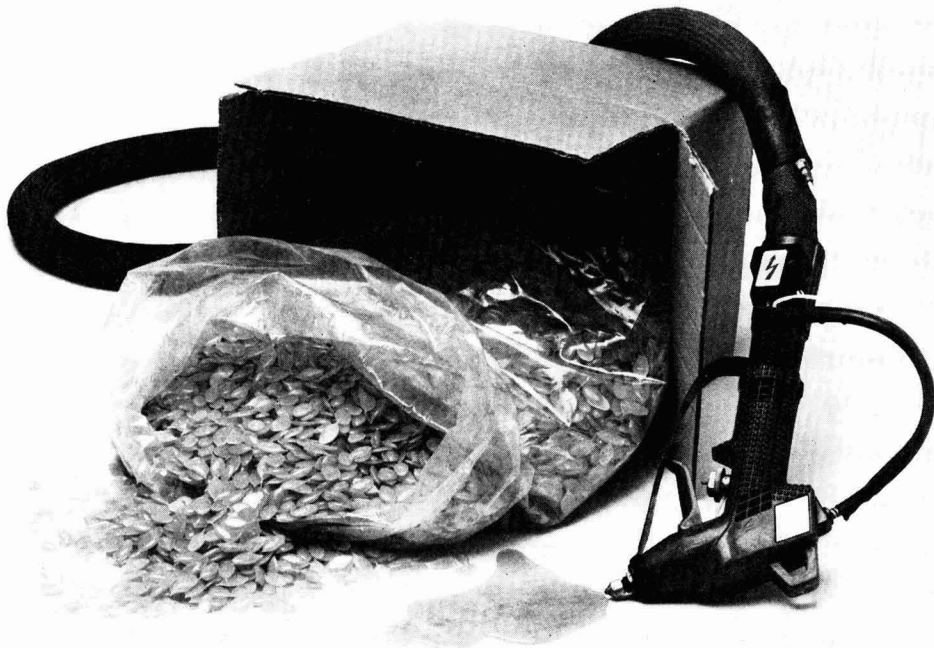


Fig. 2. Scheme of Coulter counter

Fig. 3 shows a typical particle size distribution curve of a standard white pigmented epoxy powder. This powder had been milled in the laboratory using a Bantam Pulverizer ex Mikro-Pul, Germany.



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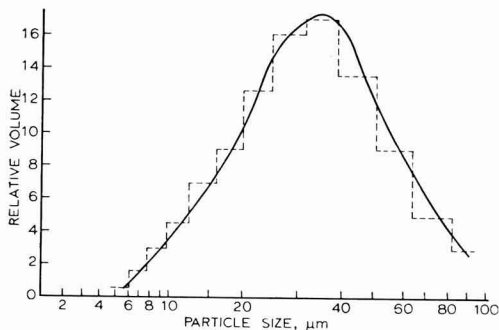


Fig. 3. Typical PSD curve of a standard white pigmented epoxy powder

### Free flowing of a powder

Ref. 1

It is well known that the transport and spraying characteristics of powders are highly dependent on their flow properties. Usually the "flow angle" is taken as a measure of the flowability. In this method the powder is made to flow out of a funnel and form a cone-shaped heap, the angle of which depends on the flow properties. The objection to this method is that the powder is used alone, whereas during application it is mixed with air. It, therefore, appears to be more in accordance with practice to study the flowing characteristics of the powder in a fluidised state.

The Paint Research Institute TNO, Holland, has developed a new method for the determination of the flow properties of powders<sup>1</sup>. The equipment (see Fig. 4) used for this test consists of:

- vessel *A*, for fluidising the powder
- a flowmeter *B*, for adjusting the air flow
- a container *C*, which collects the powder.

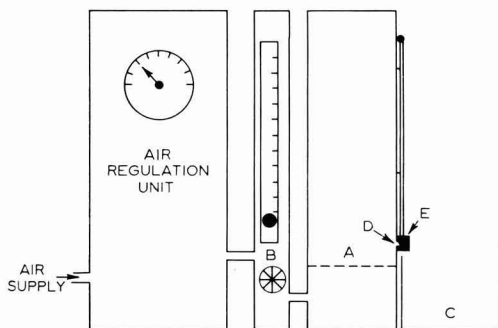


Fig. 4. Diagram of fluidimeter AS100

In the wall of the vessel near the porous bottom is a 4 mm nozzle *D*, which can be closed with a stopper *E*. This equipment, the "Fluidimeter AS 100" has been commercialised and marketed by Tunzini Sames, France. The test procedure is as follows:

The vessel is charged with 250 g of the powder and air is introduced at the rate of 200 litres/hour, which is sufficient for fluidisation. During the fluidisation, the powder is stirred until its height (in cm) remains constant ( $V_1$ ). After the air supply has been switched off, the powder soon returns to its original level and the height (in cm) is again measured ( $V_0$ ). For the flow test, the powder is now fluidised again at the same rate of air supply. When the fluidised powder has reached a constant height, the stopper *E* is removed from the nozzle and the powder which runs out during 30 seconds is collected in *C* and weighed in (*G*) grammes. At least five determinations should be made. TNO found quite empirically that the formula  $R = G \cdot V_1 / V_0$ , in which *R* can be taken as the flow factor, is a good measure of the flow characteristics of a powder. This was compared with what is normally found in practical assessments and gave the following correlation:

flow factor <i>R</i>	free flowing
>180	very good
140–180	good
120–140	acceptable
80–120	moderate
<80	poor

Results found with various powders are completely in line with the actual spraying properties. In general, commercial epoxy powders lie between > 180 and 140–180.

### Reactivity

The gelation time of powder coatings provides valuable information on the reactivity of a powder at a given temperature. However, there are great variations in gelation time test results among powder manufacturers. The differences are due mainly to variations in individual methods, or to poor temperature control or constancy of the apparatus during the test. The difficulties encountered with this test can be overcome by the method and apparatus used in the author's laboratories.

The hotplate used is a steel plate measuring  $190 \times 190 \times 30$  mm, heated electrically. The temperature is adjusted by a variable transformer. This system was chosen in preference to a hotplate with a thermostatically controlled temperature, such as a Simmerstat, which gives rise to large temperature fluctuations due to the bimetallic element used for the on-off control. The temperature readings are taken by inserting a thermometer into an 8–10 mm wide well in one of the sides of the hotplate, extending to its centre. Regular checks of the temperature of the plate are made by melting crystals. To determine the gelation time, approximately 0.5 g powder is put on the hotplate, which is set at a temperature of 180°C. At that temperature the material will melt instantly and the stopwatch is started. With a flat, rather flexible spatula the molten mass is continuously kept in close contact with the centre of the hotplate by alternatively heaping and spreading it. The moment at which gelling occurs is when the spatula, upon being moved away from the hotplate, no longer pulls any threads. The time recorded in seconds is the gelation time. The repeatability and reproducibility of the method were found to be at least  $\pm 2\frac{1}{2}$  per cent and  $\pm 5$  per cent, respectively. Fig. 5 gives the gelation times of three powders with different reactivities as a function of temperature.

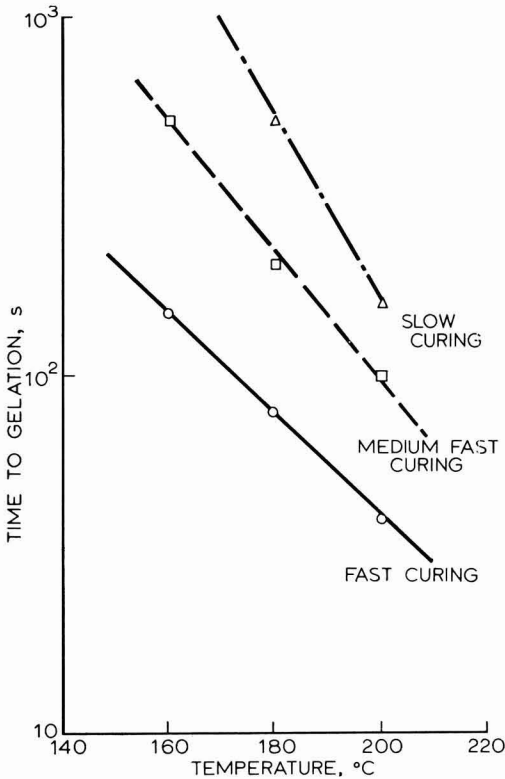


Fig. 5. Gelation time as a function of temperature of various epoxy powders

### Stability

A powder must remain as such from the moment of production until its use. It should be borne in mind, however, that whilst still being a powder, the material sometimes will not melt during stoving. Therefore, there are two types of stability:

- (1) physical stability
- (2) chemical stability.

#### Physical Stability

Shipment and storage of coating powders can present serious problems since the powder might block or sinter into an unusable mass, especially during the hot summer months. Blocking tendency is even more of a problem with the recent advent of thin-film powder coating, because powder coating manufacturers are using a lower melting point epoxy resin to obtain better flow properties at these lower film thicknesses. Although powder manufacturers have developed their own blocking tests, which range from the simple storage of bulk powder at elevated temperature to more sophisticated tests at controlled pressures and temperatures, there is still no universally accepted test method.

The author's laboratory work has led to a blocking test that employs a constant pressure to simulate the weight encountered at the bottom of a commercial package (50-pound weight) and also a temperature that is reasonably close

to an expected maximum. It should be clearly understood that successful performance in this accelerated test is not a guarantee that a given powder formulation will have a long package stability in actual practice. On the other hand, failure in the test raises doubts about the stability of the formulation in practice.

#### Test procedure

A 200 mm tall test tube is filled with powder to a height of 38 mm (1½") from the bottom. Using a knife, slice a 1.5 mm (1/16") thick disc from a rubber stopper. Place this disc on the surface of the powder so that it can support a weight of 100 g. Next, place the tube in the oven for a period of 2-7 days. The test can be carried out at temperatures of 40° and 50°C.

At the end of the exposure period remove the test tube from the oven and immediately remove the stopper and the weight. While holding the tube in a horizontal position, gently tap the end containing the powder. The powder should flow freely, any evidence of hard lumps or compaction of the powder suggests potential storage stability problems. Fig. 6 gives a diagram of the test apparatus.

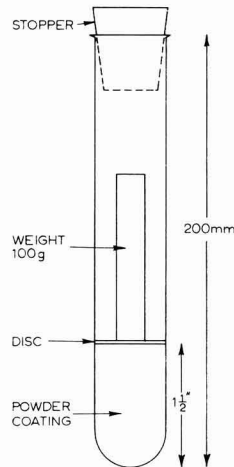


Fig. 6. Apparatus for testing physical stability

#### Chemical stability

To determine whether prepolymerisation has taken place after storage at elevated temperature, the gelation time can be determined. The powder from the physical stability test is used for this. From practical experience it is known that for an epoxy powder a reduction in gelation time of 10-15 per cent at 40°C and 25 per cent at 50°C as compared with freshly prepared powder may be considered acceptable.

#### Volatiles

There is no doubt that one of the reasons for the development of powder coating was to reduce air pollution. However, there are now powders on the market which during the stoving procedure give off a certain amount of volatile material and it is important to know how much. Apart from the pollution aspect, this loss can adversely affect the number of square metres to be covered, but—more important—when

material sublimates it can cause problems in the oven. For instance, a powder which contains 5 per cent of volatile material capable of sublimation, applied at a rate of 500 kg per day, will produce 25 kg of sublimate in the oven. The volatiles content is measured by weighing 1–2 g of powder before and after one hour at 180°C. In this test an epoxy powder coating will give 0.8–1 per cent volatiles, which is mainly moisture.

### Minimum stoving time

A simple method of determining minimum stoving time is to apply the powder to an aluminium sheet of 0.06 mm thick and place it in the oven at a given temperature for increasing periods of time, *e.g.* from 2 to 20 minutes. At the end of each period the sample is taken out and the aluminium sheet quickly folded along a sharp edge. If the film breaks, this is an indication of insufficient cure. Aluminium sheet has been chosen to eliminate as far as possible the heat capacity of the substrate. Fig. 7 shows the minimum stoving time as a function of stoving temperature for standard, white pigmented powder formulations containing curing agents of various reactivities. In the second part of this paper this subject is considered further when discussing the differential scanning calorimeter.

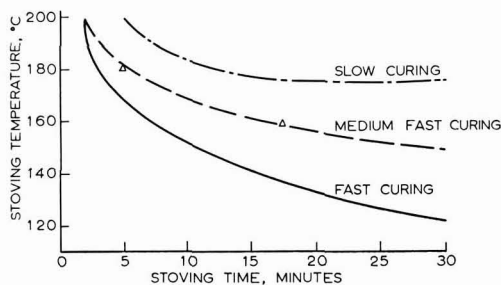


Fig. 7. Minimum stoving time as a function of temperature for various epoxy powder coatings applied to aluminium sheet

## Tests on the powder coating

### Appearance

Refs. 2, 3

#### Film defects

The paint film is examined visually for defects, such as cratering, pinholing, orange peeling and contamination by foreign materials, over a large area coated with the powder.

#### Flow

Flow (or film smoothness) can be determined visually or by the "Talysurf" method. The latter method is described below.

**Talysurf.** The surface appearance of paint films is usually judged subjectively by simply looking at the finished panel and then expressing a personal opinion on the film appearance *per se* or in comparison with a reference paint film of high quality.

This situation of subjective judgement can, in principle, be improved by using profilometers. A profilometer is an instrument for measuring and recording the smoothness of a surface by amplification of the minute variations in texture.

Originally meant for measuring the profiles of machined or pretreated metal surfaces, the instrument now tends to be used also to assess the appearance of coating<sup>2</sup>. Its use leads to an objective evaluation, for instance by recording the profile and/or measuring the CLA (centre line average) values<sup>3</sup> of the surface of the coating.

The profile drawn by the Talysurf (see Fig. 8) enables us to describe the surface defects of a powder coating:

—waviness (secondary texture) is due to the well-known defect in film formation: orange peeling.

—roughness (primary texture) is due to occasional small irregularities in the surface, such as cratering, pinholing and imperfections caused by foreign particles.

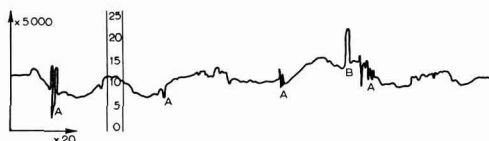


Fig. 8. Typical example of a powder coating profile (CLA value = 18)

The wavy base line indicates the amount of orange peel (CLA = 18) superimposed "roughness" on base line

A: deflection typical of cratering

B: deflection typical of foreign particles in the film

### Gloss

Gloss is the measured quantity of light reflected by the coating surface. Sometimes a coating when examined visually has a satisfactory gloss, but shows a surprisingly low measured gloss value. It should be remembered, however, that the quantity of light reflected is also dependent on the smoothness of the coating. For historical reasons, gloss is normally measured according to Lange 45/45 degrees angle, although a more official standard is the one using the Gardner glossmeter (ASTM 523–67).

### Whiteness

The visual determination of differences in whiteness and colour changes influenced by yellowing is very much dependent on the individual observer and the type of illumination. To overcome these difficulties, the Zeiss Elrepho reflectance photometer has been adopted, equipped with light filters transmitting light of narrow wavelength bands between 420 and 680  $\mu\text{m}$ . The measurements are carried out using a white standard as absolute value related to the ideal matt white surface, according to the recommendations of the CIE (Commission Internationale d'Éclairage). To test the colour stability of powder films based on various resins and curing agents, the degree of whiteness is measured on a standard powder formulation containing titanium dioxide as the sole pigment. The degree of whiteness is calculated according to the formula of Stephansen: Whiteness = twice the reflectance value obtained with the blue filter (420  $\mu\text{m}$ ) minus the reflectance value measured with the red filter (620  $\mu\text{m}$ ). The tendency to yellowing as a result of weathering or overbake can also be determined; it is expressed as the difference in the degree of whiteness before and after an accelerated weathering test or deliberate overbake. As an example Fig. 9 shows the values obtained with powder coatings based on three different hardeners. The coatings were applied and

stoved for 15 minutes at 180°C and subsequently subjected to an overbake of 15 and 30 minutes at 180°C.

	Powder A	Powder B	Powder C
<i>Whiteness</i> (Stephansen value)			
original cure	85.8	78.1	83.9
overbake 15 min 180°C	82.0	75.9	79.8
overbake 30 min 180°C	81.0	73.9	77.1
<i>Yellowing</i> ( $\Delta$ whiteness)			
after 15 min 180°C overbake	3.8	2.2	4.1
after 30 min 180°C overbake	4.8	4.2	6.8

Fig. 9. *Whiteness*

Powder *A* gives relatively high whiteness values, especially when compared with powder *B*. Upon visual assessment of the degree of yellowing one, powder *B*, would seem to have the best overbake resistance, but the whiteness figures show that yellowing of the films had already occurred during the normal baking schedule, resulting in a low degree of whiteness initially. Powder *C* shows an intermediate performance; the original whiteness and the yellowing resistance are inferior to those of powder *A*. These examples show that this reflectance technique gives the possibility of expressing whiteness and yellowing of white powder films numerically and can replace the visual assessment used previously. Moreover, it enables a better comparison to be made with previously determined data.

## Physical tests

### Determination of the film thickness

It is important to know film thickness because it usually determines the appearance and the degree of protection. Besides, many physical properties of a coating are related to its thickness. The determination is normally carried out by means of an electromagnetic gauge such as Permascope ex Fischer, Germany.

### Determination of hardness

Hardness is normally determined according to Buchholz (DIN 53153) and König (DIN 53157) methods. The Buchholz hardness is an indentation test, whereas the König uses a pendulum apparatus measuring the surface hardness. The König hardness is considered to be more relevant for powder coatings.

### Determination of adhesion

A coating, whether intended for protection or for decoration, should adhere firmly to the substrate. A good and simple way of determining adhesion is the cross-cut (Gitterschnitt) test for organic coatings according to DIN 53151.

## Mechanical properties

### Slow deformation

The most popular test method is the slow penetration test according to DIN 53156 (Erichsen)

### Rapid deformation

The resistance to rapid deformation or impact both on the coating itself and on the reverse of the test panel is determined. Several methods are used, viz. those according to Erichsen, BS and ASTM D 2794-69 (Gardner).

### Conical mandrel bend

The best method for this is ASTM D 522-60, which measures the flexibility of the coating on flat metal substrates when bent round a conical mandrel.

Having discussed the various test methods, the typical properties of an epoxy powder coating are summarised in Fig. 10.

Film thickness	50-60 $\mu$ m
Buchholz hardness	100
König hardness	195s
Adhesion (Gitterschnitt)	GT O (excellent)
Erichsen slow penetration	>8 mm
Erichsen impact (reverse)	7 mm
Ford-direct	>80 inch/lbs
Ford-reverse	80 inch/lbs

Fig. 10. *Typical properties of an epoxy powder coating after 15 minutes stoving at 180°C*

## Resistance upon exposure

### Chemical resistance

For this test the powder, properly applied to the substrate and stoved, is exposed to the chemicals concerned at the required temperature. The surface pretreatment and film thickness should be equal to those used in actual practice. Fig. 11 shows the high chemical resistance of two epoxy powder coating formulations applied to grit-blasted and preheated steel panels, at a film thickness of 200  $\mu$ m.

Medium ↓	Slow curing powder		Fast curing powder	
	Exposure time, years→		1	2
Distilled water	10	2 F	10	10
½%w detergent solution	10	2 M	10	10
5%w sodium hydroxide	10	10	10	10
30%w sodium hydroxide	10	10	10	10
20%w ammonium hydroxide	4 F	2 D	10	2 F
5%w sulphuric acid	10	10	10	10
40%w phosphoric acid	10	10	10	10
3%w chromic acid	10/cc	3 F/cc	10/cc	10/cc
5%w formic acid	2 MD	—	4 M	3 M
5%w acetic acid	10	2 F	10	10
Silo acid*	10	10	10	10
Xylene	10	10	10	10

Fig. 11. *Chemical resistance at room temperature of a slow and a fast curing epoxy powder coating*

Key: blistering according to ASTM blister scale 714-56  
cc = colour change

\* = a solution in water of 1% acetic acid, 1% lactic acid, and 1% butyric acid by weight.

### Corrosion resistance

*Salt spray resistance.* The standard method used here is ASTM B 117-64. On phosphated steel panels epoxy powder

coatings should not show any rust formation or rust creep in the applied scratch after 240 hours of exposure.

**Humidity resistance.** Method used is BS 3900-F2 or DEF 1053 No. 25. Epoxy powder coatings applied to phosphated steel should show no rust formation after 240 hours' exposure in the humidity cabinet.

#### UV and outdoor resistance

Although the physical properties of a powder coating may be studied in order to predict its probable behaviour in practice, there are occasions when UV and/or outdoor resistance are required. There are two main procedures: artificial weathering and natural weathering.

**Artificial weathering.** The Atlas Xenon Arc Weather-O-Meter is used according to ASTM D 822-60/G 26. In this cabinet the coated panel is exposed to a cycle of 102 minutes light, followed by 18 minutes light together with water spray.

**Natural weathering.** The area most frequently used to evaluate coatings for their resistance to natural weathering is the weathering site in Miami, Florida, USA. There is another field in the desert of Arizona, 40 miles north of Phoenix, which greatly differs from Florida in atmospheric conditions. Because of the elevation (2000 feet above sea level) and the clear, dry atmosphere (38 per cent relative humidity as the annual average) the percentage of ultraviolet in the solar radiation is higher in Arizona than in the humid climate at sea level in Florida. (Arizona has 4000 sun hours per year, Great Britain 1000-1400 hours.) In Fig. 12 the yearly average

	Hours of sunlight	Inches of rain	% RH	Average temp
Arizona	3.993	6.36	38	21 °C
Florida	2.721	58.32	58	24.5 °C

Fig. 12. Yearly average climatological data for Arizona and Florida

climatological data of Arizona and Florida are compared. In Arizona there are not only natural weathering facilities but also two types of specialised equipment for accelerated tests:

EMMA Equatorial Mounts with Mirrors for Acceleration

EMMAQUA same as EMMA except that samples are sprayed with distilled water for 8 minutes during each operating hour.

It has been found impossible to correlate the data of the natural and artificial methods. Natural weathering obviously gives more definite data than accelerated weathering

Although epoxy powder coatings have an excellent chemical and corrosion resistance, a loss of gloss due to chalking may be observed after exposure outdoors. The reduction in film thickness due to chalking is very low and in the order of 1-2  $\mu\text{m}$  per year.

### Thermal behaviour and appearance

During the past six or seven years, after a modest start, an enormous growth in epoxy powder coatings has taken place. It is interesting to note that the main impetus to this growth

has come not from powder coatings replacing chemically resistant or electrically insulating coatings, but from their use instead of normal alkyd/melamine formaldehyde stoving enamels on metal surfaces. Since epoxy powder coatings are used mainly for decorative applications, surface appearance is a very important aspect and justifies additional discussion.

During the stoving of powder coatings, the material is subjected to an extensive heating programme (both isothermal and non-isothermal), as a result of which it is transformed from a powder, via the fused state, to a crosslinked film. The ultimate surface appearance is determined both by this heat history and by the combination of physical and chemical characteristics of the formulation, which characteristics are strongly interrelated. If, for example, the curing reaction is very fast, there will be little or no opportunity for flow to take place, which is undesirable when flow is needed to obtain good levelling. Therefore, a knowledge of such properties as reactivity and viscosity of the coating under both isothermal and non-isothermal conditions is of paramount importance.

### Reactivity

Ref. 4

The curing behaviour of powder coatings can be conveniently and rapidly studied by Differential Thermal Analysis (DTA) or Differential Scanning Calorimetry (DSC). Both are widely accepted thermal techniques in the field of thermosetting materials. DSC has been chosen because this technique is superior to DTA in terms of speed, simplicity and sensitivity, and in quantitative measurements has the important advantage that it is capable of direct determination of transition energies, such as heat of cure. The instrument used is a Perkin Elmer Differential Scanning Calorimeter model DSC 2<sup>4</sup>. Fig. 13 shows the essentials of the equipment: the

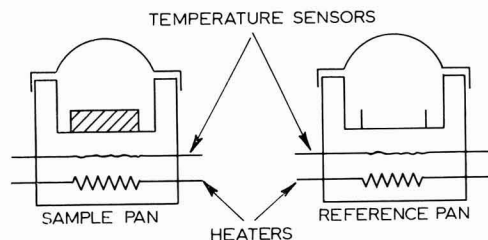


Fig. 13. Scheme of DSC sample holder

DSC sample holder. The technique is based on the temperature control of the two holders—one containing the sample, the other the reference—which are continuously maintained at the same temperature level. The holders can be heated at a controlled rate. As the sample absorbs or evolves energy, more or less power is required by the sample holder to maintain it at the same temperature as the reference. It is this differential power of energy per unit time which is recorded as a function of sample temperature. Fig. 14 shows a typical DSC thermogram obtained on epoxy-resin-based powder coatings under scanning conditions. The vertical axis gives the difference in heat flux required to maintain the temperature equilibrium between sample and reference whilst being heated at a constant rate. On the horizontal axis the temperature of the sample is given, which is in fact directly related to time via the heating rate selected. On the thermogram the following effects can be clearly seen: glass transition, melting, cure.

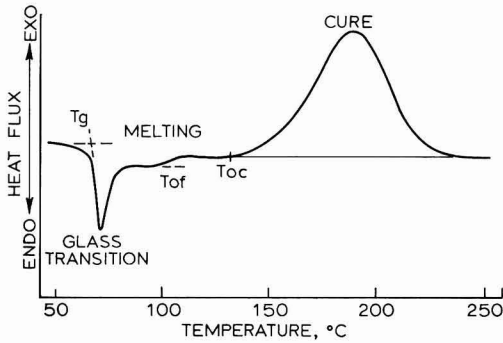


Fig. 14. Typical DSC thermogram for an epoxy resin based powder coating under scanning conditions

**Glass transition**

The first deviation from the base line, viz an endothermic effect superimposed on a baseline shift, indicates the glass transition temperature  $T_g$  of the uncured powder coating.

**Melting**

The second baseline shift observable in the DSC thermogram corresponds to the melting of the powder coating, as a result of which a change in heat contact between sample and sample pan occurs. The temperature of melting has been designated  $T_{of}$ , that is, the onset of flow of the powder coating.

**Cure**

The cure of a powder coating, finally, is observed as an exothermic peak, the area under the peak being a measure of the heat generated. For all epoxy powder coating systems investigated the heat of reaction is  $16 \pm 1$  cal/g. Since, moreover, the position of the curing exotherm is indicative of the reactivity of the powder coating system, useful information can be obtained from a comparison of, for instance, the peak maxima or the start of this exothermic peak,  $T_{oc}$  (the onset of cure), for different powder coating systems. This is shown in Figure 15, where the effect of the curing agent on the cure behaviour of epoxy powder coatings is given. It is seen that the use of a slow type of curing agent instead of a fast one results in a considerable decrease in reactivity of the powder coating system. Consequently, the slow type of curing agent gives a powder coating with a better flow and a better appearance.

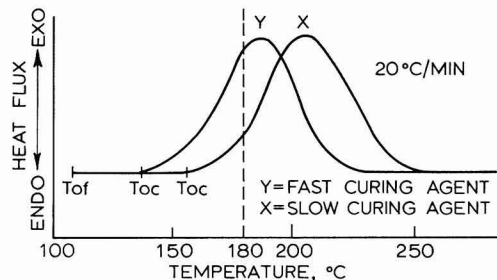


Fig. 15. Effect of curing agent on cure behaviour of epoxy resin based powder coating at a heating rate of 20°C/min

**Minimum cure**

A method of measuring the minimum stoving time has already been described. The DSC technique can also be used to determine the stoving time required for the completion of cure. In order to simulate the heating conditions occurring in the actual stoving of a powder coating system, combined scanning and isothermal experiments have been carried out by scanning the powder coating sample at a rate of 20° and 80°/min to 180°C, followed by an isothermal operation at 180°C. Fig. 16 shows a typical DSC thermogram of a combined scanning and isothermal experiment for epoxy-resin-based powder coatings. From the figure it can be seen that after a total stoving time of about 13 minutes, the isothermal part of the cure levels off to a straight baseline indicating completion of the cure reaction.

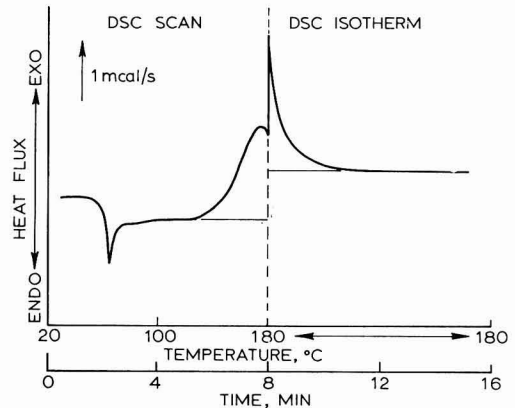


Fig. 16. Typical DSC thermogram of a combined scanning and isothermal experiment for epoxy resin based powder coatings

Powder coatings prepared with different epoxy resins and curing agents were evaluated in combined scanning and isothermal experiments. The experiments were carried out by scanning at the same rates. Fig. 17 shows the minimum stoving times so obtained. It should be stressed, however, that these figures also include the time required for scanning the sample up to 180°C. This takes as long as 8 minutes using a heating rate of 20°/min and only 2 minutes using a rate of 80°/min. The results presented show the effect of the type of epoxy resin and curing agent upon the minimum stoving times of powder coatings. They also demonstrate that minimum stoving times are highly dependent upon the heating conditions used, high heating rates resulting in a considerable reduction of the minimum stoving times.

Heating rate (Up to 180°C)	Epikure 107 FF		Epikure 108 FF	
	Epikote 1055	2057	1055	2057
20°C/min	16	21	13	16
80°C-min	13	17	7	10

Fig. 17. Minimum stoving times of various epoxy-based powder coatings derived from DSC experiments under different conditions

**Effect of stoving conditions**

Another factor which may affect the initiation of cure of a given system is the heating rate of the oven used for curing the



powder coating. Fig. 18 shows the curing exotherm of an epoxy powder coating system containing a fast curing agent at three different heating rates, viz. 20, 40 and 80°/min. From the position of the curing exotherm it can be seen that the reactivity of a powder coating system is indeed highly dependent upon the heating rate. An increase in heating rate by a factor of two shifts the peak maxima up the temperature axis by approximately 15°C. It shows that high heating rates considerably raise the temperature that will initiate the curing reactions in a powder coating system; consequently, viscosity during the stoving process will be lower, resulting in a better levelling of the final coating. This demonstrates that the user of powder coatings, too, can influence flow by using the right type of oven for the stoving process.

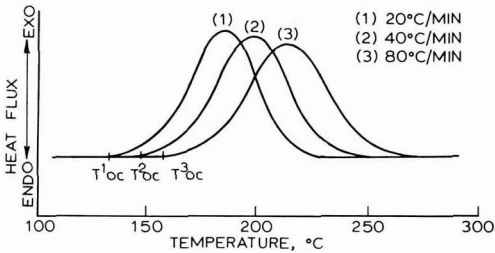


Fig. 18. Effect of heating rate on the cure of epoxy powder

## Conclusions

The test methods described provide a suitable basis for a more systematic approach to powder coating evaluation work. After all, powder coatings have been among the spectacular and fast developments in the surface coating field and consequently test methods have hardly had a chance to become established, let alone be standardized. Their rapid development has certainly been favoured by the availability of epoxy resins, the only type of resin which at the time happened to have the quality and curing characteristics required for this purpose. More recently, as was to be expected, other resins have gradually been finding application in powder coatings as well, and the test methods discussed may help to compare them with those already on the market.

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# The effect of oxidative and coordination drier systems on film properties\*

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## Summary

This paper reports some findings made during an investigation of the effects of different metal compounds on several alkyd paint film properties. The metal compounds selected for study were soaps of cobalt, lead, zirconium and calcium (neutral and basic) *i.e.* conventional driers, and an aluminium complex.

The film properties studied were: durability, hardness, flexibility, adhesion, yellowing in the dark and drying.

It is concluded that differences in hardness, flexibility and adhesion are not significant when using conventional driers. Durability,

however, is better when using zirconium instead of lead and basic calcium instead of the neutral calcium soap. Differences in yellowing in the dark were noted.

The aluminium complex is shown to give harder, more durable films which are markedly less prone to yellowing in the dark.

Aluminium is also shown to confer a much higher degree of through drying, when used with cobalt, than the traditional auxiliary driers.

## Keywords

### *Types and classes of coatings and allied products*

gloss finish

### *Raw materials for coatings binders (resins, etc.)*

alkyd resin

### *paint additives—driers*

calcium drier

cobalt drier

lead drier

zirconium drier

aluminium complex

### *Properties, characteristics, and conditions primarily associated with:*

#### *materials in general*

flexibility

#### *coatings during application*

drying time

#### *dried or cured films*

gloss retention

chalk resistance

yellowing

hardness

### *Processes and methods primarily associated with analysis, measurement or testing*

accelerated weathering

bending test

## L'influence sur les caractéristiques de film qu'exercent des siccatisifs d'oxydation ou de coordination.

### Résumé

Cet article rend compte des observations mises en évidence au cours d'une investigation de l'influence exercée sur les caractéristiques des films de diverses peintures glycérophthalliques. Les composés métalliques choisis pour l'étude comprenaient les savons de cobalt, plomb, zirconium et calcium (neutre et basique), c'est-à-dire les siccatisifs normaux, et d'ailleurs un complexe d'aluminium.

Les caractéristiques de film faisant l'objet de l'étude étaient la durabilité, la dureté, la flexibilité, l'adhérence, le jaunissement dans l'obscurité, et la siccativité.

On conclut que lorsqu'on se sert des siccatisifs normaux, les diffé-

ences à l'égard de dureté, flexibilité et adhérence ne signifient rien. Cependant, la durabilité est supérieure où l'on utilise un siccatisif à base de zirconium au lieu de plomb, ou à base de calcium basique au lieu de calcium neutre. On a observé des différences à l'égard du jaunissement dans l'obscurité.

On démontre que le complexe d'aluminium rend des films à la fois plus durs et durables et qui sont fortement moins susceptibles à jaunissement dans l'obscurité.

On démontre d'ailleurs que lorsque le composé d'aluminium est employé en combinaison avec cobalt il assure un degré de séchage beaucoup plus élevé que les siccatisifs supplémentaires classiques.

## Die Wirkungen oxidativer und koordinativer Trockenstoffsysteme auf Filmeigenschaften.

### Zusammenfassung:

In dieser Arbeit wird über einige Resultate hinsichtlich der Auswirkungen verschiedener Metallverbindungen auf die Eigenschaften einer Anzahl von Alkydackfilmen berichtet. Die ausgewählten Metallverbindungen waren Kobalt-, Blei-, Zirkonium- und Kalziumseifen (neutral und basisch) d.h. handelsübliche Trockenstoffe, sowie ein Aluminiumkomplex.

Die geprüften Filmeigenschaften waren: Dauerhaftigkeit, Härte, Biegsamkeit, Haftung, Vergilben im Dunkeln und Trocknung.

Es wurde geschlossen, dass bei Benutzung handelsüblicher Trockenstoffe keine nennenswerten Unterschiede hinsichtlich Härte,

Biegsamkeit und Haftung bestehen. Dauerhaftigkeit ist jedoch länger, wenn anstelle von Blei Zirkonium, und basische Kalzium anstelle von neutraler Kalziumseife verwendet wird. Unterschiede im Vergilben wurden bei Exposition im Dunkeln beobachtet.

Der Aluminiumkomplex ergab härtere, dauerhaftere Filme, welche viel weniger zum Vergilben im Dunkeln neigten.

Es ergab sich, dass Aluminium in Verbindung mit Kobalt auch zu viel besserer Durchrocknung beitrug, als dies bei den handelsüblichen Hilfstrocknern der Fall ist.

\*Extended version of paper presented at a Symposium on Films—formation and behaviour, held by the Manchester Section on 6 and 7 April 1976

## Introduction

Refs. 1, 2

The most common drier systems employed today in alkyd paints are based on Co/Pb/Ca and Co/Zr/Ca, although the use of lead is decreasing because of its toxic nature. Cobalt and lead function as oxidation catalysts accelerating the autoxidation of unsaturated fatty acids, thus achieving a rapid conversion to the cross-linked state. Zirconium, it is believed, operates by utilising its coordinating power and acting as a cross-linking centre by reacting with the polar groups attached to the polyester chains of the alkyd. Calcium soaps, although having no drying function of their own, can accelerate or change the character of Co/Pb or Co/Zr systems, particularly under conditions of low temperature and high humidity.

More recently, aluminium complex modifiers have been reported<sup>1, 2</sup> which are capable of reacting with the functional groups of the alkyd during film formation leading to covalent and coordination cross-links, which are not dependent solely upon the normal autoxidation process.

Previously reported work on driers has concentrated, perhaps naturally, on drying as such, with little or no reference to film properties. The work described in this paper is an attempt to redress this imbalance by studying some fundamental film properties and how they may be affected by various conventional drier systems and also by an aluminium complex of the type mentioned above.

Cobalt was used as the primary drier in all cases and the metals calcium, lead, zirconium and aluminium were used as auxiliary driers in various combinations.

Calcium driers are available commercially as basic soaps or neutral soaps with excess acid. These may be described respectively as  $\text{CaX}_{c-2}$  and  $\text{CaX}_{2y}\text{XH}$  where  $\text{XH}$  is a mono-basic carboxylic acid. A basic and a neutral soap (based on the same fatty acid) were used in this study to show up any differences there might be between these two soap types.

The film properties selected for study were: durability, hardness, flexibility and adhesion, and yellowing in the dark. For completeness, drying tests were also included.

## Experimental

### Base paint

A white gloss alkyd paint was prepared containing cobalt drier alone (see Table 1).

Table 1  
White gloss paint

Formulation	
Rutile Titanium Dioxide*	33.40
Long oil alkyd† (80% N.V.C.)	52.19
18% cobalt drier solution	0.14 (= 0.06% Co)
Other driers	14.27
White Spirit	
	100.00
Dispersion: ball mill	
Paint characteristics:	
Pigment/binder ratio	0.8/1
Pigment + resin	75.2%

\*Chloride Process  $\text{TiO}_2$  with inorganic and organic coating

†Long oil alkyd with following characteristics:

Oil length	70%
Type	Penta/phthalic/linoleic rich
Acid value	10mg KOH/g max.
Solids	80 ± 2%
Viscosity	22–28 poise @ 25°C
Solids at 2 poise	approx. 62%

### Auxiliary Driers

Portions of the base paint were taken and modified by the addition of one or two auxiliary driers (see Table 2). The driers employed were: a basic calcium soap, neutral calcium soap, lead soap, zirconium soap and an aluminium complex.

Table 2  
Metal loadings

Paint	% metal on alkyd solids
1	0.6 Pb/0.2 Ca (B)
2	1.2 Pb/0.2 Ca (B)
3	0.6 Pb/0.2 Ca (N)
4	1.2 Pb/0.2 Ca (N)
5	0.6 Pb/0.4 Ca (B)
6	1.2 Pb/0.4 Ca (B)
7	0.6 Pb/0.4 Ca (N)
8	1.2 Pb/0.4 Ca (N)
9	0.09 Zr/0.2 Ca (B)
10	0.18 Zr/0.2 Ca (B)
11	0.09 Zr/0.2 Ca (N)
12	0.18 Zr/0.2 Ca (N)
13	0.09 Zr/0.4 Ca (B)
14	0.18 Zr/0.4 Ca (B)
15	0.09 Zr/0.4 Ca (N)
16	0.18 Zr/0.4 Ca (N)
17	1% Al
18	2% Al
19	None
20	0.6 Pb
21	1.2 Pb
22	0.2 Ca (B)
23	0.4 Ca (B)
24	0.2 Ca (N)
25	0.4 Ca (N)
26	0.09 Zr
27	0.18 Zr

B = basic soap

N = neutral soap

The metals were tested as sole auxiliary driers at two levels and in certain combinations, viz: Pb/Ca and Zr/Ca. Twenty seven paints were prepared in all, including the base paint (paint 19) as a control. Care was taken to ensure that the final resin plus pigment content of each paint was the same.

After maturing for several weeks, the paints were applied to the substrates appropriate for the range of tests contemplated.

### Durability

The durability of the paints was assessed by accelerated weathering (BS 3900 F3), measuring gloss, and also chalking, as and when it appeared, after intervals of time in a weatherometer. Stainless steel was the substrate used, since this allows an assessment of film durability without the complicating factor of substrate corrosion which might occur with, say, mild steel.

Paint films were applied to the steel panels giving a dry film thickness of about 38 micron.

After drying for one week, the painted panels were placed in the weatherometer.

### Hardness

50 micron thick wet films of paint were applied to glass and the hardness measured at intervals. Hardness was determined by the König pendulum (DIN 53 157).

**Flexibility and Adhesion**

The paints were applied to degreased tin plate panels (50 micron thick wet films) and allowed to dry for 140 days (20 weeks) before testing for flexibility (bend test BS3900 E1) and adhesion (cross-cut method ISO 2409).

**Yellowing in the dark**

The paints were applied to aluminium panels dried for one week, one half of each panel was then masked with black photographic paper. The panels were placed in a horizontal position illuminated by a north east facing window. After 8 months, they were examined visually for colour difference between the masked and exposed portions and ranked in order of increased yellowing.

**Drying**

Drying was determined under laboratory conditions by the Beck Koller drying recorder using two wet film thickness (38 micron and 76 micron).

**Results and discussion**

**Durability**

The results for the gloss and chalking values at 250 hour intervals in the weatherometer are given in Table 3. When the gloss values for the 27 paints are plotted against time, a family of curves is obtained which shows an extremely wide range of gloss retention. In Fig 1. the graphs for the most durable paint (1 per cent Al) and the least durable paint (0.6 per cent Pb/0.4 per cent Ca,N), are shown with the control paint (cobalt only) and the best conventional drier system for

durability (0.18 per cent Zr). These illustrate some trends which are indicated in more detail below: namely that aluminium and zirconium give improvements in durability, compared with cobalt alone, and that lead and calcium driers contribute greatly to the degradation of the paint.

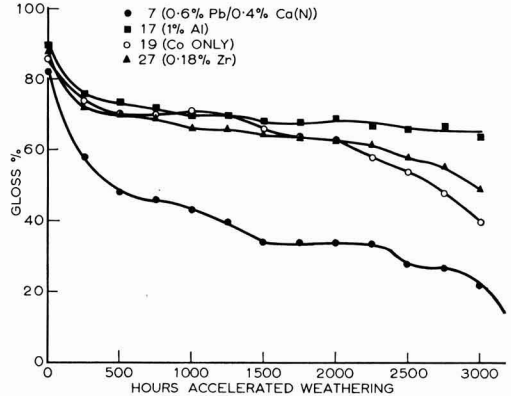


Fig. 1. Durability—60° gloss

Two methods were used to compare the durability of the paints. These were:—

- (i) time in weatherometer to reach 60 per cent gloss and
- (ii) time to onset of chalking. These are given in Table 4 and Table 5 respectively.

Table 3  
Durability—60° Gloss ASTM D523/Kempf chalking

Paint	Hours												
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1	89	72	65	60	56	52	46	43(8)	40(8)	38(7)	34(7)	28(6)	23(5)
2	86	66	57	50	44	41	36(8)	36(8)	32(8)	32(8)	28(7)	26(7)	21(5)
3	87	69	57	52	47	43(9)	34(7)	34(7)	26(7)	26(7)	24(6)	22(6)	19(6)
4	86	60	52	46	43	42(9)	36(8)	35(8)	33(8)	28(8)	27(6)	24(6)	20(5)
5	87	68	60	56	54	52	46	42(9)	39(9)	38(9)	34(8)	30(7)	26(7)
6	86	63	53	48	43	43(9)	36(8)	36(8)	34(8)	32(8)	30(7)	26(6)	22(6)
7	82	58	48	46	43	40(9)	34(8)	34(8)	34(8)	34(8)	28(7)	27(7)	22(6)
8	86	60	47	47	43	40	35(9)	35(9)	32(8)	31(8)	26(7)	25(7)	22(6)
9	88	87	78	72	68	63	55	54	50	48	35(7)	38(6)	35(6)
10	87	79	72	67	67	66	58	58	56	53	49	45	40(7)
11	89	78	72	67	65	62	54	52	50	47(9)	41(8)	40(8)	36(6)
12	90	81	76	71	69	67	61	60	58	54	51	48(9)	43(8)
13	89	73	70	68	68	67	63	62	62	58	55	52	45(7)
14	90	76	72	71	68	66	64	64	64	60	58	56	48(9)
15	89	69	63	59	58	55	48	47	47	44(9)	42(8)	38(8)	33(6)
16	90	72	64	64	63	62	60	58	59	57	53	50	42(9)
17	90	76	73	72	70	70	68	68	69	67	66	67	64(9)
18	88	74	70	70	70	70	70	68	70	70	67	67	58(None)
19	86	74	70	71	71	70	66	64	63	58	54	48(9)	40(7)
20	82	75	68	65	62	60	52	50	47(9)	43(8)	39(7)	35(6)	27(6)
21	89	69	62	58	58	56	53	50	49	46(9)	42(9)	36(9)	30(6)
22	88	77	72	68	66	58	51	48	45(8)	42(7)	37(6)	33(6)	26(5)
23	88	69	64	61	60	56	54	54	52	50	46	42(9)	34(7)
24	87	73	67	62	58	55	48	46	43(8)	40(8)	36(7)	30(6)	24(5)
25	82	67	50	46	45	42	38(9)	36(8)	35(9)	34(7)	30(7)	28(6)	21(6)
26	86	72	68	68	68	68	64	62	63	60	57	54	45(7)
27	88	72	70	69	66	66	65	64	63	62	58	56	49(8)

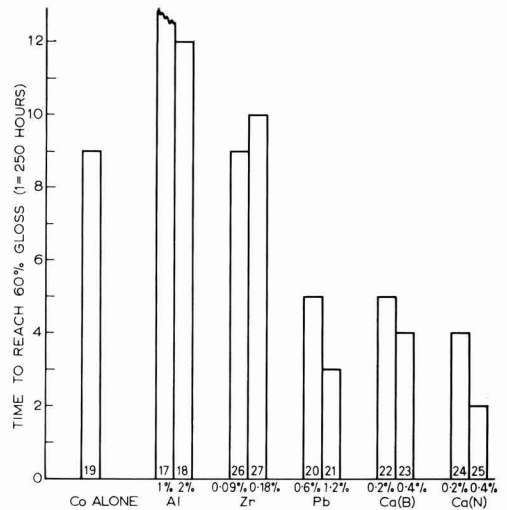
Figures in brackets refer to chalking (Kempf scale)

**Table 4**  
Durability—time to 60% Gloss

Rank	Paint	Metal content	Time*
1	17	1% Al	12+
2	18	2% Al	12+
3	27	0.18% Zr	10
4	13	0.09% Zr/0.4% Ca (B)	9
	14	0.18% Zr/0.4% Ca (B)	9
	19	Cobalt alone	9
	26	0.09% Zr	9
5	12	0.18% Zr/0.2% Ca (N)	7
6	9	0.09% Zr/0.2% Ca (B)	6
	10	0.18% Zr/0.2% Ca (B)	6
	11	0.09% Zr/0.2% Ca (N)	6
	16	0.18% Zr/0.4% Ca (N)	6
7	20	0.6% Pb	5
	22	0.2% Ca (B)	5
8	23	0.4% Ca (B)	4
	24	0.2% Ca (N)	4
9	1	0.6% Pb/0.2% Ca (B)	3
	15	0.09% Zr/0.4% Ca (N)	3
	21	1.2% Pb	3
10	2	1.2% Pb/0.2% Ca (B)	3
	3	0.6% Pb/0.2% Ca (N)	2
	5	0.6% Pb/0.4% Ca (B)	2
	6	1.2% Pb/0.4% Ca (B)	2
11	4	1.2% Pb/0.2% Ca (N)	1
	7	0.6% Pb/0.4% Ca (N)	1
	8	1.2% Pb/0.4% Ca (N)	1

\*time to reach 60% gloss reading; scale from 1 = 250 hours to 12 = 3000 hours

clearly seen that the metals contribute to durability in the order Al > Zr > Pb ≈ Ca(B) > Ca(N).



**Fig. 2. Durability—gloss retention single metals**

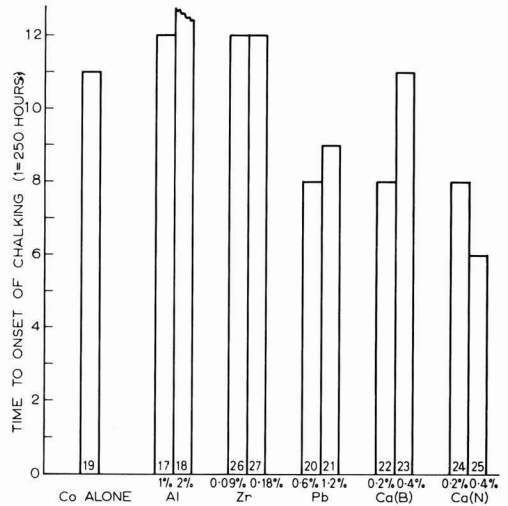
**Table 5**  
Durability—time to onset of chalking

Rank	Paint	Metal content	Time*
1	18	2% Al	12+
2	17	1% Al	12
	27	0.18% Zr	12
	13	0.09% Zr/0.4% Ca (B)	12
	14	0.18% Zr/0.4% Ca (B)	12
	26	0.09% Zr	12
	10	0.18% Zr/0.2% Ca (B)	12
	16	0.18% Zr/0.4% Ca (N)	12
3	19	cobalt alone	11
	12	0.18% Zr/0.2% Ca (N)	11
	23	0.4% Ca (B)	11
4	9	0.09% Zr/0.2% Ca (B)	10
5	11	0.09% Zr/0.2% Ca (N)	9
	15	0.09% Zr/0.4% Ca (N)	9
	21	1.2% Pb	9
6	20	0.6% Pb	8
	22	0.2% Ca (B)	8
	24	0.2% Ca (N)	8
7	1	0.6% Pb/0.2% Ca (B)	7
	5	0.6% Pb/0.4% Ca (B)	7
8	2	1.2% Pb/0.2% Ca (B)	6
	25	0.4% Ca (N)	6
	8	1.2% Pb/0.4% Ca (N)	6
9	3	0.6% Pb/0.2% Ca (N)	5
	6	1.2% Pb/0.4% Ca (B)	5
	4	1.2% Pb/0.2% Ca (N)	5
	7	0.6% Pb/0.4% Ca (N)	5

\*time to onset of chalking; scale from 1 = 250 hours to 12 = 3000 hours

Reference to these tables alone is sufficient to show the trends referred to above, but is even clearer when the results are presented in histogram form (Figs. 2–5).

In Figs. 2 and 3 the gloss and chalking ratings for those paints with only one auxiliary drier metal are given and it is



**Fig. 3. Durability—chalking single metals**

Figs 4 and 5 give the gloss and chalking ratings for the paints with a binary auxiliary drier system. From these histograms it can be seen that the poor durability expected for the calcium is offset to a very large extent when it is used in conjunction with zirconium. When lead and calcium are used in combination, the durability is, generally, worse than when these metals are used singly. Again, it is clearly seen that where basic calcium is used, the durability is a little better than when the neutral calcium soap is used in a comparable drier combination.

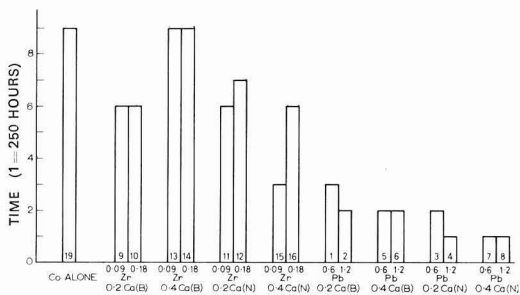


Fig. 4. Durability—gloss retention double metals

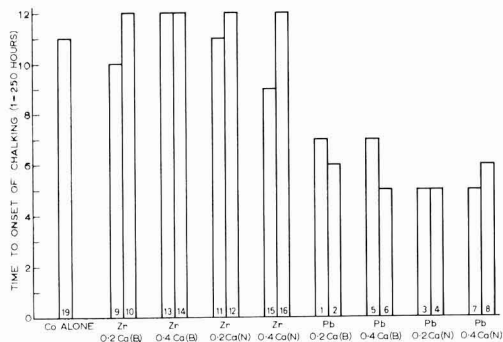


Fig. 5. Durability—chalking double metals

**Hardness**

Refs. 1, 2

The hardness of the paint films was measured at intervals until no further significant hardening was apparent (Table 6). Maximum hardness was reached after about 10 days in the case of those paints containing conventional driers and after about 20 days with those containing aluminium. This is clearly seen in Fig. 6, where the hardness curves for the aluminium containing paints are compared with the hardest and softest of the other paints (paints 8 and 24 respectively). The paints containing conventional driers showed similar hardness maxima, within probable experimental error, the average value being 23 per cent on the König hardness scale.

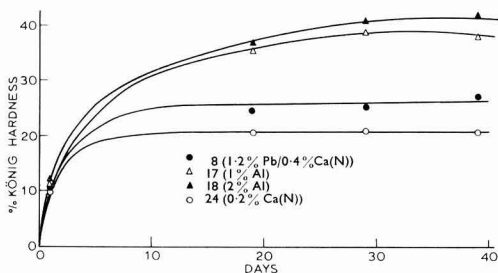


Fig. 6. Hardness

In contrast, the aluminium containing paints were about 74 per cent harder (about 40 König) although no further significant increase in hardness was shown when the aluminium level was raised from 1 to 2 per cent.

Table 6  
Hardness (% König)

Paint	Days			
	1	19	29	39
1	9.1	20.5	21.2	21.2
2	8.6	21.25	21.2	22.2
3	8.6	21.25	20.7	22.2
4	9.1	22.4	22.5	22.9
5	9.1	20.3	21.4	21.9
6	9.1	20.7	21.6	22.9
7	9.7	21.8	23.4	24.1
8	10.2	24.3	24.9	26.7
9	9.1	21.25	21.8	21.6
10	9.1	21.65	21.9	21.6
11	8.6	20.14	21.9	21.9
12	9.1	22.6	24.4	23.7
13	9.7	22.8	23.6	24.6
14	10.7	23.7	24.0	25.2
15	8.6	22.8	24.2	25.2
16	10.2	25.6	26.8	23.5
17	11.3	35.3	38.4	37.6
18	12.3	36.65	40.2	41.6
19	10.2	22.2	23.8	23.7
20	10.2	21.8	22.9	22.9
21	9.7	22.2	22.7	22.4
22	10.2	20.5	20.8	20.7
23	9.7	20.3	20.1	20.9
24	9.7	20.5	20.7	20.5
25	10.2	22.8	23.1	26.3
26	11.3	23.5	25.1	23.3
27	11.3	23.15	24.35	23.5

Plate Glass = 100%

These results would indicate that conventional driers catalyse the autoxidation process giving final dried films of similar cross-link density and consequently similar hardness. Whereas the aluminium modified paints have at least one other form of cross-linking superimposed over that derived from the autoxidation alone. From a knowledge of the chemistry of these aluminium compounds<sup>1,2</sup>, a combination of covalent and coordination linkages would be expected to contribute to this cross-linking.

**Flexibility and adhesion**

After drying for 20 weeks, the paints all passed the 3/16" bend test and even more surprisingly, a simple bend over/bend back test. Furthermore, the cross-cut test showed no differences between the paints. Adhesion was excellent in every case, there being no detachment of paint after brushing the cross-cut film and the knife cuts were absolutely clean with no indication of embrittlement.

The extra cross-linking contributed by the aluminium compound as indicated by the increase in hardness did clearly not reach the levels at which embrittlement occurred.

**Yellowing in the dark**

The visual ranking for the exposed panels after 8 months is given in Table 7. It was observed that the exposed portions were of more or less equal whiteness, whereas the masked portions showed varying degrees of yellowing. Paint 18 (2 per cent Al) showed the least yellowing of all, in fact, yellowing was so slight that the difference in whiteness could only just be discerned. Those paints ranked in second place were only slightly cream coloured and the worst paints (ranked 7th) were a very dingy buff.

Table 7  
Yellowing in dark after 8 months

Paint	Visual Rating
1	6
2	3
3	2
4	6
5	4
6	3
7	2
8	2
9	4
10	5
11	4
12	5
13	4
14	2
15	3
16	2
17	2
18	1
19	5
20	6
21	6
22	6
23	3
24	4
25	5
26	5
27	7

1 = least yellowing; 7 = most yellowing

In Fig. 7 and Fig. 8 the histograms showing the yellowing ranking for single metal systems and double metal systems respectively are shown. No clear patterns are evident, but it is interesting to note that auxiliary drier systems containing two metals tend to be generally better than those containing only one. Of particular merit in this respect were 0.09 per cent Zr/0.4 per cent Ca (basic or neutral), 0.6 per cent Pb/0.2 per cent Ca (N) and 1.2 per cent Pb/0.4 per cent Ca (N) which were surpassed only by the paint containing Al at the 2 per cent level.

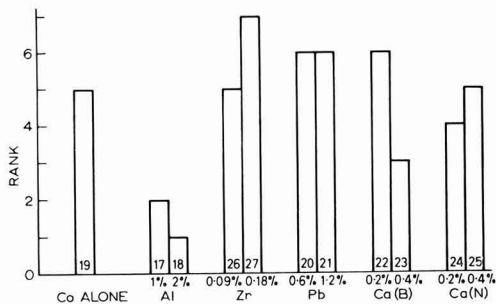


Fig. 7. Yellowing in the dark single metals

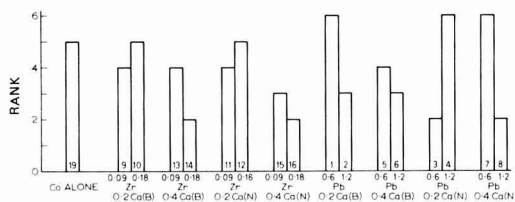


Fig. 8. Yellowing in the dark double metals

In view of the considerable visual difference between paints 17 and 18 and what has already been said about aluminium content and hardness and durability, it would appear that somewhere between 0 and 1 per cent Al contributes to cross-linking, and consequently hardness and durability, whilst the remainder (up to 2 per cent) in some way retards the yellowing in the dark, which is a feature of all alkyls, even the linoleic rich ones of the type used in these paints.

Drying

The BK drying results for thin and thick films (38 μm and 76 μm thick respectively) are given in Table 8, which shows the different stages in drying shown by the BK recorder.

Table 8  
Drying times—BK Recorder 20°C/50% RH

Paint	38 μm				76 μm			
	Drying stages				Drying stages			
	1	2	3	4	1	2	3	4
1	1.7	2.3	2.7	6.7	2.0	2.5	8.4	22+
2	1.3	1.8	3.6	8.3	2.0	—	11.8	''
3	1.3	1.8	3.8	12.3	2.0	—	7.8	''
4	1.1	1.6	4.5	10.3	2.0	—	8.0	''
5	1.3	2.2	4.1	10.4	2.0	—	7.0	''
6	1.2	1.7	5.8	11.0	2.0	—	7.0	''
7	1.3	1.7	5.0	11.5	1.5	—	16.5	''
8	1.3	—	5.8	9.7	1.5	—	5.5	''
9	1.8	2.6	3.0	9.6	2.0	2.3	9.8	''
10	2.1	3.0	3.8	12.0	2.4	—	8.8	''
11	1.8	2.3	2.8	8.0	2.3	—	5.7	''
12	1.7	2.1	2.9	11.8	1.8	2.2	10.3	''
13	1.8	3.0	3.5	9.4	2.5	—	7.8	''
14	1.3	2.0	4.0	8.3	1.9	—	12.7	''
15	1.2	1.8	4.5	11.5	2.0	2.7	8.0	''
16	1.3	2.0	8.3	15.0	2.3	—	8.0	''
17	0.8	2.4	3.6	6.8	1.9	3.9	5.2	''
18	0.4	2.4	3.8	7.4	3.8	6.7	9.5	''
19	1.8	2.3	7.5	—	2.8	—	9.8	''
20	2.2	2.8	3.2	8.7	2.3	—	8.4	''
21	1.5	2.0	2.3	7.2	2.5	—	9.0	''
22	2.1	2.8	3.5	7.2	3.3	—	6.3	''
23	1.8	2.3	2.8	11.0	3.0	—	8.0	''
24	1.8	2.5	3.0	8.8	2.7	—	6.5	''
25	1.5	2.0	4.2	14.8	2.3	—	11.7	''
26	2.1	2.8	4.0	4.8	2.5	—	6.5	''
27	1.8	2.7	3.3	8.3	3.3	—	7.7	''

Times in hours

For the thin films (Figs. 9 and 10) it can be seen quite clearly that through drying is improved by the addition of auxiliary driers as shown by the decrease in the length of stage 3. This effect is, of course, well known, since this is the reason why auxiliary driers are used. However, this decrease in stage 3 was often accompanied by an extension of stage 4—an increase over that for the control paint (19).

The drying times for the aluminium containing paints (17 and 18) were equal or shorter than for cobalt alone, but with a much reduced stage 3.

In general, shorter drying times are given at the lower level of zirconium and there would appear to be little advantage in increasing lead from 0.6 per cent to 1.2 per cent.

From the single metal results (Fig. 9) the neutral calcium soap was seen to give longer drying times than when the basic soap was used at the same concentration.

For the thick films all paints took longer than 24 hours to hard dry. However, the aluminium containing paints, on inspection of the BK drying track, could be seen to give far

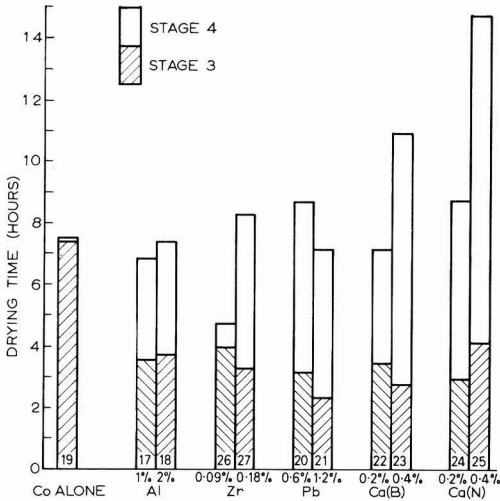


Fig. 9. Drying times—BK recorder 38 μm wet film single metals

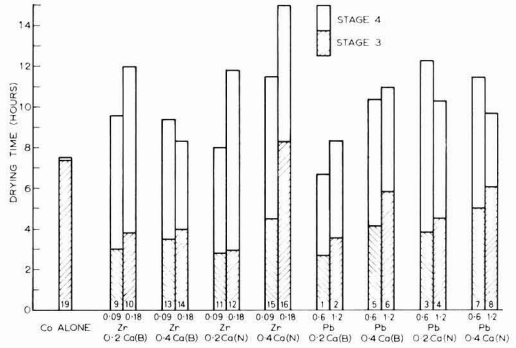


Fig. 12. Drying times—BK recorder 38 μm wet film double metals

better through drying than did the other driers. The conventional drier systems showed excessive tearing of the surface skin to the end of stage 3 and a wrinkled track thereafter. In contrast, those containing aluminium gave only a slight "picking" at the surface during stage 3 and a faint scratch only for stage 4.

In thick films (Figs. 11 and 12), where through drying is more important and consequently more evident, the order of drying for the different metals is:

$$Al > Zr \approx Ca(B) > Pb > Ca(N)$$

It was noteworthy that the lowest levels of single auxiliary driers gave the best result for stage 3.

**Conclusions**

When cobalt is used as the primary drier in an alkyd paint, the final paint film properties will depend upon the choice of auxiliary drier metals.

The hardness, flexibility and adhesion are not significantly affected by conventional driers, but aluminium gives a considerable increase in hardness without detriment to flexibility and adhesion.

Durability is greatly affected by the nature of the auxiliary drier(s) present. Lead and calcium soaps give a considerable deterioration in durability, though a basic calcium soap gives better results than a neutral one. Aluminium and zirconium can give considerable increases in durability compared to cobalt alone, and the adverse effects shown by calcium alone are masked to a great extent when zirconium is present.

Yellowing in the dark may be reduced to an exceedingly low level by using aluminium. The other driers give varying degrees of yellowing with no clear cut trends.

All the auxiliary metal driers tested contributed to the through drying character of the paint, but aluminium is shown to be very much more effective in this respect. Because aluminium complexes introduce another mode of cross-linking in addition to autoxidation, it is able to give effective through drying in films which would normally be considered too thick. This feature of aluminium could be used to good effect in high build, thick film alkyd paints.

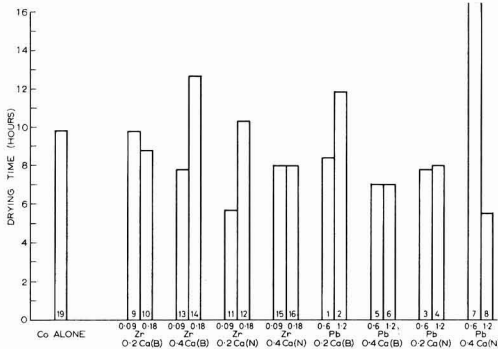


Fig. 10. Drying times—BK recorder (stage 3) 76 μm wet film double metals

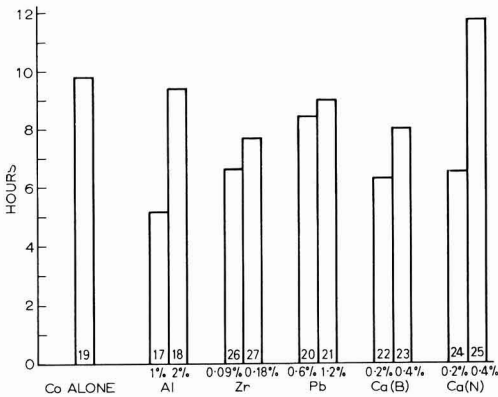


Fig. 11. Drying times—BK recorder (stage 3) 76 μm wet film single metals



An important generalisation is that driers do not simply dry paints. The effects they have on other film properties can be quite dramatic and this, it is suggested, must be considered in paint formulation.

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# The integration of the protection function when building a ship\*

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## Summary

This paper explains why good preservation of a ship's steel structure can only be obtained by integrating the preservation requirements at the preplanning stage with the overall building procedures. The role played by the initial cleaning and protection of plates and sections is fully described including the requirements of the protective coating (blast primer) and stockholding problems if any.

The damage to the initial protection during the unit fabrication and the methods for remedying this are described in detail, together

with the importance of completing all ancillary welding and burning at this stage by detailed planning.

The further protection problems occurring during unit assembly are described together with methods for dealing with these.

The paper concludes with some thoughts on the organisational structure necessary to ensure good preservation using optimum specifications.

## Keywords

*Types and classes of structures or surface to be coated:*

steel

*Processes and methods primarily associated with surface preparation before coating*

abrasive blasting

surface preparation

*Specifications, standards and regulations*

British standard specifications,

maritime administration specifications,

standard procedures

## L'harmonisation des procédés de protection avec les autres qui interviennent dans la construction navale.

### Résumé

Dans cet exposé on explique la raison pour laquelle on ne peut assurer de bonne protection aux éléments en acier de la structure d'un navire qu'en cadrant les besoins protecteurs avec tous les procédés de construction navale. On décrit amplement le rôle joué par le nettoyage et la protection initiale des plaques et des profils et d'ailleurs les caractéristiques du revêtement protecteur (Blast Primer) et également les problèmes de stockage de l'acier.

Les dégâts que subissent la couche de protection initiale lors de la fabrication des éléments de base ainsi que les méthodes de rectification sont décrits en détail. Également on souligne l'im-

portance d'assurer, grâce à la planification détaillée, qu'à ce point tout soudage et toutes les opérations assimilées sont achevés.

On décrit à la fois les autres problèmes de protection qui se produisent lors du montage des éléments, et les méthodes pour résoudre ces problèmes.

On finit l'exposé par quelques observations sur la structure de l'organisation nécessaire à assurer de bonne protection en faisant appel à des normes optimales.

## Die Integrierung der Schutzfunktion beim Bau eines Schiffes.

### Zusammenfassung:

In dieser Abhandlung wird erklärt, warum guter Schutz der Stahlkonstruktion eines Schiffes nur dann möglich ist, wenn die Integrierung der notwendigen Schutzmassnahmen bereits beim Planen des ganzen Bauprogrammes erfolgt.

Die Rolle der anfänglichen Reinigung sowie der Schutz von Platten und Abschnitten wird ausführlich beschrieben, ebenso wie die an den Schutzanstrich (Blast Primer) zu stellenden Anforderungen sowie Probleme der Lagerhaltung.

Der während der Fabrikation der Einheiten schon im Anfang (im Bezug auf Schutz) zugefügte Schaden und die Methoden einen solchen wieder in Ordnung zu bringen, werden ausführlich

beschrieben. Dabei wird die Wichtigkeit betont, alles Hilfschweissen und Abtrennen während dieses Stadiums nach bis ins kleinste gehender Planung vorzunehmen.

Die weiteren beim Zusammenbau der Einheiten auftretenden Schutzprobleme werden gemeinsam mit Methoden diese zu meistern, erwähnt.

Die Abhandlung schliesst mit einigen Vorschlägen hinsichtlich der zur Sicherstellung guten Schutzes notwendigen organisatorischen Struktur unter Benutzung bestmöglicher Lieferungsverschriften.

## Introduction

The unit fabrication of ships has greatly increased the efficiency of shipbuilding. The structure and its outfitting is subject to a very high degree of preplanning, often with the help of the computer. This is much less true for the

preservation of the steel structure and it is the authors' contention that good preservation cannot be achieved unless it is an integral part of the preplanning. Preservation must start with the protection of plates and sections before fabrication and be maintained during the fabrication of units and the building of these into the completely preserved ship.

\*Paper presented at a joint meeting of the Newcastle Section and the Institute of Corrosion Technology on 7 October 1976

In shipyards the planners by tradition concentrate their efforts on structural and outfit requirements and consider preservation can be dealt with at the final stages of construction. This is one of the main causes of early breakdown of ships' preservation and becomes more evident with the increasing usage of so called "longer life" systems. Modern ships require longer maintenance free periods and this can be achieved only if the preservation procedures are integrated into the overall planning and building of the ship.

These planning procedures start with a cardinal date plan followed by more detailed planning for the construction of each unit and the flow of these into the main erection programme. By the application of terotechnology the optimum functioning of all trades involved for the benefit of the whole must be fully integrated, and this must include the preservation function.

Detailed planning must follow on a monthly, weekly and if necessary, day-to-day basis which not only specifies the tasks to be done but feeds back information on the progress or lack of progress made. The planning must be sufficiently flexible to make use of feed back information to update the work load and the work in hand.

It will be realised that the planning problems are inevitably greater for a "one off" ship or the first of a series.

## The initial cleaning and protection of plates and sections

### Cleaning

*Ref. 1*

Millscale formed on steel at the mill must be removed since it easily cracks on flexing of the steel and if left causes corrosion in moist conditions by galvanic action between the steel and millscale.

If the steel is allowed to rust mainly by contact with atmospheric pollutants, the removal of the resulting rust producing products is a much more difficult problem.

Abrasive blast cleaning in automatic plants is the modern method used to clean plates and sections. As described in another paper<sup>1</sup> the lack of appreciation of the differences in requirements for cleaning a millscaled and a rusted surface results in a large amount of the throughput from automatic blast cleaning plants being substandard.

It is, therefore, necessary to optimise the process and the following considerations are vital to the shipbuilder who prefers to carry out his own cleaning process rather than have it done at the steel mill.

Plates and sections as received from the steel mill normally have had no time to rust and should be processed to remove their only contaminant—millscale—as soon as received.

It is a grave error first to stockpile in open or damp conditions and allow them to rust, as the subsequent cleaning is much more difficult to accomplish.

If stockpiling does prove necessary this should always be done in well ventilated conditions and under cover to avoid condensation. This will slow down the rusting and rust pitting processes.

For blast cleaning, angular abrasive (preferably chilled iron grit) is recommended. Round abrasive (particularly steel shot) should not be used as this tends to hammer in millscale rather than chisel it off. Automatic blast cleaning plant manufacturers continue to advise the use of shot in order to cut down wear on working parts. This self-defeating policy should be resisted and more wear resistant parts demanded. The term "shot blasting" is a misnomer which is more appropriate to peening and stress relieving processes.

Grit conforming to BS 2451 Size G 17 or less is recommended since smaller abrasive cleans faster and gives a finer profile. Small proportions of larger particles are necessary only when the millscale is particularly thick.

The abrasive in use must be continually recycled to remove all dust and debris, but not cleaned fine grit.

The use of large size abrasive for topping-up must be prohibited as this will create rogue peaks.

An "in-line" hot water or steam treatment is beneficial. By removing surface soiling and grease it helps to keep the abrasive cleaner. It also helps to crack the millscale.

### Protection

*Ref. 2*

After blast cleaning plates and sections it is only possible to protect with a thin paint film (the blast primer or pre-fabrication primer) 15–25 microns thick in order to meet the welding and cutting requirements.

The importance of the protection given by this primer during the unit fabrication stages<sup>2</sup> and the maintenance of its protective qualities afterwards and until such times as the full protection system can be applied should be self-evident, but this can only be achieved by careful planning.

Since most modern ships are cathodically protected the choice of primer is limited to those that do not saponify under operating conditions. The authors favour two-pack epoxy primer, preferably light in colour, so that early visible warning of possible breakdown by rusting is easily seen. Pigmentation with zinc phosphate is preferred to the zinc rich type since, although the latter may appear to give a longer rust free period, the soluble zinc products formed on the surface, due to reaction with atmospheric pollutants, are difficult to remove before overcoating and if this is not done serious blistering can occur. The authors also recommend the incorporation of some yellow iron oxide into the pigmentation since this on heating turns red, and gives a useful colour indication where heat damage to the primer has taken place due to welding, cutting or heat straightening during fabrication.

All such damaged primer must be scheduled for removal and the area reprotected.

The formulation and film properties must be carefully optimised. The liquid primer must have rheological characteristics which will ensure a fairly even dry film thickness over the blast cleaned profile and this, of course, is more easily achieved when the profile is fine. The dry film itself must be suitable for overcoating with blast primer initially and after weathering or ageing, without impairment of adhesion, and then being overcoated with any of the final protection coatings required including the stringent require-

ments of the various types of high duty tank coatings. In the author's experience many blast primers tend to be over-pigmented to achieve fast drying, and much better results are obtained at low pigment volume concentrations.

Application of the primer must be by skilled operators or by use of a foolproof automatic system. The authors have noted that automatic application can often be a poor substitute for manual application. This is because it is seldom synchronised sufficiently well to the plate or section through-cut speed and adjustment to speed variations is difficult. It is also vulnerable to spray nozzle blockage and in horizontal plates proper inspection of the underside is difficult.

### Stockholding

As already stated it is important not to stockpile unprotected steel from the steel mill.

If the blast cleaned and primed steel cannot be scheduled for immediate fabrication it should at least be stored under cover in the fabrication area and used in rotation as far as possible.

Outdoor storage is bad practice. If allowed and the plates and sections rust they must be scheduled for reblast-cleaning and priming prior to fabrication.

### Fabrication of units

During fabrication the blast primed steel is cut, welded and burned and mechanical damage to the primer also occurs. Although the primer is badly damaged, no serious rusting takes place within the confines of the fabrication shops as the temperature is fairly constant, and little or no condensation of moisture occurs.

To enable the proper integration of the protection process the fabrication of the unit should be as complete as possible before leaving the shop. In addition to being a structural unit, it should have attached to it all appendages such as pipe clips, cable hangers, insulation and lining supports etc. This is an essential part of the preplanning at this stage to eliminate minor welding after fabrication and at the assembly stage.

Traditionally these appendages are made from black iron or strip steel which has never been blast cleaned and once welded on are never properly cleaned and indeed provide the major source of rust when the ship is in service.

The authors' solution to this problem is to process all such appendages through a rotary barrel blast cleaning machine and then prime prior to welding onto the structure.

The preplanning should be such that the units leaving the fabrication shop require no further welding or cutting except along the edges to be welded to adjoining units.

### Protection of units after fabrication

It follows that the making-good of all blast primer damage can be planned as a separate operation just prior to the units leaving the fabrication shops or preferably in a separate heated building just prior to going to the building berth.

It should, therefore, only be necessary to reclean and reprime areas which have been damaged.

The traditional method of cleaning by hand wire brushes, rotary wire brushes, rotary abrasive discs etc., are completely useless other than for cleaning of simple mechanical damage, and if used will lead to early failure of finishing systems. The cutting, welding and heat straightening processes produce reformed millscale (bloom), burned primer fused into the steel surface and residual weld fluxes and weld spatter. These can be removed successfully only by blast cleaning back to the steel substrate. The authors favour vacublast cleaning of these areas, but pencil blasting with a fine grit whilst satisfactory necessitates the cleaning up afterwards of much spent grit.

During the unit fabrication many sharp edges are formed and at this stage these should be radiused using suitable grinding tools.

The minimum acceptable procedures for good subsequent preservation should at the end of the fabrication stage be planned as follows:

- (a) If the unit is dirty and greasy, wash down thoroughly with an emulsion cleaning solution followed by fresh water. Solvent washing in the authors' opinion is bad practice, as this may spread a thin layer of grease over the surface.
- (b) Remove all sharp edges to a radius of at least 2-3 mm with suitable fine grinding tools.
- (c) Remove all weld spatter with suitable grinding tools, and where hand welding is very rough grind smooth at sharp edges.
- (d) On all deck surfaces flush all welds especially in way of deck traffic. This greatly improves protection properties of subsequent deck coatings.
- (e) Vacublast or pencil blast clean all welds, and heated areas where millscale has reformed and all areas where primer has been destroyed by burning.
- (f) After cleaning surfaces free from residual abrasive and dust, coat all cleaned areas with one coat of the appropriate blast primer and follow with one overall coat of blast primer.

The unit is now ready for transport to the building berth where it can be stored for a short time, if required, before building into the ship in construction.

When building large tankers and where large and relatively flat surfaces area are involved it may be possible and is often advisable and economically sound, to apply either the full protective system (e.g. tank interiors) or all of it except the final coating before transporting to the building berth.

In such circumstances, the joining edges are left in blast primer only, by suitably masking off at least 50 mm.

Some shipbuilders with the capacity to handle very large units for very large crude oil carriers (VLCC's) have equipped themselves with air conditioned treatment buildings where these units can be completely reblasted and painted. The authors do not consider that complete reblasting is always necessary and advise concentrating on welds, burn damage and any rusting as described above.

### Unit assembly for ship construction

Many different methods of assembly at berth can be envisaged. Obviously bottom units must be a starting point.

Some methods start from the mid ship bottom units and work fore and aft, building up deck upon deck. In large tanker construction centre tank units may reach upper deck level before side tanks and outer shell are added. Building methods will also vary according to launching procedures, for example, building on the flat bottom of a dry dock to be flooded for launch can be planned differently from building on a sloping launchway. In some modern shipyards, extrusion procedures from a building hall are used.

Whatever the basic assembly pattern for units, the detailed planning should take account of the following important preservation requirements:

- (a) Open structures should be decked over as soon as possible.
- (b) When not decked over and subject to rainfall, any water collecting is immediately pumped out or temporary drainholes are provided at the lowest points.
- (c) Hatches on open decks should always be closed when not in use and deck openings for access suitably shielded with adequate temporary covers, from ingress of inclement weather.
- (d) Once a section of ship is decked over it should be freely ventilated with a positive draught capable of providing a dry enough current of air to prevent condensation.

If the procedures for unit construction have been followed, very little additional welding is required other than welding units together. This should be planned so that, as far as possible, compartments are completed in a sensible rotation to allow the final preservation to proceed. The initial task is to blast clean and prime the joining areas in exactly the same manner as described for treatment of units after fabrication, and this will be followed by the final preservation treatment appropriate to that part of the ship.

The completion of the exterior preservation of the ship should not be unduly delayed during the building period, as inadequate attention to maintenance of initial preservation at this stage of the building is likely to lead to early breakdown in service. The planning should, therefore, be such that as units with external surfaces are erected, the adjoining compartments and/or passageways are completed at least to the extent that no additional welding or burning is required on the outer shell of the unit.

### Organising the preservation procedures

*Refs. 3, 4*

The types of preservation materials are legion and serve only to confuse both the shipbuilder and the shipowner. Suppliers must largely carry the blame for surrounding these with so much mystery.

All preservation material must have adequate adhesion and this is largely dependent on good surface preparation and even those that are tolerant to variations in this respect are always best in conjunction with good surface preparation. However, some of the most sophisticated preservation materials used because of their special resistance properties are not at all tolerant to poor surface preparation. The other desirable properties are dependent on the usage requirements and shipbuilders can build up a useful background on these, especially if they have qualified coatings experts on their staff. Many potentially satisfactory protective coatings applied

over a properly prepared surface have failed because of unsatisfactory application, and as coating materials become more sophisticated this has to be matched with greater skill in application. The application skill may involve conditioning equipment for the material and the surrounding atmosphere as well as the actual means of application. It is essential that the operators and supervisors are highly skilled, they should have formalised training and be in possession of a certificate of competence.<sup>3, 4</sup>

The authors suggest that shipbuilders could materially cut their overall preservation costs and at the same time provide for themselves more satisfied customers for relatively corrosion-free ships, by employing at least two highly skilled coatings experts at management level, one in the planning department and one attached to the production department.

The coatings expert in the planning department should receive the preservation specifications from the ship design department and liaise closely with them. The integration of these specifications into the overall planning and the provision of the necessary flexibility for the absorption of feedback for revising schedules or introducing future improvements into the overall planning should also be his responsibility.

The coatings expert in the production department should have full responsibility for the functioning of all surface preparation equipment for plate and section cleaning, unit cleaning and the necessary preparation and surface cleaning of the ship in building. He must be in overall charge of the coatings application work force and its training, and be responsible for obtaining and maintaining the required application equipment. In addition, his advice should be sought in the provision of all the necessary cover and ventilation required, during the building, for all trades and should act as or work in close liaison with the Health and Safety Officer. He should also be responsible for overseeing all sub-contracted protective coating operations. He should work closely with the planning department coatings expert.

### Preservation specifications

These specifications are largely decided between the shipbuilders' design department and the actual shipowner. Tendering procedures involve the coating supplier and sometimes a coatings contractor. Indeed, the coating supplier may prefer to offer a package deal in conjunction with his own or a chosen coatings contractor. The optimum preservation specifications are not likely to be obtained unless the technical experts are fully involved.

All too often initial cost considerations are given preference over the total cost of preservation during the life of the ship and in this latter respect the cost of "out of service" is often overlooked in the initial considerations.

This paper is not intended to deal with this subject in depth but the authors offer a few golden rules applicable in this field.

- (a) Never employ a coatings contractor until his ability to do the job has been investigated.
- (b) Never specify a highly sophisticated protective system without a knowledge of all the risks, and only if a less sophisticated one will not fulfil the requirement.
- (c) Never specify roller application, as it is unlikely to give a continuous protective coating over a rough steel surface and especially over welds and the like.

- (d) Avoid two-pack materials where one pack materials are known to be equally satisfactory.
- (e) Whether contracting out or doing the protection with the shipyard work force, make sure that only the best available equipment is used.
- (f) Provide plenty of good supervision, but see that it is really competent.
- (g) If the operators take a pride in their equipment and keep it in good condition, it can be assumed that the application is likely to be satisfactory.

### Conclusion

The procedures necessary for the integration of the preservation tasks into the overall and day-to-day planning of a ship in construction are described.

To effect this it is necessary that the shipbuilder employs a coating expert in both the planning and production departments.

The achievement of better preservation by adopting these recommendations is likely to cut overall preservation costs during the life of the ship.

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# Steel cleaning standards—a case for their reappraisal\*

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## Summary

This paper traces the background which has led to the existing standards for surface preparation of steel (American, Swedish, British and Japanese) and explains how their present interpretation by the Steel Construction Industry often fails to achieve the necessary clean surface requirements. This is often because of a lack of appreciation of the added difficulties involved in cleaning rusty

steel as opposed to "as rolled" steel contaminated with mill scale only. The fault also often lies with the inadequacy of cleaning equipment (especially the more expensive types) to meet the required standards. It is suggested that further safeguards are necessary and should be built into the existing standards by early revision.

## Keywords

*Types and classes of structures or surfaces to be coated*

steel

*Processes and methods primarily associated with surface preparation before coating*

abrasive blasting

surface preparation

*Specification, standards and regulations*

British Standard specifications

maritime administrative specifications

standard procedures

## Les normes concernant le nettoyage d'acier—un plaidoyer pour leur évaluation de nouveau.

### Résumé

Dans cet exposé l'auteur décrit les circonstances qui ont mené à l'établissement des normes actuelles (américaines, suédoises, anglaises et japonaises) pour la préparation des surfaces d'acier et il explique la manière dans laquelle l'interprétation accordée à ces normes par l'industrie de construction de charpentes en acier est très souvent inapte à assurer la provision d'une surface propre. Cette possibilité se produit fréquemment à cause d'une manque d'appréciation des difficultés de surcroît en ce qui concerne le nettoyage d'acier rouillé, vis-à-vis l'acier direct du laminage et

qui est souillé seulement par les écailles de laminage. Le défaut se trouve souvent dans l'inefficacité du matériel de nettoyage (surtout dans le cas des types plus coûteux) en répondant aux normes nécessaires.

L'auteur suggère que les précautions supplémentaires sont nécessaires et qu'elles doivent être incorporées dans les normes actuelles au cours d'une prochaine révision.

## Normen für Stahlreinigung—Ein Fall für deren Revidierung.

### Zusammenfassung:

Diese Abhandlung zeichnet den Hintergrund auf, welcher zu den bestehenden Normen (amerikanische, schwedische, englische und japanische) für die Vorarbeiten auf Stahloberflächen führte und erklärt, wieso die derzeitige Interpretation durch die Eisenkonstruktionsindustrie häufig ausserstande ist, die Anforderungen an die notwendigerweise sauberen Oberflächen zu erfüllen. Der Grund hierfür liegt häufig an mangelhafter Kenntnis der zusätzli-

chen Schwierigkeiten beim Reinigen verrosteten Stahls im Gegensatz zu nud mit Walzhaut (as rolled) behaftetem Stahl. Oft liegt der Fehler auch in der Unzulänglichkeit der Reinigungs-ausrüstung (besonders der teureren Arten), um der erforderlichen Norm Genüge zu leisten. Es wird vorgeschlagen, dass, weil weitere Sicherheitsmassnahmen notwendig erscheinen, solche durch baldige Revision in die bestehenden Normen eingearbeitet werden.

## Introduction

*Refs. 1-11*

Since man began to use iron and steel he has always been bedevilled with its instability in damp atmospheres and its reversion to oxides of iron or rust.

With the increasing usage of steel as a cheap material of construction and its wider use in industrial buildings, where the pollutants caused by the industrial processes accelerated the corrosion process, it became more and more necessary to provide effective protection against corrosion, usually in the form of special protective coating materials. There are many special situations to be considered and perhaps the largest single industry where the steel used is subject to a continuous threat of very severe corrosion is the shipbuilding industry which, of course, now embraces the sea-going installations

and ancillary pipe lines etc., required for such projects as North Sea Oil.

It has long been recognised that any protective coating is likely to adhere better to and, therefore, to protect longer a *Clean* steel surface. Even in the days when red lead in oil and drying oil paints or bitumen were the main protective coatings these performed better when a pre-cleaning process was involved.

With the advent of more sophisticated protective coating materials it became apparent that better cleaning procedures were required to avoid total early failure. Even when apparently good cleaning procedures were used failures could and often did occur.

It, therefore, became necessary to consider formalised cleaning standards for surface preparation. Work towards

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the preparation of these was being considered prior to 1940 and to a greater extent after the second world war. The first real progress was made by the Steel Structures Painting Council of America who originally established specifications in 1952<sup>1</sup>, revised in 1963<sup>2</sup> and 1975<sup>3</sup>; the more widely quoted Swedish standards were first issued in 1962<sup>4</sup> and revised in 1967<sup>5</sup>. The British Standards Institution added their contribution in 1967<sup>6</sup> (BS 4232). The Japanese with their vast shipbuilding industry felt the need to issue a standard in 1969<sup>7</sup> for assessing the derusting of shop primed steel which had been exposed during construction. More recently in 1975<sup>8</sup> they have issued Primary and Secondary Surface Preparation standards for steel and shop primed steel respectively. The Dutch Corrosion Centre issued standards in 1973<sup>9</sup>, the German Standards Organisation issued DIN55928 in September 1975<sup>10</sup>, and there is also an Australian Standard issued in 1974<sup>11</sup>. For the purpose of this paper the American, Swedish, British and Japanese standards only will be dealt with.

### American standards

*Refs. 12, 13*

Various American organisations issued steel cleaning specifications, but it is sufficient for the purpose of this paper to mention in detail only those issued by the Steel Structures Painting Council of America.

These as at 1 October 1963 are listed in Table 1 and by and large were reflecting and trying to up grade current practice at that time.

It should not be overlooked, however, that in America their National Association of Corrosion Engineers (NACE) are very active in this field and, for example, have recently issued a NACE standard for water blast cleaning<sup>12</sup>. Also the American Society of Naval Architects and Marine Engineers have issued Pictorial standards<sup>13</sup>.

With regard to Table 1, the field can be narrowed by stating that there are basic objections to standardising such unsatisfactory methods of cleaning as hand or power tool cleaning and flame cleaning, except as means of removing heavy deposits of rust prior to blast cleaning, if considered necessary. Pickling, which is highly satisfactory as a pre-treatment for the galvanising process, is limited in its application to the cleaning of structural steel prior to painting. Again solvent cleaning is intended as an auxiliary cleaning process to be used in conjunction with other surface preparations.

Five blast cleaning specifications remain—white metal near white metal, commercial blast cleaning, brush off blast cleaning and weathering followed by blast cleaning. The first four of these specifications differ only in the definitions of the surface finish required and these are reproduced in Table 2.

<sup>1</sup> The definitions imply that the standards are capable of achievement irrespective of the condition of the steel (new steel from the mill, rusty steel, painted and rusty steel etc.) However, in the appendices it is clear that the cost of achieving a white metal finish will be high and subject to a wide cost variation depending on difficulties in removing contaminants. Nevertheless, it is implied that a uniform degree of cleanliness can be achieved despite great differences in the original surfaces.

Table 1  
Surface preparation specifications

Specification	Subject	Purpose
SSPC-Vis 1-63T	Description of visual standard	Photographic standards used as optional supplement to SSPC surface preparation numbers 2, 3, 5, 6 and 7.
SSPC-SP. 1-63	Solvent cleaning	Removal of oil, grease, dirt, soil, salts and contaminants by cleaning with solvent, vapour, alkali, emulsion or steam.
SSPC-SP. 2-63	Hand tool cleaning	Removal of loose rust, loose mill scale, and loose paint to degree specified, by hand chipping, scraping, sanding and wire brushing.
SSPC-SP. 3-63	Power tool cleaning	Removal of loose rust, loose mill scale, and loose paint to degree specified, by power tool chipping, descaling, sanding, wire brushing and grinding
SSPC-SP. 4-63	Flame cleaning of new steel	Dehydrating and removal of rust, loose mill scale, and some tight mill scale by use of flame, followed by wire brushing.
SSPC-SP. 5-63	White metal blast cleaning	Removal of all visible rust, mill scale, paint and foreign matter by blast cleaning by wheel or nozzle (dry or wet) using sand, grit or shot. (For very corrosive atmosphere where high cost of cleaning is warranted.)
SSPC-SP. 10-63T	Near-white blast cleaning	Blast cleaning nearly to white metal cleanliness, until at least 95 per cent of each element of surface area is free of all visible residues. (For high humidity, chemical atmosphere, marine or other corrosive environment.)
SSPC-SP. 6-63	Commercial blast cleaning	Blast cleaning until at least two-thirds of each element of surface area is free of all visible residues. (For rather severe conditions of exposure.)
SSPC-SP. 7-63	Brush-off blast cleaning	Blast cleaning of all except tightly adhering residues of mill scale, rust and coating, exposing numerous evenly distributed flecks of underlying metal.
SSPC-SP. 8-63	Pickling	Complete removal of rust and mill scale by acid pickling, duplex pickling or electrolytic pickling. May passify surface.
SSPC-SP. 9-63T	Weathering followed by blast cleaning	Weathering to remove all or part of mill scale followed by blast cleaning to one of the above standards.

The specifications then enumerate the alternative blast cleaning methods which may be used to achieve the required standards. These methods are listed in Table 3.



Table 2  
Definitions of surface finish required for SSPC blast cleaning specifications

White metal	New white metal	Commercial	Brush off
<p>“White metal blast cleaning is a method of preparing metal surfaces for painting or coating by removing all mill scale, rust, rust-scale, paint, or foreign matter by the use of abrasives propelled through nozzles or by centrifugal wheels. A white metal blast cleaned surface finish is defined as a surface with a grey-white, uniform metallic colour, slightly roughened to form a suitable anchor pattern for coatings. The surface, when viewed without magnification, shall be free of all oil, grease, dirt, visible mill scale, rust, corrosion products, oxides, paint or any other foreign matter. The colour of the clean surface may be affected by the particular abrasive medium used. Photographic or other visual standards of surface preparation may be used to further define the surface if specified in the contract”.</p>	<p>“Near white blast cleaning is a method of preparing metal surfaces for painting or coating by removing nearly all mill scale, rust, rust-scale, paint, or foreign matter by the use of abrasives propelled through nozzles or by centrifugal wheels, to the degree hereafter specified. A near white blast cleaned surface finish is defined as one from which all oil, grease, dirt, mill scale, rust, corrosion products, oxides, paint or other foreign matter have been completely removed from the surface except for very light shadows, very slight streaks, or slight discolourations caused by rust stain, mill scale, oxides, or slight, tight residues of paint or coating that may remain. At least 95 per cent of each square inch of surface area shall be free of all visible residues, and the remainder shall be limited to the light discolouration mentioned above. Photographic or other visual standards of surface preparation may be used to modify or further define the surface if specified in the contract”.</p>	<p>“Commercial blast cleaning is a method of preparing metal surfaces for painting or coating by removing mill scale, rust, rust-scale, paint or foreign matter by the use of abrasives propelled through nozzles or by centrifugal wheels, to the degree hereafter specified. A commercial blast cleaned surface finish is defined as one from which all oil, grease, dirt, rust scale and foreign matter have been completely removed from the surface and all rust, mill scale, and old paint have been completely removed except for slight shadows, streaks, or discolourations caused by rust stain, mill scale oxides or slight, tight residues of paint or coating that may remain; if the surface is pitted, slight residues of rust or paint, may be found in the bottom of pits; at least two thirds of each square inch of surface area shall be free of all visible residues and the remainder shall be limited to the light discolouration, slight staining or light residues mentioned above. Photographic or other visual standards may be used to modify or further define the surface if specified in the contract”.</p>	<p>“Brush-off blast cleaning is a method of preparing metal surfaces for painting or coating by rapidly removing loose mill scale, loose rust, and loose paint, to the degree hereafter specified, by the impact of abrasives propelled through nozzles or by centrifugal wheels. It is not intended that the surface shall be free of all mill scale, rust, and paint. The remaining mill scale, rust, and paint should be tight and the surface should be sufficiently abraded to provide good adhesion and bonding of paint. A brush-off blast cleaned surface finish is defined as one from which all oil, grease, dirt, rust-scale, loose mill scale, loose rust and loose paint or coatings are removed completely, but tight mill scale and tightly adhered rust, paint and coatings are permitted to remain provided that all mill scale and rust have been exposed to the abrasive blast pattern sufficiently to expose numerous flecks of the underlying metal fairly uniformly distributed over the entire surface. Photographic or other visual standards of surface preparation may be used to modify or further define the surface if specified in the contract”.</p>

Table 3  
Blast cleaning methods given in SSPC specifications

- (1) *Dry sandblasting* using compressed air blast nozzles and dry sand of a maximum particle size no larger than that passing through a 16 mesh screen, US sieve series.
- (2) *Wet or water-vapour sand blasting* using compressed air blast nozzles, water and sand of a maximum particle size no larger than that passing through a 16 mesh screen, US sieve series.
- (3) *Grit blasting* using compressed air blast nozzles and crushed grit made of cast iron, malleable iron, steel or synthetic grits other than sand, of a maximum particle size no larger than that passing through a 16 mesh screen, US sieve series. The largest commercial grade of metal grit permitted by this specification is SAE No G-25 abrasive material.
- (4) *Shot blasting* using compressed air nozzles and cast iron, malleable iron, steel or synthetic shot of a maximum size no larger than that passing through a 16 mesh screen, US sieve series. The largest commercial grade permitted by this specification is SAE No S-330.
- (5) *Closed, recirculating nozzle blasting* using compressed air, vacuum, and any of the preceding abrasives.
- (6) *Grit blasting* using centrifugal wheels and crushed grit made of cast iron, malleable iron, steel or synthetic grits of a maximum particle size no larger than that passing through a 16 mesh screen, US sieve series. The largest commercial grade of metal grit permitted by this specification is SAE No G-25.
- (7) *Shot blasting* using centrifugal wheels and cast iron, malleable iron, steel or synthetic shot of a maximum particle size no larger than that passing through a 16 mesh screen, US sieve series. The largest commercial grade permitted by this specification is SAE No S-330.

These specifications also give some good advice on such essential ancillary matters as cleaning up procedures after blast cleaning, time lapse between blast cleaning and protecting and profile considerations. The more important of these points are tabulated in Table 4.

Table 4  
Important considerations highlighted in SSPC blast cleaning specifications

*Essential precautions*

The compressed air used for nozzle blasting shall be free of detrimental amounts of condensed water or oil. Adequate separators and traps shall be provided. Blast cleaning operations shall be done in such a manner that no damage is done to partially or entirely completed portions of the work.

Dry blast cleaning operations shall not be conducted on surfaces that will be wet after blast cleaning and before painting, or when ambient conditions are such that any visible rusting occurs before painting or coating.

If any rust forms after blast cleaning, the surface shall be reblast cleaned before painting.

The blast cleaned surface shall be examined for any traces of oil, grease, or smudges. If present, they shall be removed as outlined in Spec. SSPC-SP 1-63, “Solvent cleaning”.

Moisture condenses on any surface that is colder than dew point of the surrounding air. It is therefore recommended that dry blast cleaning should not be conducted when the steel surface is less than 5°F above the dew point.

Table 4—Continued

*Time lapse between blast cleaning and painting*

Where chemical contamination of the surface may occur, the steel should be painted as soon as possible after blast cleaning.

The blast cleaned surface must be treated or primed before any rusting occurs, otherwise the benefit of blast cleaning is lost.

The freshly exposed bare metal will rust quickly under conditions of high humidity, when wet, or when in a corrosive atmosphere. Under normal mild atmospheric conditions it is best practice to prime or chemically treat within 24 hours after blast cleaning. Under no circumstances should the steel be permitted to rust before painting, regardless of the time elapsed. The permissible time interval between blast cleaning and priming will vary greatly (from minutes to weeks) from one environment to another, in order that the surface remain free of corrosion, etc.

If a maximum interval is desired it shall be so specified in the contract covering the work.

*Cleaning procedures after blast cleaning*

The surface, if dry blasted, shall be brushed with clean brushes made of hair, bristle or fibre, blown off with compressed air (from which detrimental oil and water have been removed), or cleaned by vacuum, for the purpose of removing any traces of blast products from the surface, and also for the removal of abrasive from pockets and corners.

The surface, if wet sandblasted, shall be cleaned by rinsing with fresh water to which sufficient corrosion inhibitor has been added to prevent rusting, or with fresh water followed by an inhibitive treatment. This cleaning shall be supplemented by brushing, if necessary, to remove any residue.

*Profile considerations*

The maximum height of profile is the height of the anchor pattern produced on the surface, measuring from the bottom of the lowest pits to the tops of the highest peaks.

The height of the anchor pattern can be determined by grinding a flat spot on the blasted surface until the bottoms of the pits are almost reached. The height may then be measured with a micrometer depth gauge graduated to read 0.001 in and with a base having a bearing length of 2 in and a measuring rod of  $\frac{3}{8}$  in diameter.

Maximum profile will vary somewhat with the angle and velocity of particle, with the hardness of surface, with the amount of recycling of working mixtures (of shot and grit) and with the thoroughness of blast cleaning.

The height of profile of the anchor pattern produced on the surface shall be limited to a maximum height that will not be detrimental to the life of the paint film.

The maximum permissible size of the abrasive particles will depend upon the allowable surface roughness or "maximum height of profile" of the surface; the allowable maximum height of profile is, in turn, dependent upon the thickness of paint to be applied.

The dry paint film thickness above the peaks of the profile should equal the thickness known to be needed over a smooth surface for the desired protection. If it is not possible to use an abrasive size small enough to produce a desirable height of profile, the dry paint film thickness should be increased to provide adequate thickness above the peaks.

Standards of comparison are also an important part of the American specifications and are cross-referenced with the Swedish Pictorial standards. The relevant paragraphs are given in Table 5.

The fifth blast cleaning specification in 1963 was for the weathering of steel followed by blast cleaning, and was an attempt to standardise a then current practice. Due warning was given against weathering for too long a period to cause excessive pitting and it was suggested as being "most effective when all parts of the surface were equally exposed" as "weathering should be discontinued when pitting inherent in the weathering begins to appear". The claim in 1963 that

weathered steel can be cleaned to white metal was quite unjustified and it is to their credit that in the 1971 revision of SSPC surface preparation standards this particular specification has been dropped.

Table 5

*Relevant paragraphs in SSPC blast cleaning specifications relating to standards for comparison*

Photographic standards of comparison may be used to define the final surface condition to be supplied under this specification.

This correlation is cross-referenced in these visual standards, which were developed by the Swedish IVA, and have been mutually adopted by the Swedish Standards Association, the ASTM and the SSPC.

The colour of the cleaned surface may be affected by the nature of the abrasive used.

Other visual standards of surface preparation may be used as required by the owner when they are specified in the contract to illustrate the degree of metal cleanliness required. The owner will provide the specified samples or standards of such size and condition that they may be compared during the entire contract. If blast cleaned steel samples are used, they should be completely protected from corrosion during the period of the contract. With the agreement of both contractual parties, examination under magnification or examination by chemical methods may be used in the evaluation of the cleanliness of the surface.

Apart from this the 1971 revisions are minor, except for the specifications for commercial blast cleaning and brush-off blast cleaning where previously statements referring to rates of cleaning were open to misinterpretation and the statement now reads "The specification is based upon a desired end condition and *not* upon a rate of cleaning test".

To sum up, the SSPC blast cleaning specifications (1971 revisions) are a very creditable attempt to specify current practice, but as will be argued later in this paper they are due for a reappraisal.

**The Swedish standards***Refs. 4, 5*

These were first issued in 1962<sup>4</sup> and reissued in 1967<sup>5</sup> by the Swedish Standards Institution. Like the Americans with whom they co-operated they were trying to standardise and up grade current practice.

They did this in the form of pictorial standards covering four grades of rusting of steel. The surface preparation was either by two preparation grades of scraping and wire brushing or four preparation grades of blast cleaning. The four rust grades are defined as:

- "A. Steel surface covered completely with adherent mill scale and with little if any rust.
- B. Steel surface which has begun to rust and from which the mill scale has begun to flake.
- C. Steel surface on which the mill scale has rusted or from which it can be scraped, but with little pitting visible to the naked eye.
- D. Steel surface on which the mill scale has rusted away and on which considerable pitting is visible to the naked eye."

For the preparation grades it is assumed that prior to treatment the steel surface has been cleaned of dirt and grease, and that the heavier layers of rust have been removed by chipping.

The two preparation grades of scraping and wire brushing and which are applied to rust grades B, C and D are defined as:

“St 2 Thorough scraping and wire brushing, machine brushing, grinding, etc. The treatment shall remove loose mill scale, rust and foreign matter. Finally the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It should then have a faint metallic sheen. The appearance shall correspond to the prints designated St 2.

St 3 Very thorough scraping and wire brushing, machine brushing, grinding, etc. Surface preparation as for St 2, but much more thoroughly. After removal of dust, the surface shall have a pronounced metallic sheen and correspond to the prints designated St 3.”

The four preparation grades for blast cleaning are defined as:

“Sa 1. Light blast cleaning. Loose mill scale, rust and foreign matter shall be removed. The appearance shall correspond to the prints designated Sa 1.

Sa 2. Thorough blast cleaning. Almost all mill scale, rust, and foreign matter shall be removed. Finally, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It shall then be greyish in colour and correspond in appearance to the prints designated Sa 2.

Sa 2.5. Very thorough blast cleaning. Mill scale, rust and foreign matter shall be removed to the extent that the only traces remaining are slight stains in the form of spots or stripes. Finally, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It shall then correspond in appearance to the prints designated Sa 2.5.

Sa 3. Blast cleaning to pure metal. Mill scale, rust and foreign matter shall be removed completely. Finally, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It shall then have a uniform metallic colour and correspond in appearance to the prints designated Sa 3.”

These standards were considered a great advancement as they established a pictorial representation of the appearance likely to be achieved from four starting points using either a scraping and wire brushing method or a blast cleaning method. The Swedes were careful not to specify, like the Americans, the types of blast cleaning to be used.

In practice, however, the pictorial standards have often been difficult to interpret properly and have been open to much misinterpretation.

### The British Standards

Three British standards refer to blast cleaning of steel.

- (1) British standard code of practice CP 2008 1966. “Protection of iron and steel structures from corrosion.”

This is now under revision and is likely to contain more updated information on blast cleaning.

- (2) British standard 2569—“Sprayed metal coatings. Part 1. 1964, Part 2 1965”.

It is considered by many that the blast cleaning provisions in this standard are due for revision.

- (3) British standard 4232, 1967. “Surface finish of blast cleaned steel for painting.”

For the purpose of this paper it will be sufficient to deal with this latter standard. It was not until December 1967 that it was issued and the then British Association of Corrosion Engineers, now the Institute of Corrosion Science and Technology, were the prime movers. Wet methods of blast cleaning were not included and the basic data was largely selected from the existing American (SSPC) and Swedish standards. The equivalencies were expressed as shown in Table 6.

Table 6  
Correlation of British, American and Swedish Standards

BS	SSPC	Swedish
First quality	White metal	SA 3
Second quality	New white	SA 2.5
Third quality	Commercial	SA 2

The exclusion of the American “brush-off grade” and Swedish grade Sa 1 was deliberate as something not to be encouraged.

Whilst the three grades were said to apply equally to the cleaning of uncoated steel whether it was new or weathered and to steel with old protective coating requiring renewal, it was also recognised that the First quality was unlikely to be attained “if the steel is deeply pitted or otherwise severely corroded before blast cleaning even though all contaminants appear to have been removed”. It also stated that “the greater the degree of corrosion before cleaning the more difficult it is to remove all surface contaminants and if this is not done the durability of the paint coating will be decreased”.

The standard also attempted to quantify the extent of contamination permitted as shown in Table 7 (this is a reproduction of Table 1 in BS 4232).

Table 7  
Qualities of surface finish of blast-cleaned steel for painting

Quality of surface finish	First quality	Second quality	Third quality
Types of steel	All steels including structural steels to BS 15, BS 968 and BS 2762		
General appearance	Whole surface to show blast-cleaning pattern		
Description of finish Clean bare steel	Whole surface	At least 95 per cent of surface	At least 80 per cent of surface
Extent of residue	Nil	Not more than 10 per cent of any single square of 25 mm (1 in) side	Not more than 40 per cent of any single square of 25 mm (1 in) side
Type of residue permitted:			
Mill-scale	Nil	} Tightly bonded residues	} Tightly bonded residues
Rust	Nil		
Paint or other coating	Nil	Nil	Nil
Loose abrasive and dust	Nil	Nil	Nil
Surface roughness	The maximum amplitude should be related to the paint system and should preferably not exceed 0.10 mm (0.004 in)		

In recognising the significances of profile in relation to paint coating performance the British standard recommended the use of metallic abrasives that would give a surface roughness of not more than 0.10 mm maximum amplitude. It also recognised that non-metallic abrasives were more likely to give a maximum amplitude of 0.18 mm and said that if these were limited to a maximum particle size of 1 mm (No. 16 Mesh BS sieve) the desirable limit of 0.10 mm maximum amplitude could be attained.

In fact this standard was a very practical approach to defining and upgrading the then current practice, for example, pointing out that for rusty steel the surface roughness obtainable will also be influenced by its inherent roughness as well as by the abrasive used. Emphasis is also placed on the use of fine abrasives. Control and inspection was admitted as difficult until better methods were developed and coupon samples were suggested as well as the use of the Swedish Pictorial standards.

The blast cleaning procedures recommended are reproduced in Table 8.

Table 8  
Blast cleaning procedure

The steel to be blast cleaned should be dry and the operating conditions should be such that condensation does not occur on it during the work. When compressed air is used, this should be dry and free from oil.

Any oil or grease should be removed from the steel surface before blast cleaning is begun.

If the steel is heavily rusted, particularly if scaly rust is present, a preliminary cleaning with power-driven impact tools will generally prove economical.

Unless an instantaneous-recovery blasting machine is employed, the cleaned surface should be air-blasted, vacuum-cleaned, or otherwise freed from abrasive residues and dust immediately after the blast cleaning.

Following the removal of abrasive material, the surface should preferably be rubbed over briefly with a nylon scraper or scourer to reduce the number of "rogue peaks".

The application of at least the first coat of paint or non-metallic coating should follow with the least possible delay and in any case before visible deterioration has occurred as compared with a freshly blast cleaned area.

It was also implied that an early revision would be required as knowledge in the field advanced.

**Japanese standards**

*Refs. 7, 8*

The first Japanese standard appeared in 1969. "Standard for de-rusting of shop-primed steel surface"<sup>7</sup>.

This standard recognised the Swedish and SSPC standards for cleaning steel and then goes on to say that in shipbuilding the shop primed steel will rust again due to physical damage, storage, exposure to open weather, transportation and manufacturing processes and will therefore require a secondary cleaning. Five types of damage were classified and these are detailed in Table 9.

These five types of damage could then be given one of three grades of secondary cleaning:

- Grade I. No treatment.
- Grade II. Common grade treatment.
- Grade III. High grade treatment.

Table 9  
Classification of shop primed steel surface

- B. Shop primed steel surfaces with dirt and little rust caused by exposure to the open weather.
- C. Shop primed steel surfaces with dirt and scratches and considerable reddish rust caused by exposure to the open weather.
- D. Shop primed steel surface with scratches and heavy rust sustained under severe conditions.
- F. Shop primed steel surface with scratches and rust suffered by fairing.
- W. Shop primed steel surface with scratches and rust sustained by welding.

Grades B, C and D are the conditions of the shop primed steel surfaces exposed to outer weather for 2-5 months at the seaside area (dockyards) and these surfaces are primed with etching primer or zinc epoxy primer after shot blasting (SIS Sa2.5).

Grade A, not specified here, indicates a condition better than Grade B, i.e. dirt or rust is very slight and does not require further secondary cleaning.

Table 10 lists all the secondary cleaning recommended for each surface conditions, and each of these is characterised in the standard by a pictorial representation similar to the Swedish presentation. These pictures are representative of two distinct types of shop primer, etch primer and zinc epoxy primer, and certainly serve as a useful guide to the standard of secondary cleaning required.

Table 10  
Secondary cleaning standards

Cleaning grade	I	II	III
B	NONE	PB1	PB2
C	NONE	PB1	PB2
D	NONE	PB2	DS + PB2
F	NONE		PB3
W	NONE		PB3

NOTE: PB1:	To brush forward and backward with the back of the power wire brush pressed lightly, and repeating this brushing on the surface all over.		
PB2:	To brush forward and backward with the back of the power wire brush pressed strongly and repeating this brushing twice on the surface all over.		
PB3:	To brush forward and backward with the back of the power wire brush pressed strongly and repeat this brushing until faint metallic gloss is noticed on the steel surface.		
DS + PB2:	To effect rough cleaning of reddish rust with a power disc-sander at the beginning, and thereafter derust by a careful power wire brushing until the surface indicates a gloss in the wave-like structure.		

The latest Japanese standard is a much more ambitious document issued in 1975 by the 139th Research Section of the Shipbuilding Research Association of Japan<sup>8</sup>. It deals with both primary and secondary surface preparation standards and is supported throughout by pictorial standards.

The primary standards are classified as two initial conditions of the steel which are cleaned to three grades of cleaning with steel shot and three grades of cleaning with slug sands or grits. These are detailed in Table 11.

The pictorial standards include all the combinations of initial surface condition with each grade of surface preparation as detailed in Table 11.

Table 11  
Classification of primary standards

Conditions of steel surface prior to surface preparation	
JA:	Steel surface covered with mill scale (rarely with a little rust).
JB:	JA Steel surface exposed to weather one and half months. (The surface is covered with red rust, but there remains mill scale without pitting underneath the red rust.)
Grades of primary surface preparation	
Sh0:	Surface prior to blast cleaning by steel shot.
Sh1:	Surface prepared by light blast cleaning by steel shot. Loose mill scale, rust and foreign matter are fairly removed.
Sh2:	Surface prepared by thorough blast cleaning by steel shot. Almost all mill scale, rust and foreign matter are fairly removed.
Sh3:	Surface prepared by very thorough blast cleaning by steel shot. Mill scale, rust and foreign matter are removed to the extent that the surface has a uniform metallic sheen.
Sd0:	Surface prior to blast cleaning by slug sand or grit.
Sd1:	Surface prepared by light blast cleaning by slug sands or grits. Loose mill scale, rust and foreign matter are fairly removed.
Sd2:	Surface prepared by thorough blast cleaning by slug sands or grits. Almost all mill scale, rust and foreign matter are fairly removed.
Sd3:	Surface prepared by very thorough blast cleaning by slug sands or grits. Mill scale, rust and foreign matter are removed to the extent that the surface has a uniform metallic sheen.

The references to these pictorial standards are given in Table 12.

Table 12  
Reference to pictorial primary standards

Conditions of steel surface prior to surface preparation			
JA	JB		
Grades of primary surface preparation			
JA Sh0	JA Sh1	JA Sh2	JA Sh3
JB Sh0	JB Sh1	JB Sh2	JB Sh3
JA Sd0	JA Sd1	JA Sd2	JA Sd3
JB Sd0	JB Sd1	JB Sd2	JB Sd3

The classification of the secondary standards is much more complicated. Three shop primers are dealt with: wash primer designated W, organic zinc primer designated Z, and inorganic zinc primer designated I. The initial condition of these primers are designated as follows:

- “WO : Surface coated with shop primer (W) on JA Sh2
- ZO : Surface coated with shop primer (Z) on JA Sh2
- IO : Surface coated with shop primer (I) on JA Sh2”.

The condition of the shop primed surface prior to secondary surface preparation is then classified into the following five types of breakdown or damage.

- “HO : Steel surface coated with shop primer (W, Z, I) which is exposed to weather about one and half months after hand welding.
- AO : Steel surface coated with shop primer (W, Z, I) which is exposed to weather about one and half months after automatic welding.

- FO : Steel surface coated with shop primer (W, Z, I) which is exposed to weather after gas burning and water cooling for removing strain of the steel.
- DO : Steel surface coated with shop primer (Z, I) on which white zinc salt is generated.
- RO : Steel surface coated with shop primer (W, Z, I) on which little rusts in the form of spots are visible because of exposure to weather.”

For secondary surface preparation the standard allows for six different grades of preparation and these are coded and defined as follows:

- “Pt1 : Surface prepared by wire-brushing for the surface conditions (H, A, D, R) and by disc-sander for the surface condition (F). Loose rust and foreign matter are fairly removed.
- Pt2 : Surface prepared by wire-brushing for the surface conditions (A, D, R) by wire-brushing and disc-sander for the surface condition (H), and by disc-sander for the surface condition (F). Almost all rust and foreign matter are fairly removed.
- Pt3 : Surface prepared by wire-brushing and disc-sander for the surface conditions (H, A) and by disc-sander for the surface condition (F). Rust and foreign matter are removed to the extent that the surface has a uniform metallic sheen.
- Ss : Surface prepared by light blast cleaning (sweep blast cleaning) of slug sands or grits. (Shop primer with the little trace of rust is noticeable.)
- Sd2 : Same surface as the grade (Sd2) of the primary surface preparation.
- Sd3 : Same surface as the grade (Sd3) of the primary surface preparation.”

The Pictorial Secondary Standards include most of the combinations of the three shop primers with the five conditions of breakdown and prepared to the six different grades of surface preparation. Table 13 records the reference numbers of the available pictorial standards.

Table 13  
Reference to pictorial secondary standards

Conditions of steel surface coated with shop primer					
WO	ZO		IO		
Grades of Secondary Surface Preparation					
W <sub>o</sub>	WHO	WHPt1	WHPt2	WHPt3	WHSd2
WO	WAO	HAPt1	WAPt2	WAPt3	WASd2
W <sub>o</sub>	WFO	WFPt1	WFPt2	WFPt3	WFSd2
WO	WRO	WRPt1	WRPt2	WRSs	
ZO	ZHO	ZHPt1	ZHPt2	ZHPt3	ZHSd2
ZO	ZAO	ZAPt1	ZAPt2	ZAPt3	ZASd2
ZO	ZFO	ZFPt1	ZFPt2	ZFPt3	ZFSd2
ZO	ZDO	ZDPt1	ZDPt2	ZDSs	
ZO	ZRO	ZRPt1	ZRPt2	ZRSs	
IO	IHO				IHSd3
IO	IAO			IAPt3	IASd3
IO	IFO			IFPt3	IFSd3
IO	IDO		IDPt3	IDSs	IDSd3
IO	IRO			IRSs	

This effort by the Japanese Shipbuilding Research Association is highly commendable and no doubt has helped to maintain a uniformity for expected protective coating performance especially in the building of very large ships. While these no doubt recognise the need for standardisation of procedures for surface preparation, both primary and

secondary, nevertheless it is the author's opinion that they, like the other national standards previously mentioned, need a reappraisal.

## Discussion

Refs. 16-19

It will have been noted that the existing national standards rely on an appearance description backed up with a pictorial representation. It is only the British Standard that hints that First Quality (SA3 or white metal) "is unlikely to be attained if the steel is deeply pitted or otherwise heavily corroded before blast cleaning, even though all contaminants appear to have been removed". In all the standards there is a general implication that rust is mainly due to moisture contamination. This, of course, is a false premise as rust as we know it in industry is mainly accelerated by atmospheric pollutants (usually chloride or sulfur dioxide ions in the moisture). These form colourless ferrous salts at points of attack which may remain at the bottom of the rust pits after the visible rust is removed. If these salts are left they will hydrolyse to form volumes of rust in a cyclic process (See Fig 1) and if this occurs under the paint film it will soon cause rust breakthrough.

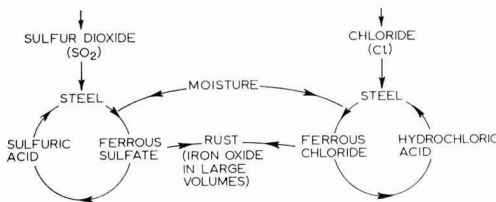


Fig. 1. Cyclic process of rusting

It only requires a relatively small amount of SO<sub>2</sub><sup>1</sup> and or Cl<sup>1</sup> ions to start the cyclic process and produce volumes of rust. It is therefore essential when cleaning rusty steel to a first quality standard to ensure the complete removal of these colourless ferrous salts and this is facilitated by testing for their continued presence<sup>15</sup>. Two methods are satisfactory. The first is to test the freshly blast cleaned and previously rusty surface with potassium ferricyanide paper (See Appendix I) and if this proves positive the surface must be blast cleaned again and the test repeated. The second is to leave the freshly blast cleaned and previously rusty surface for a few hours or overnight before overpainting. If the colourless ferrous salts have not been removed their presence will become obvious by the appearance of rust spots all over the surface usually corresponding to pitted or previously heavily rusted areas (this is the cyclic and hydrolysis process of Fig 1). If this occurs it is necessary to blast clean again and repeat the test. It is important to remember that these colourless ferrous salts are very soluble in water and it can be expected that wet blast cleaning techniques (with and without entrained abrasive) will be more effective for their removal, although because of capillary action in deep and narrow pits a slow diffusion action may be more appropriate than a high pressure water blast. When the colourless ferrous salts are completely removed, the cleaned previously rusted steel should not show any rerusting under normal atmospheric exposure free from moisture condensation.

It is, therefore, evident that First Quality (Sa3 or white metal) blast cleaning is a virtual non starter unless the steel is being cleaned at the mill when its only contaminant is

mill scale or when very special precautions are taken. It is time these constraints were built into the blast cleaning specifications. The present position is that automatic blast cleaning plants all over the world are allegedly producing a so called First Quality standard from steel plates and sections which have been allowed to become either partly or completely rusted before blast cleaning. Using the potassium ferricyanide test it is simple to illustrate that the standard achieved is only First Quality on the areas which still had mill scale before blast cleaning. However, the blast cleaned steel in these plants is so quickly covered over with automatically applied shop primer that the defects do not become apparent until after several months in service when early breakdown takes place.

Reference to Table 3 shows that the Americans assume in their standard that white metal finish (First Quality or Sa3) can be obtained by a number of listed blast cleaning methods. This is not so and, particularly, in relation to the type of abrasive used. For example, most manufacturers of automatic blast cleaning plant of the centrifugal type still recommend the use of steel ball shot on the premise that this cuts down the wear on the working parts. It is time this self-defeating policy was stopped by suitable amendment to the cleaning specifications. The use of steel shot is more appropriate to peening than cleaning. Shot is likely to hammer in small particles of mill scale rather than remove them (this can be detected by the copper sulphate test)<sup>16</sup>. Steel shot is certainly not so effective in removing rust and rust producing products as fine sharp grit, which is also capable of faster cleaning rates. It is time that this knowledge should be incorporated into the cleaning specifications especially for a First Quality standard.

Although the American and British specifications mention the removal of dust and grit (after cleaning) from the cleaned surface before painting, this very necessary part of the cleaning procedure is not sufficiently well emphasised. In fact sweeping with brushes is no use as this just transfers fine dust from one part to another part of the blast cleaned surface. Vacuum hoses without tools with brush edges are almost equally as bad. Also staging traps grit and dust and must be turned over and cleaned as a first step in after cleaning.

These remarks of course apply mainly to site blasting and most automatic blast cleaning plants have a fairly good built-in vacuum surface cleaning; however, frequent inspection is necessary to ensure that it is functioning correctly.

A light reflectance meter (the Surclean)<sup>17,18</sup>, which was originally developed as a tool to judge the initial cleanness of the surface after blast cleaning, is also extremely useful when used to check that all dust on the surface has been removed before commencing painting or metal spraying. It should be mentioned here that the use of the Surclean is valid for checking the cleanness of blast cleaned steel which has been contaminated with mill scale only (*i.e.* steel at the mill), but when blast cleaning rusty steel it should be used in conjunction with a potassium ferricyanide test.

Another parameter which requires closer specification in cleaning standards is profile and the role of the abrasive in the blast cleaning operation. The Americans specify typical maximum profile heights obtained with a wide range of abrasives in common use. The British standard specifies the coarsest grades that can be recommended and implies that finer grades, if available, are preferred. The maximum profile amplitude obtained with the coarsest grades are given. In the author's opinion this approach is wrong and as explained in previous papers<sup>17,18</sup>, the assessment of the average profile

is a more realistic way of correlating additional paint requirement due to surface roughness.

There will of course always be rogue peaks, and a useful statement in the British Standard needs to be given more prominence—"Following the removal of abrasive material the surface should preferably be rubbed over briefly with a nylon scraper or scourer to reduce the number of rough peaks". Previously it has been said that the use of steel shot is more appropriate to peening than cleaning and in fact the wide use of the term shot blasting is most unfortunate and is to be deprecated. The hardness of the abrasive is a rather neglected parameter. It must, of course, be harder than the surface being cleaned, but if very hard abrasive (*e.g.* copper slag which is black in colour) is used at a high impact velocity on a soft steel surface, very considerable abrasive embedment can be seen immediately which, of course, must be avoided. Not only is angular abrasive best for cleaning, but within reason the smaller the abrasive size the faster the cleaning rate and the finer the profile produced. The idea of large anchor pattern profiles has now been discredited; they do not improve the true adhesive values of applied coatings and may cause entrapped air bubbles as well as many rogue peaks. It is the surface cleanliness and not the roughness which enhances adhesion values of both paint and metallic coatings. The limiting factor in producing fine profiles is the effectiveness of grit recycling equipment for removal of dust as opposed to fine grit, and equipment manufacturers should be encouraged to make improvements in this direction. The cheaper and better metallic abrasive is chilled iron grit but this is often criticised on the ground that it breaks down too quickly to a fine grit; the answer is really better recycling equipment. Steel grit quickly becomes rounded and then behaves rather similar to steel shot.

The Japanese standards quoted are notable in that they introduce the concept of primary and secondary standards. There is no doubt of the requirement in the shipbuilding industry for secondary standards for the cleaning of shop primed steel that has been allowed to rust or been damaged by welding, burning, etc. The introduction of pictorial secondary standards related to their current practices gives them great credit. However, as explained in a previous paper<sup>19</sup>, it is not sufficient to wire brush or disc-sand shop primed surfaces which have been allowed to rust or been damaged by heat. Such cleaning techniques are only useful to prepare sound shop primed surfaces or those that have only received mechanical damage, otherwise it is necessary to blast clean the damaged areas before overpainting.

It should also be noted that the Japanese secondary standards (1969) are related to shop primed surfaces which have been exposed for 2.5 months and only 1.5 months in their 1975 standards. This presumably recognises in a practical way their increase in ship production rates in that period.

The primary Japanese standards incorporate most of the information already in American and Swedish standards and are therefore subject to the same criticisms. One notable point is that the Japanese recognise a difference between "shot blasting" and "sand blasting" and only two types of steel for cleaning "steel covering with mill scale" and "steel exposed to weather for 1.5 months". Incidentally the pictorial standard for this latter is entirely covered with rust.

#### Proposals for the future

If it is accepted that a case has been made for a reappraisal of steel cleaning standards it is necessary to highlight the

more important areas where revision should be urgently considered. In the author's opinion the following points should be more clearly stated in all steel cleaning standards:

- (1) If first quality finish (SA3 or white metal) is required this is best and most cheaply achieved by blast cleaning at the steel mill and as soon as possible after manufacture of plates or sections.
- (2) Rusty steel is much more difficult to clean and when very rusty a first quality finish may be impossible to achieve economically.
- (3) A potassium ferricyanide test must always be one criterion of acceptance when cleaning rusty steel especially where first quality finish is required.
- (4) Instrumental evaluation of both cleanliness and roughness must be specified as additional to visual examination.
- (5) The acceptance criteria for a particular standard of finish should be based where possible on three parameters:
  - (a) A pictorial standard
  - (b) A detailed description statement
  - (c) Physical and chemical tests as appropriate.
- (6) All cleaning standards should give more emphasis to cleaning procedures following blast cleaning and prior to overcoating. In this context the so called "4 hour rule" should be abolished.
- (7) Blast cleaning methods acceptable should be clearly defined and these should include reference to wet blast cleaning (with and without entrained grit) as well as dry blast cleaning methods. The blast cleaning requirements for both metal spraying and paint coating should be clearly defined in this context.
- (8) More precise statements should be made with reference to acceptable abrasive materials in relation to speed of cleaning, size of profile (average profile) and health hazards. In particular the preference should be for clean small profiles. The utility of using steel shot should be emphasised.
- (9) Because of the great increase in unit fabrication in much of the steel construction industry, notably bridge building and shipbuilding, consideration should be given to adopting the Japanese idea of secondary cleaning standards.

#### Conclusions

- (1) A case has been made for the revision of steel cleaning standards.
- (2) In view of the international need for a reappraisal and since standards of a similar character exist in various countries, notably Sweden, America, Japan and the UK, it would now be best to progress further revision through an International Committee of the International Standards Organisation (ISO).

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9. Reinigen Door Stralen. Onderzoekingen en Richtlijnen 1973. Nederlands Corrosie Centrum No. 201.
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11. Australian Standard 1627. Part 4—1974—Abrasive Blast Cleaning of Steel Surfaces.
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14. Dasgupta, D., and Ross, T. K., British Corrosion J. 1971. Vol 6, pp 237-241.
15. McKelvie, A. N., 6th International Congress on Metallic Corrosion, Sydney, Dec. 1975. "The planning and control of Corrosion Protection in Shipbuilding".
16. Wilson, R. W., and Zonsveld, G. G., NE Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne 1962—"The surface preparation and protection of ships' plate".
17. McKelvie, A. N., *CIRIA Report* 38. 1972.
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19. Jemitus, J. O., and McKelvie, A. N., *JOCCA*, this issue.

## Appendix

When rusty steel is being blast cleaned it is advisable to check whether or not ferrous salts remain in the pits. Moisten a small section of "cleaned" steel with a few small drops of water at a point where previously rust pitting was suspected. Allow the water to evaporate almost completely, just leaving the surface slightly moist and apply a small piece of potassium ferricyanide test paper pressed down with the thumb. Blue spots on the reverse side of the test paper, caused by the formation of prussian blue, indicates further cleaning is required. Test papers can be made by soaking filter paper in a 3-5 per cent potassium ferricyanide solution and then drying them in air. They are best kept in light proof sealed containers.

## Discussion of paper by Jemitus and McKelvie and paper by McKelvie

Mr J. Bravey commented that the authors recommended low pigment volume concentrations in the formulation of blast primers, but this could introduce intercoat adhesion problems with aged overcoating. He asked the authors to comment on this and to suggest the sort of level of PVC they had in mind.

Mr McKelvie replied that a great many primers were excessively pigmented, generally to meet drying time requirements, and although he would not like to suggest an exact level of PVC, he thought that some test could be devised to differentiate between good and bad formulations.

Mr A. E. Watson asked the authors to explain the reason for suggesting PVC in relation to film characteristics. He also queried whether the location and control of the spray heads did not play an equally important role in performance and asked how good was the supervision of the automatic blast and spray units.

Mr McKelvie answered that dry spraying was possible with high PVC primers, leading to quicker weathering of the applied film. He thought that the control of automatic spraying in shipyards was sometimes lax and in this respect manual spraying was better. Blockages and air pressure fluctuations gave rise to problems with automatic spraying, often not quickly corrected, on the underside with horizontally positioned spray guns. Mr Jemitus added that automatic spraying was, generally, controlled by the painter and this was not considered good enough.

Mr Eikers congratulated both authors on their presentations, but thought that some of the points raised could place companies in an unfavourable financial position. He agreed that standards were in need of reappraisal, but noted that in 1968 Zonsveld and Wilson had blast cleaned an eight year old tanker coated with a conventional paint system using special grit and had obtained a surface finish of SA3.

Mr McKelvie replied that more care was needed on the cleaning of rusty steel and thought that a better approach to water and abrasive cleaning was required. He further commented that although many companies were producing high pressure water equipment and dry blasting equipment, few combined abrasive and water and only one company appeared to have solved the problem of cleaning rusted steel with water and abrasive. Unfortunately, the abrasive mixture recommended by Wilson and Zonsveld was not often used and as far as was known it was never used in centrifugal plants for cleaning plates and sections, where very often there was a mixture of rusted and millscaled steel.

Mr F. Wright said that his company were pioneers in the use of blast cleaning and blast primer application. In his opinion too much emphasis was placed on the cleanliness of the steel and not enough on the standards of paint application. He stated that a vertical machine was used and that blast cleaning standards were considered good as adjudged by the copper sulphate test.

Mr McKelvie in reply said that both aspects were equally important and that the copper sulphate test only indicated the presence of residual millscale. He had rarely seen millscale unaccompanied by rusting in shipyards.

Mr Jemitus said that the areas near the edges of plates could create problems, especially when plates were not cleaned to the same degree. Before the work of the study team, he had considered his company's blast cleaning to be of a high standard, but this had been proved not to be the case.

Mr P. Hobbs queried the type of abrasive used in the work carried out, and whether the authors had compared the use of 'Eductomatic' and 'Vacublast' cleaning units.

Mr Jemitus replied that ball shot had been used in centrifugal machines for plates and sections and grit was used in the 'Centriblast' machine. Mr McKelvie thought that the 'Vacublast' machine was best for cleaning welds and damaged primer providing fine grit was used. The 'Eductomatic' was not considered suitable for corners or areas in confined spaces, since the head was difficult to manoeuvre and more awkward to support.

Mr E. Walker thought the technique described could result in costly procedures leading to management objections and asked for some indication of the cost of surface cleaning using the methods described.



Mr Jemitus replied that adequate cleaning did cost money, but that this was dependent on the standard required. Blast cleaning was quicker and cheaper for thorough cleaning than any other method. He also pointed out that rapid breakdown of paint systems occurred over areas which were not properly cleaned.

Mr J. Bravey said that the authors had stated that the use of ball shot was futile, as it tended to drive millscale into the steel surface rather than removing it. He queried if this was not overstating the case, as the logic was that surface preparation grades SA2 and SA2.5, which allow the presence of millscale, should be abandoned.

Mr McKelvie replied that there was a need to be more precise about blast cleaning standards. Ball shot gave a smoother profile, but he had a number of objections to its use and considered that millscale left on the surface after ball blasting could give rise to problems later when cathodic protection was used. Also, in practice, millscale was always accompanied by rusting unless the cleaning was done at the steel mill, and grit was much more effective in removing rust producing products.

Mr Eikers confirmed that the presence of millscale on the steel surface could lead to more rapid breakdown of paint systems where cathodic protection was used even when in the form of zinc anodes. He thought it worthwhile to emphasise the necessity for the complete removal of millscale from steel to be submerged, particularly when cathodic protection was being used. As the millscale was more noble than the steel by some 100 millivolts, the potential gradient applied across the paint coating was increased above the regular cathodic protection potential gradient causing the paint and the scale to be "blown off". As long as the cathodic protection remained operational, no rusting occurred on the exposed steel, but paint which had flaked off caused annoyance to the owner who in turn complained to the paint supplier.

Mr K. Baxter asked why engineers and designers were not yet convinced that the use of ideas put forward was good practice. Mr Jemitus replied that the battle was being won, but very slowly.

Mr J. Bravey said that both authors had presented a sound set of rules which should result in better paint performance, but one noticeable omission was that building planners should have all the welding and burning work completed before application of the paint.

Mr Jemitus stated that this point was dealt with under 'Fabrication of units' but he agreed that this was a major problem; unfortunately some organisations made a practice of changing design after application of the protective system.

Mr McKelvie thought that this emphasised the need for coatings specialists to be involved at the design stage, as normally designers were not aware of the problems which

they created. There appeared to be more of this type of planning on the Continent than in the UK.

Mr J. M. Sykes asked if the problems of chloride and sulfate contamination could not be better overcome by incorporating neutralising pigments into the primer as suggested by U. R. Evans many years ago.

Mr McKelvie agreed that there was scope for work in this area and that perhaps it would be possible in the future to paint without blast cleaning to high standards, using a much simpler and less costly process.

Mr J. Jackson (Shell) in a written contribution said he was surprised about the difficulty in cleaning corroded steel, in view of the published work of Singleton and Zonsveld. As a customer he never had any success in influencing the choice of abrasive in centrifugal machines. He judged by results and felt that the efficient working of the machine was a most important factor. Deficiencies in primer application were highly significant and undoubtedly better standards were achieved when blast cleaning and priming operations were carried out at the steel mills. He also felt that the Japanese Standard was highly practical for a new steel and, therefore, suitable for new construction. There was, however, a need for a more concise standard for cleaning corroded steel.

Referring to Mr Jemitus's paper he would prefer the blast cleaning and priming to be done at the steel mill, where conditions were better. Shell specifications called for the blast cleaning of all appendages but some shipyards considered this an unwarranted embellishment and although many shipyards planned the fitting of appendages before painting, it was regrettable that there always seemed to be a great deal of final fitting to be done. For the cleaning of rusted welds and burn back damage some shipyards now agreed to open blast, but 'Vacublast' was unpopular. Touch up with shop primer had given so many problems that Shell no longer accepted this procedure. He was surprised to see the concept of cell-painting dismissed so lightly, although this again had its problems.

In reply, Mr McKelvie said that unfortunately the finding of Singleton and Zonsfeld were not always applied. He agreed that machine operation and primer application were also significant factors. However, he felt that the Japanese Standard was applicable only where no rusting of the steel had taken place between the steel mill and the final fabrication shop. This may apply for the very quick turn round in Japan, but was certainly not universally true.

Mr Jemitus said that the only objection to priming at the steel mill was handling damage during transit. If Shell wanted to ensure the blast cleaning of appendages, they should specify the type of cleaning machine. He accepted that touch up with shop primer was practical only if first of all the correct procedures were carried out. If cell-painting included complete reblasting, he considered that the capital cost was not justified.

## Next month's issue

The Honorary Editor has accepted the following papers for publication, and they are expected to appear in the July 1977 issue of the *Journal*:

*Vinyl chloride retention in coatings formed from solutions* by C. M. Hansen

*Measurement and use of surface tension data in film-forming polymers* by F. Ewane-Ebele and H. P. Schreiber

*The microanalysis of copper oxide based marine antifouling paints in the scanning electron microscope* by R. J. Bird

*Non-conventional anticorrosive primers for steel* by D. E. A. Williams-Wynn

# West Riding

### Influence of titanium dioxide on the specular gloss of emulsion paints

A meeting of the Section was held on Tuesday, 8 March 1977 at the Griffin Hotel, Leeds. Dr L. A. Simpson of BTP Tioxide Ltd gave a talk on the above subject.

Dr Simpson first discussed the factors affecting gloss and its measurement, then the influence of factors such as the refractive index of both pigment and medium and the surface roughness of the paint film. Surface defects fall into two categories, macro and micro. Macro defects do not affect the inherent gloss of the system. Micro defects can cause an interference effect which will lead to a fall off in gloss level.

If titanium dioxide pigment is on the surface of a paint film it will obviously affect the gloss. Therefore, it is required to be submerged in the paint film. Pigment loading is one critical factor since opacity and gloss have opposing requirements. As pigment volume concentration (PVC) increases, surface roughness increases and the gloss falls away. Hence an optimum is required, and about 15–20 per cent PVC is normally employed in glossy emulsions. Efficient dispersion of the pigment is also critical and choice of pigment grade is vital for the optimisation of this property.

As the paint film dries it is important to maintain stability between the pigment and emulsion. The lecturer believes that the greatest instability occurs during the drying process, and flocculation either of the titanium dioxide or the emulsion particle can occur.

In an experiment, the change in gloss of two paints was compared. On drying, the gloss of both increased (as the refractive index increased) and reached a plateau. After a further period of time one paint showed an increase and the other a decrease in gloss. Dr Simpson postulated that in the one showing an increase the paint film was still coalescing, whilst in the other flocculation occurred during drying.

Another experiment compared opacity, flocculation gradient and mean particle size in the millbase of four different paints. It was shown that millbase particle size has no direct bearing on gloss, but that there is a relationship between the degree to which flocculation has occurred and gloss.

A lively discussion ensued with contributions from several of Dr Simpson's colleagues. Mr R. Smith proposed a vote of thanks.

R. A. C. C.

# Hull

### The optimum use of organic pigments

The fourth ordinary meeting of the current sessions was held at the "George Hotel", Land of Green Ginger, Hull on Monday 10 January 1977. Mr R. Brooks, the Section Vice-Chairman, introduced Mr D. M. Varley of Ciba-Geigy Ltd who gave a lecture entitled "The optimum use of organic pigments".

Mr Varley discussed the relationship between the size of the dispersed pigment particles and their performance in a paint or printing ink. According to theory, and confirmed in practice, the strength of a dispersed pigment is dependent on

the particle size obtained, and this increases dramatically in the 0.2–0.3 $\mu$ m range. The increase attainable varies from pigment to pigment and in addition may have other effects on, for instance, flow properties, dispersion stability and opacity. A dispersion with the particle size in the range 0.3–0.4 $\mu$ m probably gives the optimum overall results, but this may vary. As an example, a reduction in particle size of 0.5 $\mu$ m to 0.2 $\mu$ m produced by additional ball-milling of phthalocyanine blue can result in 80 per cent strength improvement.

The main problem lies in assessing the level of dispersion obtained by convenient practical methods. An optimum performance must first be determined to establish the milling conditions, charge factors, loading rates and resin concentration to give the best colouristic results combined with the most economic conditions. The *Daniel Flow Point Technique* does not necessarily give this and must be modified to consider tinctorial performance as well. All possible variables must be considered. In an example related to sandmilling, a variation of 300 per cent could be obtained between the best and worst dispersion.

Mr Varley concluded by showing a number of colour patterns and films to illustrate many of the points mentioned in his lecture. The meeting, which was attended by 11 members, was closed after some interesting questions with a vote of thanks from Mr J. Wenham.

### The alternative technologies for industrial finishes

The fifth ordinary meeting of the Hull Section was held at the "George Hotel", Land of Green Ginger, Hull on Monday 7 February 1977. Twenty-three members and visitors assembled to hear Mr J. Rackham of BTP Tioxide Ltd give a lecture entitled "The alternative technologies for industrial finishes".

Mr Rackham began by reviewing the current legislation pertaining to clean air, clean water and toxic raw materials in the UK, EEC, Japan, USA and Scandinavia. The actual or potential legislative pressures as well as the rising cost of organic solvents increased the need to eliminate these solvents from coatings. Four alternative technologies, water-borne, powder, radiation cure and high-solids, were making progress and Mr Rackham discussed each in turn.

The properties of the three types of water borne resins and paints based on these resins were compared and contrasted. Particular emphasis was placed on the effect of pigmentation on the storage stability of aqueous paints with respect to gloss. The advantages and disadvantages of water-borne coatings were also considered. The manufacture and application of powder coatings was described. The influence of titanium dioxide type on dry blend properties, extrusion rate and cure rate was fully discussed together with the effect of particle size distribution and film thickness on gloss.

In the discussion on radiation curing, Mr Rackham compared the absorption spectra of anatase and rutile; the effect of crystal grade using three different photoinitiators and three different monofunctional monomers on the cure response was illustrated. The speaker reported that in West Germany the keenest interest was being centred on high-solids systems. The influence of molecular weight on the viscosity/non-volatile content relationship of resins and oligomers was exemplified. It was intimated that in high-solids systems, the pigmentation could have an adverse effect on the hardness of the stoved film.

Mr Rackham concluded his lecture by predicting that coatings based on all these new technologies would progress at the expense of coatings based on conventional solvents but hinted that the future of each would probably lie in the hands of the politicians. The lecture was well received by the audience and the speaker was subjected to a large number of varied questions, all of which were confidently answered. The meeting closed with a vote of thanks from Mr F. D. Robinson, who humorously praised the lecturer on his first class presentation.

#### Pottery — design and decoration

The eighth meeting of the 1976/77 session was held at the "Havan Inn", Barrow Havan, Lincolnshire on Monday 2 May 1977. This was the first ladies evening organised for the "South Bank" venue. Mr T. W. Wilkinson, the Section Chairman, introduced Mr A. Simkin of Blythe Colours, who gave a talk entitled "Pottery — design and decoration".

The speaker discussed the special requirements of the pottery manufacturer with regard to colour, and described the manufacture of onglaze and underglaze pottery with particular emphasis on the strict control on the use of lead and cadmium compounds. In a number of colour slides, Mr Simkin illustrated the up-to-date Murray Print Process and the automated Screen Print Process for the decoration of tableware. The problems associated with design for mass production were outlined and it was emphasised how the designer must be very familiar with pottery manufacturing techniques.

The lecture was very interesting and informative. The meeting, which was attended by 19 members and guests, was brought to a close with a vote of thanks from Mr A. Pipes, who praised the speaker for his authoritative presentation.

D. M. W.

## Notes and News

### London Section

#### Annual General Meeting

The 39th Annual General Meeting was held at the Great Eastern Hotel, Liverpool Street, London EC2 on 14 April and was attended by 40 Members and their ladies. The retiring Chairman Mr J. T. Tooke-Kirby was in the chair.

The 1977-78 Committee was elected and will consist of the following.

Chairman:	Mr D. A. Bayliss
Immediate Past Chairman:	Mr J. T. Tooke-Kirby
Hon Secretary:	Mr B. F. Gilliam
Hon Treasurer:	Mr D. Bannington
Hon Publications Officer:	Mr A. J. Newbould
Hon Programmes Officer:	Mr H. A. Hipwood
Hon Social Secretary:	Mr H. C. Worsdall
Hon Auditor:	Mr H. A. Soane
Committee:	Mr E. Pachebat Mr K. Bargrove Mr K. J. Wiseman Mr H. H. Lavell Mr D. H. Tooke-Kirby Mr D. Eddows

With the election of Mr D. Tooke-Kirby to the Committee, father and son will be serving on an OCCA Section Committee and it is thought that this may be the first time this has happened.

The Chairman gave a detailed report to the members on the 1976/77 activities of the Section, which was received with much interest, and the Hon Treasurer presented the Section accounts, which were approved. Amendments to the Section rules were also approved, establishing the offices of Immediate Past Chairman and Hon. Social Secretary.

Tributes were paid to the dedication put into the Chairman's job by Mr Tooke-Kirby during the past two years and Mr Bayliss, the incoming Chairman, presented him with a miniature Silver Wine Cooler on behalf of the Committee and warmly thanked him on behalf of the Section. Mr

Wiseman the retiring Hon Secretary was also presented with a Silver "After 8" Holder in appreciation of his services to the Section.

The retiring members of the Committee, Dr R. C. Denney, Mr B. H. Ducker and Mr H. A. Newnham were also thanked for their sterling efforts on behalf of the Section.

At the conclusion of the AGM a presentation of the 1977 Kekwick Prize was made by Mr J. Tooke-Kirby to Mr P. Harrison, a Chemist in the Vehicle Refinishing Laboratory of Berger Paints, who had received a strong recommendation from the East Ham College of Technology in connection with a course of study in Applied Chemistry (Surface Coating) supplementary to the HNC certificate which he completed with distinction. Mr Harrison is now an Ordinary Member attached to the London Section. J.T.T.K.

### Manchester Section

#### Annual General Meeting

The 53rd Annual General Meeting of the Section was held at the New Albion Restaurant, Manchester, on Friday 15 April 1977. Eighty three Members were in attendance and Mr J. Mitchell was in the Chair. The main business of the evening was the election of new Officers, after which dinner was served in the best Lancashire traditions.

The occasion was also used to hold the Manchester Section's Quiz with Mr F. Smith as the quizmaster. Of the two teams, it was the more mature and cleanshaven who beat the young bearded men by a short whisker. F.B.W.

### Ontario Section

#### Annual General Meeting

The second Annual General Meeting of the Ontario Section was held at the Skyline Hotel, Toronto on 20 April 1977. Mr P. Birrell was in the Chair and 33 Members were present.

At the conclusion of the dinner Mr

Birrell called the meeting to order and the business of the evening began. The minutes of the 1976 AGM and the Annual report were adopted, and the death of Mr E. McDougal, a Section Officer, was recorded with regret.

Mr W. Fibiger then took over the Chair and received the chain of office from the retiring Chairman, Mr Birrell. The rest of the Section Officers were elected without opposition.

Mr Worsdall, visiting with his son, Martin, a Registered Student, from the London Section, then presented an OCCA pin to Mr Birrell and the meeting was called to a close.

### Midland Section

#### Trent Valley Branch

##### Annual General Meeting

The AGM of the Trent Valley Branch of the Midland Section was held at the Cross Keys, Turnditch, Derby, on the 1 April. Following the essential business, an excellent social evening, with wives, friends and the usual contingent from the parent Section present, was held in the Trent Valley tradition.

Branch history was made this year with the retirement, from the position of secretary, of Mr J. Tomlinson, after six years in office. The gratitude of the members was expressed by the Chairman, Mr S. Hawley, when he presented Mr Tomlinson with a tankard in recognition of his services to the Branch.

Mr Tomlinson has been elected to the position of Vice-Chairman of the Branch by the unanimous decision of the committee. The Branch Hon. Secretary, with the aid of a little coercion, is now Mr S. Watson, who will undoubtedly make his mark in due course. At present he is a little daunted by the "now follow that" history of his predecessor in office.

A further change within the committee, is the retirement from the position of Publication Secretary of Mr J. Kitchen, who now becomes a member of committee. Mr J. Fowles-Smith, a retiring committee member, is now Publication Secretary. J.E.F.S.



# OCCA-30 Exhibition

Alexandra Palace, London. 18-21 April 1978

## The continuous dialogue in the surface coating industries

### Arrangements for OCCA-30

The Exhibition Committee announces that the thirtieth annual exhibition of raw materials, plant and equipment for the paint, printing ink, colour and allied industries organised by the Association will be held at Alexandra Palace, London N22 from 18-21 April 1978.

Whilst the Committee naturally encourages the showing of new products, it does not stipulate that a new product has to be shown each year, since it fully appreciates that there are occasions when this is not possible. Accordingly, the Committee draws attention to the fact that new technical data on existing products are regarded as acceptable subject matter.

### Motif for the Exhibition

The motif, designed by Robert Hamblin, uses the symbol of a moving indicator on a calendar to emphasise the importance of the continuous dialogue year by year between suppliers and manufacturers. The inward pointing letters recall the international aspect of this unique annual focal point for the surface coatings industries which in 1977 attracted visitors from 50 countries. The colours of the motif shown on the advertisement on the back outside cover of this issue will be carried throughout the publicity leading up to the Exhibition. The two main colours of the motif, royal blue and yellow, will be incorporated on the facias of the stands and it is intended to organise complementary flower displays in the Exhibition Hall. The use of these colours will create a pleasing contrast as visitors move from corridor to corridor at the Exhibition, as the royal blue colour will be used from east to west and the yellow colour from north to south.

### Invitation to Exhibit

Copies of the Invitation to Exhibit have been despatched to companies and organisations in the UK and overseas which have shown at previous OCCA Exhibitions or

### The cost effective Exhibition

have requested information for the first time for the 1978 Exhibition. Completed application forms for stand space must be returned to the Director and Secretary of the Association not later than 1 October 1977. The interest shown in the OCCA-30 Exhibition as a direct result of the highly successful OCCA-29 Exhibition held in March this year has been considerable, and already companies have asked for larger

stands than they have had in previous years.

The Exhibition Committee was particularly pleased to see the large number of overseas companies showing at OCCA-29, both directly and through their British associates, and this emphasises the international character of the function.

### The crowd puller

Visitors at OCCA-29 are known to have come from at least 50 countries and admissions of over 10,000 were recorded at the entrance. Any organisation wishing to exhibit at OCCA-30 should write immediately for details to the Director and secretary of the Association to receive a copy of the Invitation to Exhibit.

### Facilities at Alexandra Palace

The Association has full use of the facilities at Alexandra Palace during the period of the Exhibition which include restaurants, two bars, a cafeteria and an exhibitors' bar. Another facility which is of considerable benefit to those travelling to the Exhibition by car is the ample free car parking space within the Palace grounds and the major routes to Alexandra Palace can be seen on the map opposite.

For visitors travelling to the Exhibition on the underground system, the Association will once again be running a free bus shuttle service to and from the Exhibition from Turnpike Lane Station on the London Underground Piccadilly Line. It is hoped that by the time of the Exhibition the extension of the Piccadilly Line to Heathrow Airport will be completed so that visitors flying into the country will be able to travel direct from the Airport.

Exhibitors were allowed for the first time in 1977 to serve alcoholic refreshments on their stands and this innovation will be continued at OCCA-30. Many exhibitors expressed their appreciation of this as it allowed their personnel to remain on the stands with visitors for the whole period of the Exhibition.

### Information in foreign languages

As in previous years the Association will be circulating information leaflets in six languages which will contain application forms for those wishing to purchase copies of the Official Guide and season admission tickets before the Exhibition.

### Official Guide

This unique publication contains descriptions of all companies and their exhibits at the Exhibition and is issued to each Member of the Association at home and abroad together with season admission tickets. As in 1977, several Sections will be organising coach parties to visit the Exhibition and any Members interested should contact their local Section Hon. Secretary. (Full Section Committee lists for 1978 will be published in the August 1977 issue of the Journal.) It is also hoped that several parties will be organised from overseas to visit the Exhibition.

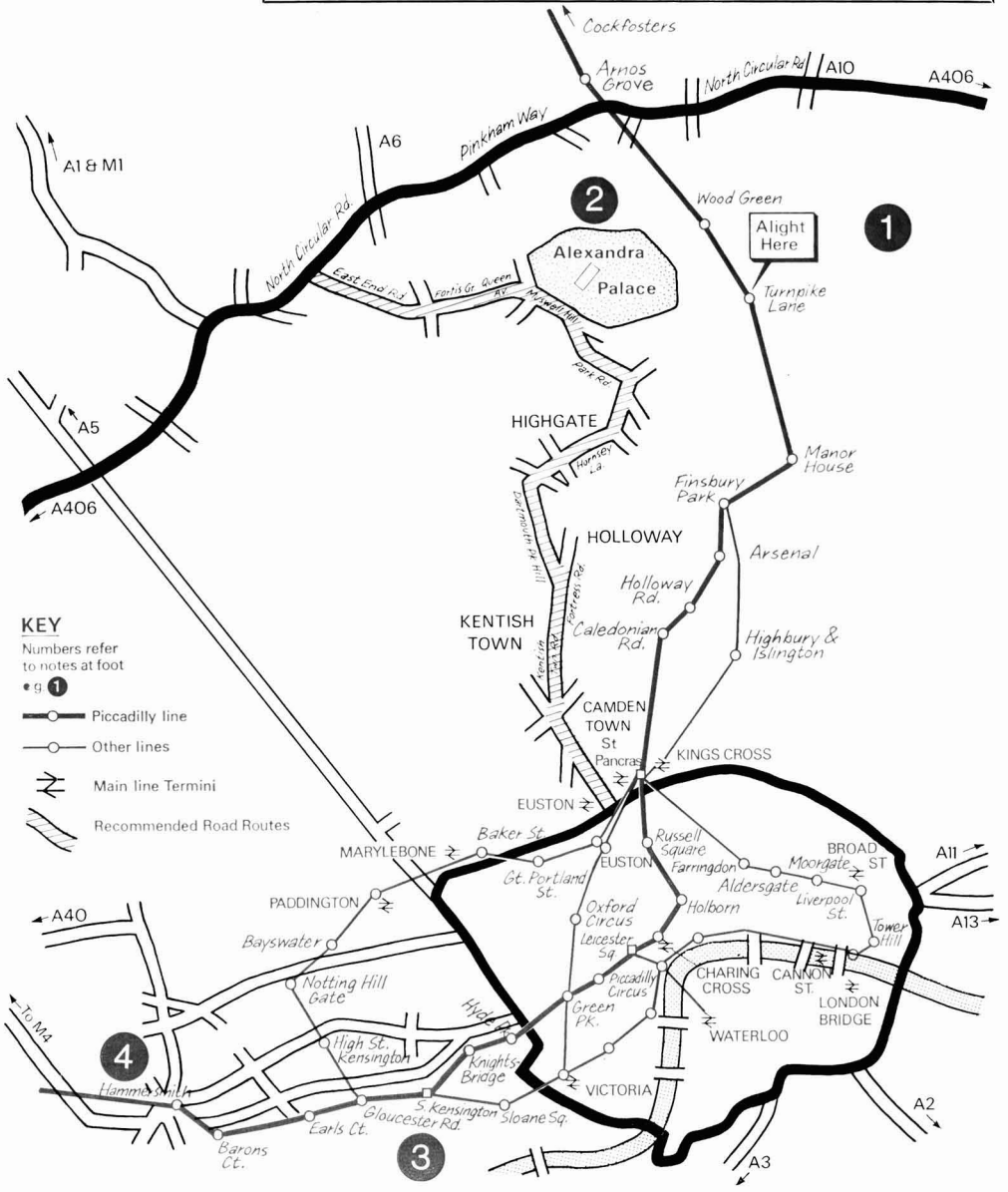


Visitors to OCCA-29 came from 50 countries

Advertising space is available in this important publication to both exhibitors and other organisations which are not able to show at the 1978 Exhibition. The Official Guide will be published early in 1978 so that visitors can obtain copies and plan the itinerary for their visits. Clearly, the Official Guide is a publication that will constantly be referred to both before and after the Exhibition and consequently any company wishing to advertise in the Guide should book space as soon as possible. Details of the advertising rates are available from Mr D. M. Sanders (Assistant Editor) at the address on the contents page. As in previous years the Official Guide and season admission tickets will be available several weeks in advance of the Exhibition (prepayment only) from the Association's offices but they will also be available for purchase at the entrance to the Exhibition Hall. A charge is made for both the Official Guide and the season admission tickets to the Exhibition. The policy was introduced several years ago to deter casual visitors who otherwise collected large quantities of technical literature from exhibitors stands; the policy has been welcomed by exhibitors and has in no way acted as a deterrent to bona fide visitors to the Exhibition.

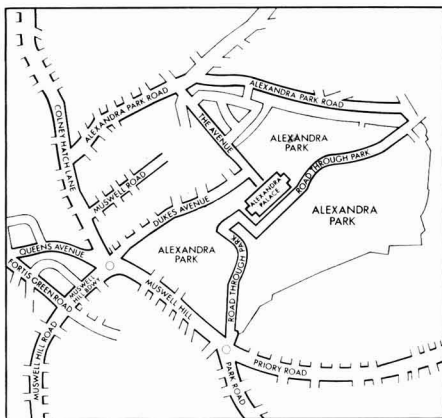
# OCCA-30

For the benefit of intending visitors to the Exhibition, a map is reproduced below of the area around Alexandra Palace showing the mainline stations in central London, the Piccadilly, Circle and Victoria Lines of the underground system and also the road links with the North Circular Road and motorways. See also the enlarged map of Alexandra Palace, reproduced on page 242.



1. A free bus shuttle service will operate between Alexandra Palace and Turnpike Lane station on the Piccadilly Line (Underground), which is denoted by the thick coloured line. Destinations of trains may be marked as "Cockfosters" or "Arnos Grove" or "Wood Green".
2. Those travelling by road will find free car parking facilities at Alexandra Palace. See map on page 242.
3. Visitors arriving at West London Air Terminal may board the Piccadilly Line trains at Gloucester Road station.
4. At present the Piccadilly Line reaches westward as far as Hutton Cross Station and in Autumn 1977 will be extended by the addition of a further station in Heathrow Airport Terminal, so that visitors will then be able to travel direct from the airport terminal to Turnpike Lane station. In the meantime, a bus service operates between the air terminal and Hounslow West station on the Piccadilly Line.
5. The map also shows the position of the mainline stations in relation to the Piccadilly Line.

## Alexandra Park and locality



There are adequate car parking facilities available at Alexandra Palace. Visitors travelling by road may consult the simplified diagram on page 241 showing the approach roads from central London and the Motorways, and the enlargement above, of the area around Alexandra Park. The entrance through Dukes Avenue is for *pedestrians only*.

*Continued from page 240*

## The international forum for the surface coatings industries

The Exhibition affords an ideal opportunity for an annual meeting of technical personnel at all levels in the supplying and manufacturing industries from all parts of the world to discuss their requirements and technical problems.

## News of Members

Mr A. Newnham, a former Chairman of the London Section, has retired after 48 years with the Berger group. Mr Newnham spent the last 15 years of his career as Managing Director of the Berger Group lead powder company, Spelthorne Metals.

Mr D. Sharp, an Ordinary Member attached to the Irish Section, has celebrated 25 years with Ciba-Geigy Ltd. Mr Sharp is a former Vice-President of the Association and has been Chairman and Hon. Publications Secretary for the Irish Section.

## Information Received

### Queen's Award

The increasing production and foreign sales successes of Rohm & Haas (UK) Ltd during the past two years are reflected in the announcement from Buckingham Palace of the Queen's Award to Industry for export achievement. Over 50 per cent of the production from the two plants in the North East now goes for Export. The Teesside plant concentrates on producing acrylic monomers and the Jarrow plant produces derivatives such as acrylic plastics, leather finishing chemicals, ion exchange resins, oil additives and emulsion paint and industrial coatings ingredients.

### Exports success

Stewart Wales, Somerville Ltd have been named runners-up in this year's Export Award for small manufacturers.

### French agency

The Directors of Roban Engineering Ltd have announced that, following a visit to the Benelux countries and to France by their Sales Manager, they have appointed Ets. Nauder as the exclusive distributor for their range of solvent pumps and flow-meters in Metropolitan France.

### BP Chemicals acquire BXL thermosetting division

BP Chemicals are expected by 1 September 1977 to become owners of the BXL Thermosetting Division, who produce phenolic resins. The company will operate under a new name which will be announced later.

### Coatings company investment

W. W. Hill Son & Wallace Ltd have boosted their production capacity of Swedish waterborne finishes by 25 per cent with a £60,000 investment programme in specialised plant including 5000 gallon storage tanks and new hydraulic mixers.

### UK subsidiary for Wacker

Wacker Chemie GmbH of Munich have announced the establishment of a subsidiary company, Wacker Chemicals Ltd, in London from 1 April 1977 to represent them in the UK. The address of the new company is Warwick House, 27/31 St. Mary's Road, London W5 5PR.

## New products

### New valve

The Reiss Engineering Co. Ltd have announced a new valve designated Type HD, especially suited to applications requiring control of thick or dry media up to a pressure of 100 bar at a maximum of 180°C for the chemical and petrochemical industries. The valve has a very compact design for space saving installation and full bore opening to allow efficient cleaning and minimum resistance to flow.

### New resin range

Synthetic Resins Ltd has announced a new range of resins especially formulated for printing ink manufacturers comprising 30 different resins. The range includes aliphatic and aromatic soluble hard resins covering the requirements from quick setting litho and letterpress inks such as those used in high-gloss gravure and flexographic processes.

### Mastermill improvements

Mastermix Engineering Co. Ltd have announced two recent significant developments to improve the efficiency of the Mastermill. A specially developed alloy is now being used for the rotor blades to increase their operating life and the internal surface of the milling chamber has been hard coated. The cooling system has also been considerably improved.

### Thermosetting powder coatings

The resistance of thermosetting powder coatings to mechanical and environmental damage makes them especially suitable for applications on such products as alloy road wheels. GKN Kent Alloys Ltd are at present producing large numbers of wheels by this method. Much of the powder used, including coloured and clear polyester types, is supplied by Drynamels Ltd, the coatings company of Tube Investments Ltd.

### Specialised paints

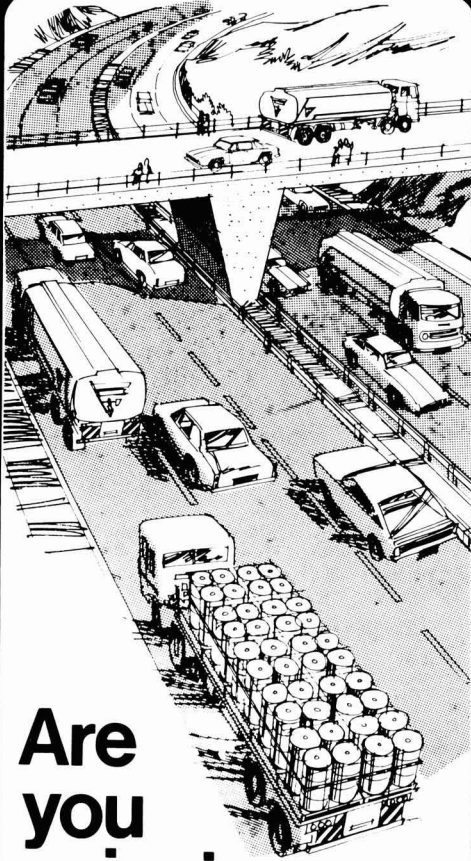
Berger Paints have introduced a retail "Berger Specialist" range of primers, sealers and "special use" products which are particularly relevant to the DIY market and have been selected from the professional range Berger introduced last year.

### New series of liquid chromatographs

A new range of modular liquid chromatographs is announced by Perkin Elmer, the series 2. Each chromatograph is compatible with all commonly available detectors, and features a unique pumping system with only three moving parts. The series can be built up from the basic 2/1 module to form the optimum system for the analytical problem. The new instruments complement Perkin-Elmer's model 601 research grade liquid chromatograph.

### New solvent recovery equipment

A new range of solvent recovery equipment is being introduced to Europe by the Weir Group. Marketed under the name of "Dyna", it will be manufactured and distributed by the French subsidiary Weiritam SA of Paris. The system is claimed to separate virtually 100 per cent of industrial solvents from contaminants, or solvent vapours from air streams at low operating costs. The systems are already being used in major paint and coatings



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companies in the USA as well as in other solvent-using industries including motor manufacturing, chemicals, ink manufacturing, etc.

**New motor**

Du Pont have developed a sealed electric motor capable of operating in temperatures exceeding 400°C which is suitable for mounting inside ventilation shafts or ducts to provide efficient smoke and fume evacuation in the event of fire in occupied buildings, as well as in hot gas filtration plants.

**Nozzle guard**

The blast-a-way self-cleaning airless nozzle of EXIT SA is now available with a new safety guard to prevent inadvertent placing of the thumb or finger over the orifice when reversing the tip for cleaning and the new guard may be added to blast-a-ways already in use to decrease the risk of expensive damage to the nozzle.

**Energy conservation**

Tests conducted by Ciba-Geigy on their epiphilic epoxy based coatings have shown that these resin systems can be applied in films 20 to 60 microns thick and cured in only 10-15 minutes at 80-90°C. This is

affording an appreciable saving in energy compared with conventional resin coating systems. The high reactivity of the Ciba-Geigy systems necessitates the use of two-component spraying equipment.

**Pressure emulsification**

Russell Kirby Ltd have installed a new pressure vessel for the emulsification of synthetic waxes including high melting point polyethylene. Emulsions with solids content of up to 35 per cent can be obtained and are used for the manufacture of printing ink, textiles and paper.

**Literature**

**Technical Dictionary**

The Quebec Paint Industries Association has published an English/French, French/English vocabulary containing 4000 words and expressions specific to the paint and coatings industry.

**Masonry paint information**

Blundell-Permoglaz Ltd have published a new information leaflet about Micatex, its masonry paint, to meet the increased use of these products on exterior surfaces.

**Lead emission**

The Lead Development Association has published guide lines for monitoring emissions from lead works in a new booklet "Lead and the environment".

**Revised British Standard**

Revision of the 1963 Editions of BS 135, BS 458 and BS 805 have been issued as one volume entitled BS 135, 458 and 805 benzene, xylenes and toluenes. The main revision is a reduction in the number of grades for each product.

**Powder coatings**

R. H. Chandler Ltd have published a book on Powder Coatings 1976 edited by Mrs J. I. Chandler giving a summary of the developments in powder coatings in the last year.

**Conferences, courses etc.**

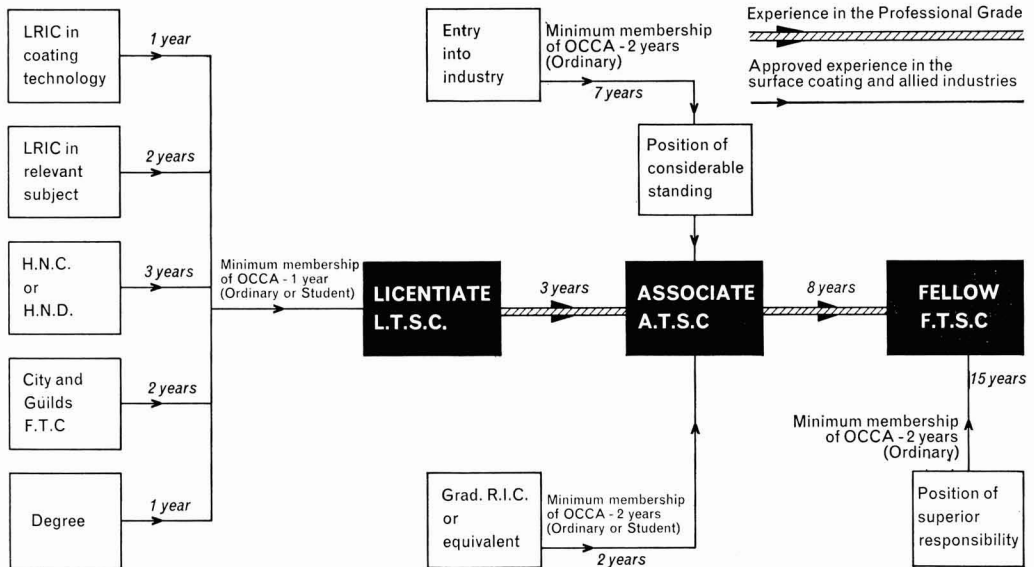
**Joseph J. Mattiello Memorial Lecture**

Dr W. K. Asbeck, a coatings consultant, will present the 1977 Joseph J. Mattiello Memorial Lecture at the Fifty-Fifth Annual Meeting of the Federation of Societies for Coatings Technology to be held October 26-28 in Houston, Texas.

# Optional Professional Grade for Ordinary Members

## Routes to the Professional Grades

The innovation of the Professional Grade has proved to be most successful, as evidenced by the impressive list of names in the December 1976 issue of the *Journal*. For the convenience of potential applicants, a chart indicating different routes to the various grades is shown below.



**Note:** At present there is no restriction on Students up to 21; between 21 and 25 a certificate from the employer or college confirming the course being taken is required.

For further details of the routes to the Professional Grades see pages 157/8 of the April issue of the *Journal*, or write to the Director & Secretary at the address on the contents page.

## Forthcoming Events

Details are given of Association meetings in the United Kingdom and Ireland up to the end of the month following publication and in other parts of the world up to the end of the second following publication.

### Association Biennial Conference and AGM

#### Grand Hotel, Eastbourne. 16-19 June 1977

The Association Biennial Conference is being held at the Grand Hotel, Eastbourne on 16-19 June 1977. Fourteen papers are being presented on the theme "The conservation of energy, materials and other resources in the surface coatings industry".

The Association Annual General Meeting will be held after the final technical session at the Grand Hotel at 4.00pm on Saturday 18 June.

### Manchester Section

#### OCCA Golf Competition

The annual competition for the OCCA Golf Trophy will be held at Stockport Golf Club, Offerton, Stockport on 7 September 1977. The competition is open to all OCCA Members, and their is a visitors prize for guests.

The occasion is also being used to hold the Manchester Section Golf Competition.

Further details may be obtained from Mr J. H. Sinclair, Anchor Chemical Co. Ltd, Clayton Lane, Clayton, Manchester M11 4SR.

### Newcastle Section

#### Second UV Symposium—September 1977

A second symposium entitled "UV polymerisation and the surface coatings industry", sponsored by the Newcastle Section of the Association, is to be held at the University of Durham on 14 and 15 September 1977. Delegates staying at the University will assemble on the evening of 13 September and disperse on the evening of 15 September. Papers are to be presented by industry covering the practical aspects of the rapidly developing technique of UV curing. Topics will include photoinitiated polymerisation, UV curing equipment, photoinitiators and photosensitive monomers. Further details may be obtained from Mr H. Fuller, Tioxide International Ltd, Carlton Weathering Station, Yarm Back Lane, Stockton on Tees, Cleveland TS21 1AX.

## Register of Members

The following elections to membership have been approved by Council. The Section to which each new member is attached is given in italics.

### Ordinary Members

ALLENDER, PETER JOHN, 9 Jeremy Grove, Solihull, West Midlands. (Midlands)  
 APOSTOLAKIS, CONSTANTIN, 1 Prousis Street, Athens 110, Greece. (General Overseas)  
 BAKER, JAMES TERENCE, 9 Mount Pleasant, Bishops Itchington, Warwicks (Midlands)  
 CRUICKSHANK, MURRAY LESLIE, BSc, Monsanto NZ Ltd, PO Box 347, Auckland, New Zealand (Auckland)  
 DEAN, RONALD MICHAEL, Leon Frenkel Ltd, Crabtree Manorway, Belvedere, Kent (London)  
 DICKS, ALLAN, Schenectady Chemicals, 309 Cornstock Road, Scarborough, Canada (Ontario)  
 DICKSON, DAVID MORROW, BSc, Rohm & Haas NZ Ltd, PO Box 22-220, Otahuhu, New Zealand (Auckland)  
 HARRISON, PETER JEFFREY, Berger Paints Ltd, Freshwater Road Dagenham, Essex (London)  
 INCE, GEOFFREY, Delfina, Lower Common Lane, Sussett, Nr. Huddersfield, West Yorkshire (West Riding)  
 INMAN, ERIC RICHARD, BSc, PhD, Burrell Colours Ltd, 262 West Ferry Road, London E14 9AQ (London)  
 ITEN, ARMIN JAKOB, 706 Grand Birches, 100 Entabeni Road, Paradise Valley, Pinetown 3600, South Africa (Natal)  
 JOPSON, ROY NIGEL, BSc, Surface Coatings Market Group, Laporte Industries, Stallingborough, Grimsby (Hull)  
 KERCHISS, THOMAS ROMAN, BSc, Pond Cottage, The Pudgeell, Great Chishill, Nr. Royston, Herts (London)  
 MCKIE, PETER, LRIC, 52 Castle Road Allington Park Maidstone, Kent (London)  
 MAKGILL, IAN JAMES, L. J. Fisher & Co, PO Box 2183, Auckland, New Zealand. (Auckland)  
 MONK, ROY STANLEY, 42 Park Avenue, Failsworth, Manchester 35. (Manchester)


PAGAN, DAVID ROY, BSc, Blue Circle Products, PO Box 1577, Benoni 1500, South Africa (Transvaal)  
 PROWSE, CHARLES WINSTON, PO Box 20152, Glen Eden, Auckland, New Zealand (Auckland)  
 ROBERTS, DOUGLAS, Flat 2, Bevere House, Bevere, Worcester (Bristol)  
 SHARP, BARRINGTON WILSON, BSc, 51 Knutsford Road, Wilmslow, Cheshire SK9 6JD (Manchester)  
 SPENCE, MALCOLM WILLIAM, PO Box 78, 125 Shepstone Road, New Germany, Natal, South Africa (Natal)  
 VERRALL, ROGER ANTHONY, 18 Stanley Road, Sudbury, Suffolk. (London)  
 WALLINGTON, DAVID, BSc, 12 Barn Croft, Hammerwich, Walsall, West Midlands (Midlands)  
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 YONG, SHIM HIAN, MSc, Revertex (Malaysia) Sdn. Bhd. PSP 508, Kluang, Johore, Malaysia (General Overseas)

### Associate Member

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 LOGAN, WAYNE FRANCIS, 36 Beckfield Road, Newall Green, Wythenshawe, Manchester 23 (Manchester)  
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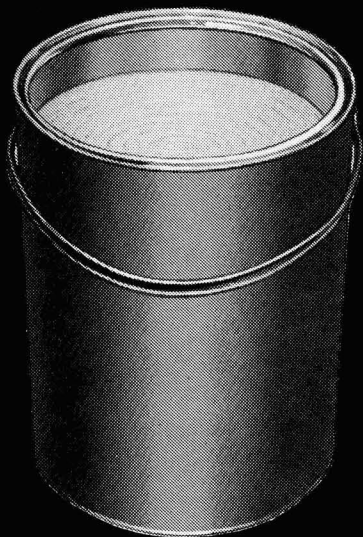
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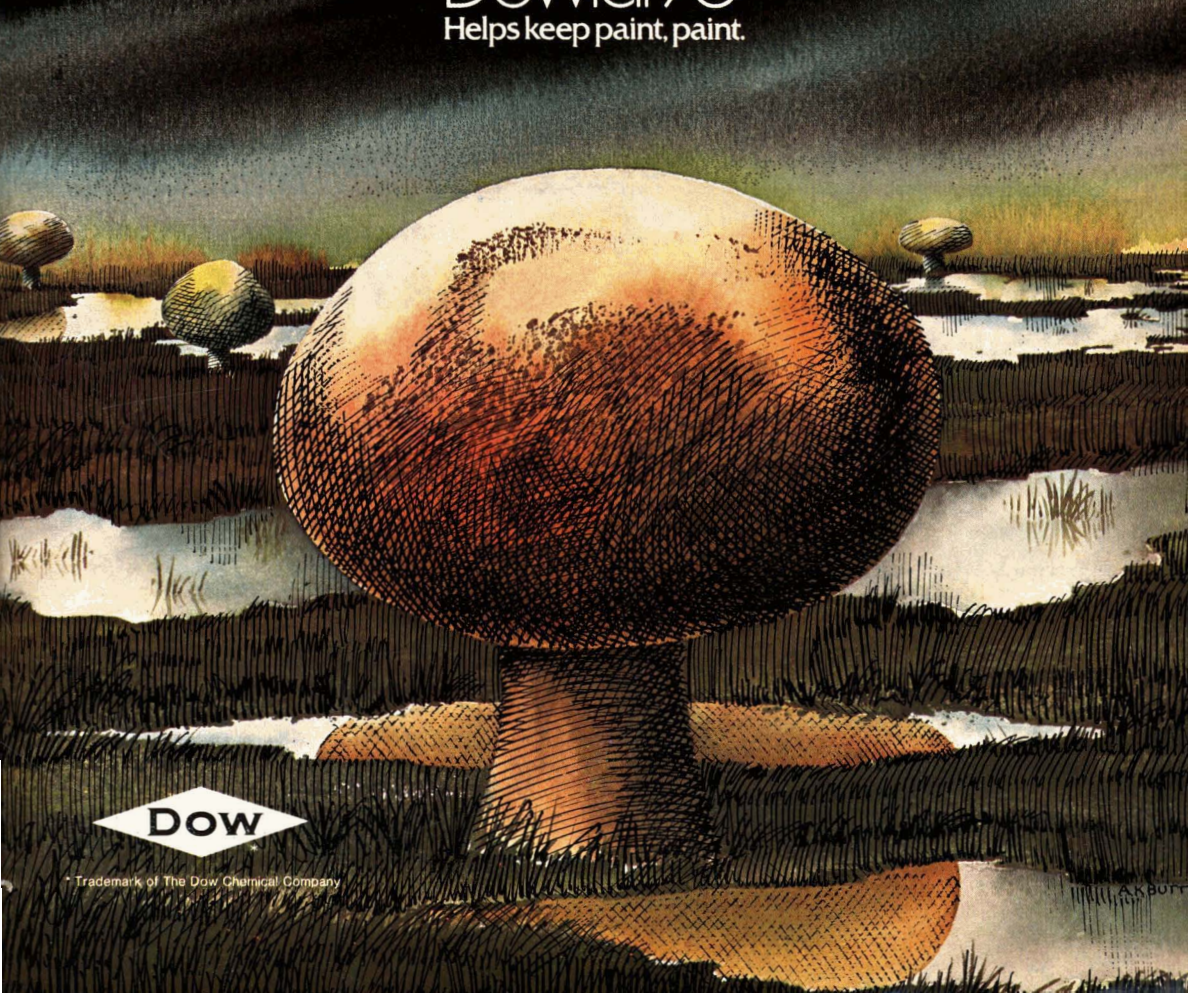
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