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**JOURNAL OF THE
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Chloride ion transport in epoxy polyamide films and the substrate effect

J. D. Murray

Environmental problems of the chemical industry

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Transactions and Communications

Chloride ion transport in epoxy polyamide films and the substrate effect*

By J. D. Murray

Materials Quality Assurance Directorate, Ministry of Defence, Royal Arsenal East, London SE18 6TD

Summary

In the field of corrosion prevention by surface coatings one outstanding problem that has remained unanswered concerns the effect of the substrate on a film's permeability properties. In other words, is it justifiable to measure these properties on free detached films?

The behaviour of free and attached films of epoxy polyamide lacquer have been observed under identical conditions by means of desorption and sorption techniques. The data has been inter-

preted in terms of the diffusion and partition coefficients for chloride ion in the polymer system.

The results have shown that it is unreasonable to employ free films to derive valid practical conclusions, since the permeability controlling coefficients are changed by removal from the substrate. The coefficients are also history-dependent and are not related to time in the same way in the two situations.

Keywords

Properties, characteristics and conditions primarily associated with dried or cured films
permeability

Binders, resins etc.
epoxy resins
polyamide resins

Le transport des ions chlore aux feuillets d'époxy-polyamide, et l'influence du support

Résumé

Dans le domaine de la prévention de corrosion par revêtements superficiels, un problème, qui reste encore sans résolution, s'agit de l'influence du support sur les caractéristiques de la perméabilité d'un feuillet. Autrement dit, est-ce qu'il est valable de mesurer ces caractéristiques au moyens des feuillets détachés?

A l'aide des techniques entraînant désorption ou sorption, on a étudié, sous les conditions identiques, le comportement des feuillets, libre ou fixe, d'un vernis époxy-polyamide. Les données ont été exprimées sous termes des coefficients de diffusion et de partition

de l'ion chlore dans le système polymère.

Les résultats ont révélé qu'il n'est pas raisonnable de se servir des feuillets libres en vue de dériver des conclusions pratiques et valables, puisque les coefficients portant sur la perméabilité sont modifiés lors de l'enlèvement du feuillet à partir du support. D'ailleurs, ces coefficients se dépendent des conditions préalables auxquelles les feuillets ont été assujettis et également ils ne sont pas liés à l'intervalle de temps de la même façon dans toutes les situations.

Chlorionentransport in Epoxypolyamidfilmen und der Substrateffekt

Zusammenfassung

Ein wichtiges Problem für das Gebiet des Korrosionsschutzes durch Anstrichmittel, welches noch unbeantwortet geblieben ist, betrifft die Auswirkung des Substrates auf die Durchlässigkeitseigenschaften eines Films. Ist es, in anderen Worten, zu rechtfertigen solche Eigenschaften an freien, abgelösten Filmen zu messen?

Unter identischen Bedingungen wurde das Verhalten freier und haftender Filme von Epoxypolyamidlacken mittels Desorptions- und Sorptionstechniken beobachtet. Die gefundenen Werte wurden

mit Hilfe der Begriffe Diffusions- und Trennwandkoeffizienten für Chlorionen im Polymersystem interpretiert.

Die Ergebnisse zeigen, dass die Verwendung freier Filme keinen Sinn hat, wenn man gültige, praktische Schlussfolgerungen ziehen will, weil die die Durchlässigkeit kontrollierenden Koeffizienten durch Entfernung vom Substrat verändert werden. Die Koeffizienten sind auch von der "Geschichte" abhängig und stehen nicht in Beziehung zum Zeitfaktor wie in den beiden Situationen.

Хлоридный перенос ионов в эпоксидных полиамидных пленках и эффект субстрата

Резюме

В вопросе предотвращения коррозии поверхностными покрытиями одна исключительная проблема осталась нерешенной, а именно вопрос влияния субстрата на свойства проницаемости пленки. Другими словами — советуется ли измерять эти свойства на свободных отделенных пленках?

Наблюдалось поведение свободных и присоединенных пленок эпоксидного полиамидного лака в одинаковых условиях, применяя технику сорбции и десорбции. Данные оформля-

лись на основе коэффициентов диффузии и разделения для хлоридного иона в полимерной системе.

Результаты показали что нецелесообразно применять свободные пленки для получения справедливых практических выводов, так как коэффициенты определяющие проницаемость изменяются удалением от субстрата. Коэффициенты являются также исторически обоснованными и не зависят от времени в одинаковой степени в этих двух ситуациях.

Introduction

The successful performance of a protective coating on a metal surface depends on many factors, one of which is its permeability towards ionic species. The more the transfer of ions can be restricted, then the more effectively can corrosion processes damaging the metal be minimised. Therefore,

although the actual mobilities of ions within an organic polymer film are very much less than in aqueous solution, if the desired protection is in terms of years, consideration of ionic permeability can become extremely important.

One question which has never been satisfactorily answered is the question of how the adherence of a film to a substrate

* Presented at the 1973 Eastbourne Conference.

affects the film's properties. Almost without exception investigations of permeability have been conducted on film specimens that have been stripped from the substrate to which they had been applied. Whether or not the information thus derived is relevant to the conditions where the film is bonded to a solid surface, is doubtful. It might be expected that strong adhesive forces at the interface will have electrical and molecular consequences within the film's polymeric structure. Even if removal of the film from its support does not change the inner surface condition (which it probably does) the diffusional behaviour in the detached film need not be related to what takes place in the adherent condition. The free film will, for example, be more susceptible to overall swelling, whereas the attached film with one face constrained is more prone to distortion or internal strain.

There continues to be a great need for testing of surface coatings to be made more strictly relevant to actual usage. In certain areas of accelerated testing, there may be little correlation with the experience of a coating under atmospheric conditions. Even though some test methods are convenient and readily provide results, the validity and usefulness of the results must be closely examined. In this computer era, where the treatment of data has become such an absorbing passion, a certain amount of discipline is necessary to question the basic assumptions and criteria underlying any model of the real world.

So it is with the permeability property: it must be determined once and for all whether or not the substrate plays an influential role in affecting the film's behaviour. Over a decade ago, Bullett and Rudram¹ claimed that "deductions drawn from work on unattached films when interpreted and applied to paint films in practice are of doubtful validity." If a substrate effect does exist, it must be always taken into account; if instead it is established that the presence of the substrate is inconsequential to the film's behaviour then it will be known that the results from free films are directly relevant to the real situation. It is also the author's intent to increase awareness in the surface coatings world to approaches that have been advanced in other areas of applied polymer science.

Previous work

An examination of the literature reveals little information regarding the effect of the substrate on film permeability. Katz and Munk² in 1969 measured the rate of water vapour transmission through nitrocellulose and chlorinated rubber lacquer coatings prepared on different surfaces. The highly polar nitrocellulose films cast on tin foil appeared to be more permeable than those prepared on polyethylene. The results for the same substrates were inconclusive for the chlorinated rubber media. All films were detached for permeability measurement, and thus the experimental conditions did not relate to practice in this respect.

A capacitance technique has been established to measure aqueous permeability of coatings adhering to electrically conductive substrates and the most recent approach by this method has been presented by Holtzmann³. Using a short period of exposure, he found the permeabilities of adherent films to be comparable to, if lower than, those of free films, obtained by the diffusion cup technique.

Some interesting information has emerged from studies of water uptake. Browne⁴ found that films of drying oil

paint sorbed less water when bound to a glass substrate than in the free condition. Similarly, in a study of water vapour sorption by hydrophilic polymers, the equilibrium concentration of water was found to be lower when the membrane was attached to glass.⁵ In contrast, Funke⁶ established the water uptake by a range of lacquer films supported on steel to be higher than that by free films, and concluded that the water sorption data for both conditions is necessary to permit a more reliable prediction of durability in a moist environment.

Theory

It is important to realise that there are limitations in the information to be derived from a permeation method. As the concentrations measured in a permeation experiment are of the solutions outside the film, the calculated proportionality constant relating the amount of transported material to the concentration gradient corresponds to the permeability coefficient, P , of the system and not to the fundamental characteristic parameter, the diffusion coefficient D . D refers to movement within the film, is related to the concentration gradient between the film's surfaces, and cannot be derived reliably from permeation rate data.

A well-known means of calculating D in polymers from permeation data has been the so-called "time lag" method. The calculation depends on the assumption that, as the steady state is approached, the graph of Q , the amount of species passing through the film against t , the time, tends towards the equation

$$Q = \frac{DC_1}{l} \left(t - \frac{l^2}{6D} \right)$$

where l is film thickness and C_1 is the constant concentration of transporting species next to the front surface (C_2 on the other side of the film is taken as zero). Values of D are deduced from the intercept on the t axis. However, the unreliability of this approach has been demonstrated by, among others, Siegel and Coughlin.⁷ On theoretical grounds, they showed that the error in the intercept will always be several times larger than the error in the slope of the line, and with experimental data from the literature they proved that a relative error of 25 per cent or more is not uncommon.

It is thus of considerable advantage that (de)sorption methods can give a value of D directly by simple treatment of the data.⁸ In addition the partition or solubility coefficient (K) for the penetrant species in the polymer system can be simultaneously derived (see results section). The value of P corresponding to the product of D and K is, therefore, also available by this approach.

The other great attraction of the (de)sorption technique is its applicability to attached films as well as to free membranes. It means that the properties of identically prepared films can be investigated for the two cases under the same conditions. The equation for (de)sorption kinetics of a free film can be applied to attached films⁸, and a free film of thickness l (see Fig. 1a) is equivalent to a system with a substrate coated on both sides by films of thickness $1/2l$ (see Fig. 1b). This can be appreciated by visualising the free film as having an infinitely thin, central equilibrium plane across which there is no net transfer of diffusing species during (de)sorption just as there is a thick, central barrier plane in the case of a coated, inert substrate.

*Personal communication from Professor J. Crank, Department of Mathematics, Brunel University.

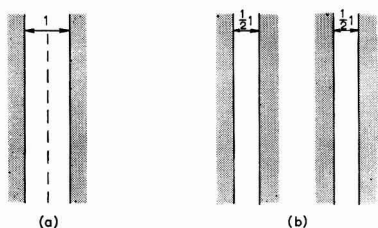


Fig. 1. Comparison of a free film with a substrate coated on both sides

There are also practical advantages in the (de)sorption technique. For instance the efficiency of the sealing of the film in the cell is no longer a problem and, whereas small imperfections in a thin membrane can completely alter the permeation rate, they have very little effect on (de)sorption kinetics.

Desorption

Experimental

The epoxy polyamide systems and their film preparation as unpigmented, air-drying lacquers have been described previously.⁹ Epikote 1001 and Versamid 115 were used as the components with the weight ratios as 1:1 and 2:1. For these studies, one film coat was regarded as sufficient although two or more are necessary for permeability determinations. Free film samples were prepared on glass panels and peeled off after a few minutes' immersion of the panel in water; attached film specimens were applied to glass and hard aluminium substrates. The aluminium panels were chromated to BS 3900 A3, and wiped before usage with tissue dipped in petroleum ether. All films were aged for ten days at 40°C to minimise solvent retention.

Prior to the desorption rate experiment, the samples were equilibrated by immersion in 10 per cent sodium chloride solution which was stirred periodically. The equilibration time was varied from two to six weeks. For coated aluminium panels, the edges of the panel were protected with a wax edging material. An attached film on glass was equilibrated by placing a vertical glass tube of the same internal diameter as the desorption cell (7.5cm) on the horizontal glass panel, sealing the joint with soft picein wax and pouring 10 per cent NaCl solution into the tube. In this way the film edges did not come into contact with the solution and lateral uptake between the film and the panel was impossible.

After removal from the equilibrating solution, samples were swiftly and carefully wiped dry with soft absorbent tissue. They were normally submitted to desorption as soon as possible.

Film thickness measurement with a metric dial gauge was performed just before the desorption of free films. For attached films it was carried out on samples stripped from the substrate at the finish of desorption.

The monitoring of the passage of chloride ion at 25°C through surface coatings has been described.⁹ The measurement of desorption rate was conducted by essentially the same means using a solid-state ion-selective electrode.

The desorption system consisted of a continuously pumped liquid stream (initially distilled water) passing across both

surfaces of the sample and then through an electrode cell holding the Cl⁻ selective electrode and the reference electrode. The total liquid volume of the system was approximately 200ml. The sample cell could accommodate free films or coated panels under identical conditions.

Measurements of the chloride desorbed from the film were made during the first six hours of the experiment at about hourly intervals. A final reading was normally taken after the experiment had continued for over 72 hours.

Results

Epoxy/polyamide (1:1)

Several exploratory experiments were performed with 1:1 epoxy/polyamide unpigmented films. Fig. 2 shows the typical curves obtained for desorption by free and attached films.

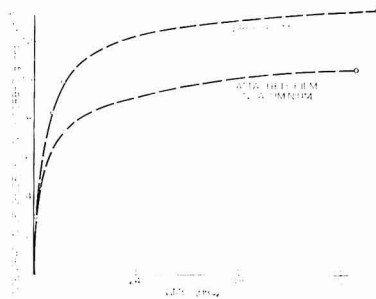


Fig. 2. Desorption of Cl⁻ from epoxy/polyamide (1:1) films after two weeks' equilibration in 10% NaCl

In view of the non-Fickian behaviour demonstrated by these films towards Cl⁻ permeation⁹ (owing to interaction between the polymer system and the aqueous medium), it was decided to test the "Initial Rate Desorption" analysis approach advocated by Yasuda¹⁰ for salt permeation of hydrophilic polymer membranes. As well as offering a treatment of general non-Fickian diffusion, this technique also provides a correction for errors encountered in the calculation of partition coefficients.

For the initial stages of desorption even if D is a function of penetrant concentration, it can be shown¹⁰ from a solution of Fick's law that:

$$M_t = \frac{M_\infty}{l} \left(\frac{16 \bar{D} t}{\pi} \right)^{1/4}$$

where M_t is the amount of Cl⁻ desorbed after time t , M_∞ is the equilibrium amount of Cl⁻ desorbed after infinite time and \bar{D} is an average diffusion coefficient applying over the range of concentration experienced by the film. Consequently, when the plot of M_t against $t^{1/4}$ is linear, \bar{D} may be obtained directly from the slope.

Fig. 3 shows the typical result from a plot of M_t against $t^{1/4}$ and demonstrates the straight line relationship existing during the initial stages of desorption. The analysis method appears, therefore, to be applicable.

Yasuda¹⁰ has presented evidence indicating that loss of sorbed salt during blotting of the surface is responsible for the line passing below the origin. He regards it reasonable

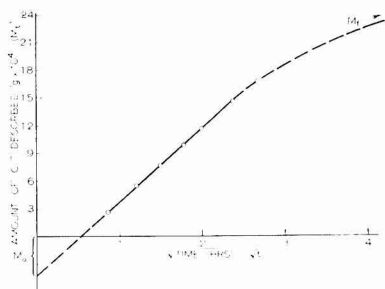


Fig. 3. Initial rate desorption analysis for Cl^- from an epoxy/polyamide (1:1) free film after four weeks' equilibration in 10% NaCl

to extrapolate the linear slope back to time zero in order to estimate the contribution of possible loss of salt in the membrane phase, M_0 . (See Fig. 3). Then the M_∞ value is derived from

$$M_\infty = M_f + M_0$$

where M_f is the final desorbed Cl^- reading actually recorded. His investigations showed that the M_0 correction reduced the variance in values found for \bar{D} and K . He calculated the latter from the equation

$$K = \frac{M_\infty}{C_1 V_m}$$

which applies when the final salt concentration at the finish of desorption is very much less than the pre-equilibrating solution concentration, C_1 , and where it is assumed that changes in K and the membrane volume, V_m , are small during the desorption experiment.

Following the exploratory experiments, a closely controlled programme was conducted with 1:1 epoxy/polyamide films. A large number of curves were obtained and values of \bar{D} and K calculated from the results according to the methods of Yasuda. (See Table 1).

Table 1
Desorption results for epoxy/polyamide 1:1

Substrate	Equilibration time (weeks)	Film thickness (μm)	\bar{D} ($\text{cm}^2 \text{sec}^{-1}$)	K	\bar{P} ($=\bar{D}K$) ($\text{cm}^2 \text{sec}^{-1}$)
None	2	23	2.9×10^{-11}	0.19	5.5×10^{-12}
Aluminium	2	18	5.9×10^{-11}	0.083	4.9×10^{-12}
None	6	24	2.7×10^{-11}	0.25	6.8×10^{-12}
Aluminium	6	21	7.0×10^{-11}	0.16	1.1×10^{-11}

As borne out in the preliminary experiments, the diffusion coefficient is always markedly higher and the partition coefficient always lower when the film is adhering to the aluminium substrate.

In determinations carried out with films attached to a glass substrate, the values of \bar{D} were higher than for a free film, but the K values were also above those of a free film equilibrated for the same length of time. This latter result is not believed truly to represent the actual partition coefficient of the film. Although the film was not released from the glass panel during the experiment, there was considerable diminu-

tion of adhesion strength and wetting of the glass surface under the film was evident. It is therefore likely that the chloride content of this aqueous layer was sufficient to give an anomalously high value for the total salt desorbed from the film.

It is necessary at this juncture to consider whether a similar interfacial layer, (albeit of much lower thickness), exists with epoxy polyamide bonded to chromated aluminium metal. For an epoxy/Versamid resin on steel, Funke⁶ attributed the high water uptake to accumulation of water at the interface and Anderton¹¹ was also aware of a "water rich layer" at coating/steel interfaces.

Certainly good adhesion is retained to aluminium during both the equilibration and desorption periods, and there is no evidence of corrosion or blister formation. Nevertheless, films are more readily stripped away from the substrate at the end of the experiment and, although there is no visible sign of wetting of the metal and X-ray fluorescence showed the aluminium surface to be completely free of Cl^- , it would be unwise to dismiss the possibility of an ultra-thin interfacial aqueous film. The important question to decide is whether the presence of such a layer will in any way influence the process of desorption.

Considering the substantial increase in K for attached films on aluminium after six weeks equilibration, it seems possible at first sight that, although there was no visible evidence for it, a water-rich interfacial layer may have added to the Cl^- uptake. However this possibility cannot be a major factor, since an appreciable rise in K for a free film also takes place in the same time and, relatively, the free film still has a far greater Cl^- uptake. This latter feature does not correlate with Funke's⁶ observations of water uptake being higher for supported films because of interfacial action.

It is necessary also to examine the possibility of a Cl^- containing interfacial layer affecting the measured diffusion coefficient. There is evidence indicating the unlikelihood of such an occurrence. There is the high \bar{D} value for the attached film after only two weeks' equilibration, associated with a low K . There is also the relatively small rise in \bar{D} (<20 per cent) as the equilibration time is increased to six weeks. If after two weeks the water rich layer was already exerting a sufficient "pressure" to raise the \bar{D} value to twice that for the corresponding free film, then equilibration for a period three times as long with concurrent 100 per cent rise in Cl^- uptake would be expected to cause a substantially greater rise in \bar{D} than is found.

Epoxy/polyamide (2:1)

When epoxy/polyamide 2:1 systems are examined similar trends reveal themselves, as shown in Table 2.

Table 2
Desorption results for epoxy/polyamide 2:1

Substrate	Film thickness (μm)	\bar{D} ($\text{cm}^2 \text{sec}^{-1}$)	K	\bar{P} ($\text{cm}^2 \text{sec}^{-1}$)
None	20	1.2×10^{-11}	0.03 (3)	4×10^{-13}
Aluminium	20	3.5×10^{-11}	0.02 (7)	1×10^{-12}

Notes—For these experiments the equilibration time was eight weeks with the final two weeks under acidified conditions (pH 3, HCl) to enhance Cl^- uptake.

Since the Cl^- levels were much lower in these experiments the significance of the second figure is in some doubt.

Again the attached film has a higher diffusion coefficient. The partition coefficient is similar for the two cases although it appears to be lower in the attached film. The attached film is more than twice as permeable as the free film under these conditions.

Both \bar{D} and K are lower than any corresponding values found with the 1:1 system and the difference is appreciable. This must be a direct consequence of the more extensive cross-linking in the 2:1 material, which is much closer to the stoichiometric ratio (1.8:1) based on epoxide and amine equivalents. Another reason for the lower degree of aqueous permeation is the lack of free amine groups which are provided when the polyamide component is present in excess. It is not surprising, therefore, that the calculated \bar{P} values are appreciably lower than for the 1:1 epoxy/polyamide material.

Discussion

If it is accepted that for films adhering strongly to a metal substrate the partition coefficient is lowered and the diffusivity raised, a theoretical explanation must be provided in the light of the system's chemical composition (see Fig. 4) and the excess of polyamide molecules present in the 1:1 case. A consideration of K and its low value leads into two possible areas of explanation: molecular constraint or surface phenomena.

film. There will be a greater constraint on the molecular system and fewer polar sites will become available to incoming ions.

It is not certain that this plasticisation phenomenon, which is very marked in the early permeation of dilute chloride solution, will be a controlling force under the conditions of equilibration in strong chloride solution. Therefore, the reason for the low partition coefficient of attached films may instead be associated with the nature of the film surfaces. Each free film has originally been in contact with a substrate and consequently has an inner as well as an outer surface presented to the incoming solution; for the attached film, on the other hand, solution occurs at an outer surface only. The free films were prepared on glass and the magnitude of interaction appears not to be great as indicated by the ease of separation. Nevertheless, there will undoubtedly be a difference between the inner surface and the outer skin arising from the whole sequence of events during or subsequent to the film forming process. Katz and Munk² found that water vapour permeability always appeared to be higher for a film when the inner surface was exposed to the penetrant, and in a preliminary trial a higher value of K was obtained with a 1:1 free film removed from an aluminium substrate than found for free films prepared on glass. Thus it is reasonable to assert that this is one factor which will often render free films irrelevant to practice. The stripping from the substrate and exposure of the inner side of the film means

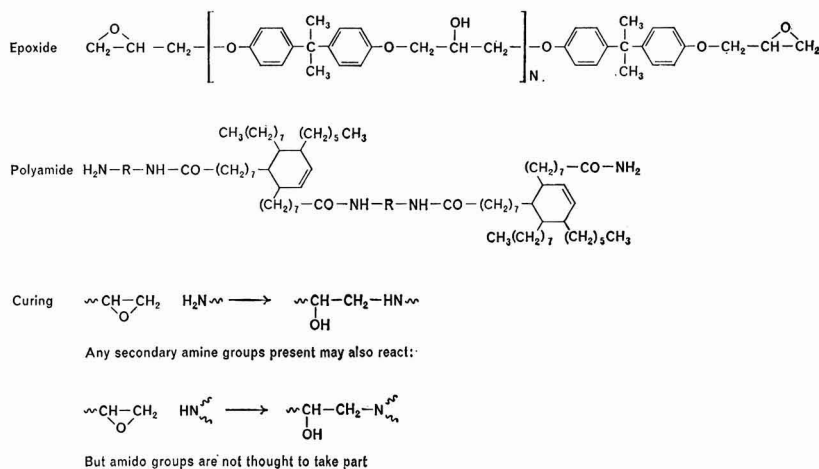


Fig. 4. Epoxy/polyamide system

In the earlier paper⁹ it was observed how the rapidly increasing permeability of the free 1:1 epoxy polyamide films was not a simple consequence of film swelling. As ionic entities become associated with polar sites within the polymer network the intermolecular secondary bonding existing in the dry condition becomes disturbed and undergoes reduction in strength and influence. As a direct consequence, there is a greater ease of movement of the polymer system, i.e. plasticisation, which continues as the uptake of ionic species proceeds. An increasing solubility is thought to arise as more and more polar sites become "exposed" or accessible by virtue of the polymeric movement. However, for a film adhering strongly to a metal surface, electrical and hence structural effects may be felt through the film, and it is to be expected that the polymer chains and segments will not enjoy the same degrees of freedom as experienced in the free

the introduction of interactions, and mechanisms at that surface affecting the film's overall properties.

Considering now the diffusion coefficient result, it is not obvious why Cl^- ions should move more rapidly in a film when it is adhering to a substrate. As free films have greater Cl^- content, it is reasonable to expect them to be more plasticised and therefore more co-operative to penetrant movement. That this is not borne out by the desorption results gives further indication that the nature of permeation for dilute solutions⁹ is not directly comparable to the desorption process after equilibration in concentrated solution. (It can be seen also that increase in Cl^- content for 1:1 free films does not bring about an increase in \bar{D} , as the equilibration time is extended (see Table 1). In addition, the form of the M_t against $t^{1/2}$ plots, where the linearity extends to

approximately $M_{\infty}/2$, points to a diffusion coefficient being virtually independent of concentration under these desorption conditions⁸.)

The non-uniformity of strain within an attached film may provide the explanation. The regions lying close to the outer surface will be more swollen and plasticised than the inner regions. Consequently, the movement of Cl^- close to the outer side may be faster than is found in a corresponding free film which has been more uniformly swelled. As it is the initial desorption rate which determines the diffusion coefficient, the attached film may therefore allow a higher average mobility to the Cl^- for this reason.

Sorption

Experimental

Using free and attached films of epoxy/polyamide (1:1) prepared under the same conditions, sorption experiments were performed by immersing films in 10 per cent NaCl solution which was frequently agitated, and then determining their Cl content. Coated panels were edged as before to minimise aqueous penetration via the edges.

In a similar approach to desorption, measurements were made on samples removed during the initial stages of Cl^- sorption and then on the final sample, which had remained immersed for about three weeks.

The chloride content was determined by means of an X-ray fluorescence technique on specimens of film of diameter 3.8cm. Free film samples were affixed to a solid support by means of adhesive transfer tape; attached film samples were punched out as discs. Each of the five standards for calibration was prepared by making up an epoxy polyamide lacquer in the normal way, but with isopropanol containing an accurately weighed quantity of chlorobenzoic acid. To minimise background and dimensional effects, the standard films must resemble the samples as closely as possible, and so an identical method of film manufacture was used.

For the X-ray fluorescence measurements, a Philips PW 1220 spectrometer operating with a chromium anode at 50 keV was used under vacuum conditions. Counts in duplicate were taken for periods of 40 secs for each sample at the chlorine $K\alpha$ peak angle. Background was estimated from counts taken either side of the peak so that counts/sec, peak minus background were obtained.

Thickness measurements were performed on samples after withdrawal from the aqueous solution. There was no measurable change in thickness for samples during the initial sorption period, and the increase for the final sample was only of the order of 5 per cent.

Results and discussion

The situation revealed by the sorption studies of 1:1 epoxy polyamide is less simple than found in the desorption programme and does not lend itself to a rigorous quantitative interpretation. However, there are several general results that have emerged.

First, the sorption pattern is anomalous in shape and does not follow the initial $t^{1/2}$ linear desorption law (see Fig. 5). Such behaviour has been reported for many systems¹² where the sorption curve is generally sigmoid in shape and

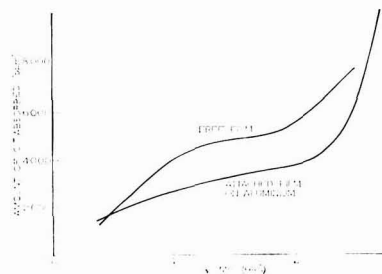


Fig. 5. Sorption patterns for Cl^- in epoxy/polyamide (1:1) films immersed in 10% NaCl

the desorption curve is initially steep but soon changes into a slowly rising line. These features are typical of the slow processes occurring in polymers in the glassy state.* Various explanations have been offered for this phenomenon, including time or history dependent diffusion coefficients, two-stage processes and the effect of internal stress. It is beyond the scope of this work to establish the underlying cause behind the anomalous behaviour, but the different time-dependency of a protective film in the free and attached state is well illustrated.

In the very early stages of sorption during the first hour the sorption rate (ppm $\text{Cl}^- / t^{1/2}$) from the slope appears faster in the free film but after about six hours the sorption rate of a comparative attached film has greatly increased and is indicative of a higher D having established itself in the attached film.

The final concentration levels, corresponding to approximately three weeks' immersion, gave a higher partition coefficient for the free film by a similar ratio as found for desorption after two weeks' equilibration.

Permeation

One of the results emphasised in this work is the secondary nature of permeability and the way diffusion and/or partition affect it. With desorption data derived after two weeks' equilibration (see Table 1), there was a low diffusion rate matching a high partition coefficient for the free film and the converse situation for the attached version, which resulted in permeability coefficients very close to one another. With the extension in equilibration time, the relative increases in \bar{D} and K for the attached film were sufficient to make it apparently far more permeable. It can also be seen how the permeability in the very early stages of sorption may not resemble that predominating later. A similar behaviour was observed in the study of permeability of detached films towards dilute (0.05N) NaCl solution,⁹ where the permeation rate changed with time. Fig. 6 shows the variation of P over a period of 10 days for a 1:1 film of 30 μm thickness which had been pre-conditioned in water for several weeks. Although the rate appeared to level off after 8 days, later readings for up to two weeks showed that P was still increasing. It is interesting to note the sigmoid character in the curve as found in the sorption study. The average value of P over the period represented is approximately $5 \times 10^{-11} \text{ cm}^2 \text{ sec}^{-1}$. This is about ten times higher than \bar{P} determined by desorption in this work, emphasising how permeability is dependent on concentration conditions.

* T_g of the epoxy polyamide used was approximately 60°C, determined from differential scanning calorimetry.

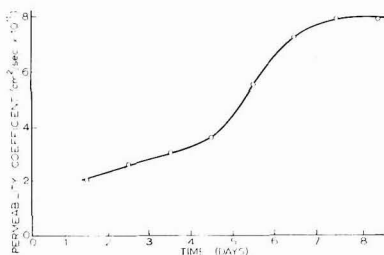


Fig. 6. Variation of permeability coefficient from permeation method (Derived from results of previous work.)

It is important to realise that the protecting behaviour of the film is affected by the content of penetrant within the film, and also by the period of time for which interaction with an aqueous medium has occurred. Moreover, the time dependency is not the same for free films and attached ones and the permeability ratio between them cannot be expected to remain unaltered and may well reverse at some stage.

Conclusion

Evidence is presented which shows that the free detached film does not have the same ionic permeability characteristics as a film that is attached to a substrate.

Among the factors believed to contribute to the different rates of permeation are the exposure of the film's inner surface in the free film condition and the molecular constraint of

Discussion at Eastbourne Conference

PROF. W. FUNKE said that Dr Murray had mentioned in his paper that the chloride ion uptake of free and supported films does not correlate with the respective water absorption. He thought that such a correlation was not to be expected, because both permeating species (chlorine and water differed considerably in their interaction with the film material and, therefore, also in their permeation rates.

There was, in addition, some evidence from recent results that ion permeation became negligibly small in films of film thickness above about 50 μ m, whereas water permeation was still considerably high in this range of film thickness.

In the case of epoxy amide resin, some ion exchange properties might be expected and, therefore, chloride ions would not simply solvate the polymer chains via secondary valence forces, but would be bonded ionically. Moreover, a salt concentration as high as 10 per cent by weight, would decrease the water absorption of a film significantly below the level obtained on exposure to pure water; so a lower degree of swelling was to be expected and this again might influence the permeation rate. He thought that from the two explanations given by the author for the differing rates of chloride absorption by free and supported films, a different molecular condition at the inner surface seemed to be more convincing than a molecular constraint, at least after equilibrium conditions had been obtained, because according to the results of Walker, and later of the Forschungsintut in Stuttgart it might be expected that adhesion was more or less lost after prolonged exposure to water and that a thin

movement and non-uniform internal strain experienced in the attached film case. The presence of an interfacial aqueous layer between coating and substrate may also be important.

The next phase of work is to study other systems of practical importance to establish whether the non-validity of permeability determinations on free films is universal.

Acknowledgments

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water layer separated the film from the substrate, even though this might not be perceived in a superficial inspection. Therefore, the mobility of polymer segments adjacent to the substrate was no longer restricted and stress relaxation might occur.

He thought it was very important in this connection to know whether plasticisation of the film by water had proceeded so far that the glass transition temperature mentioned in the paper was lowered to below the experimental temperature, because this would have a decisive influence on the rate of all processes leading to an interfacial failure of a paint film.

Prof. Funke concluded with a general remark which, he pointed out, was not intended as a criticism of this very interesting paper. He thought that after the basic research on corrosion protection with paint films by Kittelberger, Elm and Mayne, there was no great need to find new mechanisms to explain paint film behaviour under corrosive conditions, but it was very important to correlate reasonably the various known factors involved in the interfacial failure and subsequent under-rusting in order to obtain a useful evaluation of a paint system for protection against corrosion and in order to explain film failure.

DR J. D. MURRAY replied that there was not a lot of disagreement between these comments and his own views. Prof. Funke probably realised that a purpose of the paper was to stimulate the paint research world to consider again whether much of the research should be done with adhering coatings. The meaning of free film results had been questioned over a decade ago and still needed answering.

Dr Murray said he would just comment very briefly on the matters which had been raised. First of all, he agreed that water permeation need not correlate with chloride ion transport. He did not intend any criticism of Prof. Funke's data when this was mentioned in the paper. There would be differing mechanisms for ions and water which were difficult to determine, especially since the hydrating power of water within the polymer system was uncertain—although some recent work suggested that diffusing chloride ions were partially hydrated with, on average, approximately half a molecule of water attached. Workers in this field ought to be aware of results derived in other polymer studies, which showed that water in a polymer film was not the same as normal water; it could be bound and also have abnormal hydration properties.

Dr Murray found surprising the theory that above a certain film thickness, ionic permeation fell dramatically. He had always believed that the concentration gradient was the controlling force.

Commenting on the question of ion exchange in a film, Dr Murray said that when he had first entered this field, he had become aware that it was not really known in what condition the ion was when inside a polymeric environment. It might be bonded strongly in an ion charge site or floating freely. The ion exchange theory had been with paint chemists for a long time and it was widely accepted, but no-one had yet proved that a truly reversible and reproducible ion exchange process occurred in a paint film. He was still waiting to see a publication which proved this.

DR J. E. O. MAYNE said that in general, water could enter a free film more easily than an attached one, and the free film would, therefore, take up ions more readily. This was borne out by the higher values of the solubility coefficient K in the case of the free films (Table 1). In contrast, the difference was much less when the films were more highly crosslinked and less water could enter (Table 2).

The attached films had been cast on aluminium, which had been treated with a mixture of potassium dichromate and sulfuric acid and subsequently wiped with petroleum ether. Consequently, the surface would have been highly contaminated with ions. This might account for the fact that the values of the diffusion coefficient D in both Table 1 and Table 2 were higher for the attached film.

They had in Cambridge measured the resistance, which was a function of the ionic permeability of attached and free films. It was found that when epoxy/polyamide films (approx. 2:1) were attached to an inert substrate such as platinum or stainless steel, then the resistance of the attached films was two orders of magnitude higher than that of free films. On an iron substrate, however, the resistances of the free and attached films were of the same order of magnitude. It seemed that the higher resistance was obtained when ions diffused from only one side. It was concluded that results were very dependent on the method of preparation of the films and that caution should be exercised in drawing general conclusions.

DR MURRAY commented firstly on the question of the ionic content of the aluminium surface interfering with the ionic diffusion measurements. This seemed unlikely because consistent results had been obtained with free films removed from the aluminium substrates and with films on a glass substrate. In every case, a higher value of D was observed for the attached film. It was a moot point that Dr Mayne had mentioned on the evidence derived from resistance

measurements. Dr Murray did not feel so happy with an indirect method where the species being investigated and measured could not be identified. From other areas in polymer science, there was a lot of evidence that for resistance measurements on polymer films, it was not certain whether the resistance properties of the polymer in an aqueous medium were being investigated, or the resistance properties of the aqueous medium within a polymer environment. There was some work in America by Barker, and by Bureau in France, which indicated that water could supply the charge carriers (ions such as H^+ , OH^- or H_3O^+) and that it could not be ascertained from conductivity or resistance measurements exactly which ion was carrying the charge. Far more work needed to be done by direct methods, and the use of radio-tracers was probably going to give most of the important evidence in this field.

MR J. S. BOROKY commented that the permeability of an epoxy/polyamide film by ionic species was also dependent on the crosslinking within the polymeric film. If maximum crosslinking occurred, permeability differences might be negligible between free and attached paint films. He asked whether Dr Murray could indicate how he had arrived at the 1:1 combination of epoxy/polyamide components.

DR MURRAY replied that according to the Shell manufacturing information, ratios from 1:1 to 3:1 epoxy/polyamide were acceptable and gave good films. A 1:1 ratio proved extremely useful because it gave fast rates of permeation; he had done some work on a 2:1 system, which was much closer to a stoichiometric combination, as described in the paper, and the evidence did seem to lie in the same direction as found for the 1:1 system.

MR A. M. VAN LONDEN suggested to the author that he look into the possibilities of using electron-scan analysis as a very direct method for studying processes in paint films.

DR MURRAY agreed with this assessment. He was interested in this technique, but had found with lacquered films that, unfortunately, the energy of the electron beam was too high for use of an X-ray probe; it actually damaged the lacquer film. Nevertheless, this was obviously one of the best tools for paint films.

DR MAYNE pointed out that Kittelberger and Elm (*Ind Eng Chem*, 1952, 44, 326) had measured the rate at which sodium chloride diffused through a wide variety of paint films and found that it was directly proportional to the electrolytic resistance of the films, thus indicating that the resistance was controlled by the migration of sodium and chloride ions and not by any other ionised, or non-ionised species.

Regarding the process of ion exchange, which occurred when films were exposed for some time to solutions of electrolytes, the phenomenon had been established by resistance measurements, by chemical analysis and by the use of radioactive tracers.

DR MURRAY said that ionic penetration is a slow process compared with water permeation, but thinking in terms of four or eight years of protection, it would then become important. There was obviously a difference of opinion between Dr Mayne and himself which would need a long time to sort out. It was noteworthy that Kittelberger had reached a conclusion about the permeation of sodium chloride, as such, without realising that any of the films he was looking at could in fact show selectivity, and that there was no evidence for the two ions going through together as salt.

Environmental problems of the chemical industry*

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Summary

The major causes of pollution to the air and water are outlined. Pollution caused by the dyestuffs industry is discussed under the general heading of water pollution. Solid waste from installations producing dyestuffs is mentioned.

The most serious air pollutants are sulfur dioxide and carbon

monoxide. Purification of liquid effluent is the most expensive problem of the chemical industry, and it is likely that, in the future, cleansing plants will be sited so that they are able to process both municipal and industrial effluent. The objectives towards the year 2000 should be to prevent rather than cure, and to this end concerted effort is required of both the individual and industry.

Keywords

Miscellaneous
pollution

Problèmes de l'environnement dans le domaine de l'industrie de chimie

Résumé

On trace les grandes lignes des causes principales de la pollution de l'atmosphère et des eaux. On discute la pollution provoquée par l'industrie de matières colorantes sur la rubrique générale de pollution d'eau. On mentionne les déchets solides à partir des installations consacrées à la production de matières colorantes. Les produits de pollution les plus graves ce sont le dioxyde de soufre et l'oxyde de carbone. La purification des écoulements

liquides constitue le problème le plus coûteux qui existe à l'industrie de chimie, et à l'avenir il semble probable que les installations d'assainissement soient situées où elles pourront traiter les écoulements des collectivités ainsi que ceux des établissements industriels. D'ici vers l'an 2000, les objectifs devraient être la prévention plus que le remède et à ce but les efforts arduement s'exigent de la part de l'individu et également de l'industrie entière.

Umweltprobleme der chemischen Industrie

Zusammenfassung

Die hauptsächlichsten Ursachen für die Verunreinigung von Luft und Wasser werden kurz aufgeführt. Von der Farbstoffindustrie verursachte Pollution wird unter der allgemeinen Überschrift Wasserverunreinigung besprochen. Feste Abfallprodukte von Farbstoffe erzeugenden Anlagen werden erwähnt.

Am ernstesten zu nehmen sind die Verunreiniger Schwefeldioxid und Kohlenstoffmonoxid. Die Läuterung flüssiger Abwässer ist

das kostspieligste Problem der chemischen Industrie. Wahrscheinlich werden in Zukunft Reinigungsanlagen so plziert werden, dass sie im Stande sind sowohl städtische als auch Industrieabwässer zu behandeln. Das auf das Jahr 2000 gerichtete Ziel sollte sein eher zu verhüten, als zu kurieren, und zu diesem Zwecke müssten gemeinsame Anstrengungen sowohl von Individuen als auch von der Industrie gemacht werden.

Проблемы окружающей среды в химической промышленности

Резюме

Рассматриваются главные причины загрязнения воздуха и воды. Загрязнение от красительной промышленности обсуждается под общим заголовком загрязнения воды. Упоминаются твердые отходы от установок для производства красителей.

Наиболее вредными загрязнителями являются двуокись серы и окись углерода. Очистка жидких истоков является наиболее

дорогой задачей в химической промышленности и возможно что в будущем очистительные установки будут располагаться таким образом чтобы быть в состоянии обрабатывать как муниципальные так и промышленные отбросы. Достижением к 2000-му году должно быть предохранение скорее чем излечение и с этой целью нужны общие усилия как со стороны отдельных лиц так и со стороны промышленности.

Introduction

The general title of the Conference is "Towards 2000," and it is therefore desirable to define where the chemical industry stands today concerning environmental problems before making any effort to project to where it could be by the end of the century.

Although it is only a few years ago that the environmental problems became an issue of public concern, it has to be stressed that they have existed ever since men started their activities on this planet.

Parallel to the formation of large scale production centres, a demographic change took place. People living before the

industrial age as farmers in rural areas were attracted by the rapidly growing industries and moved towards the new industrial sites. The developing cities prompted an aggravation of the pollution problems of the industry. Signs of deterioration of living conditions and the effects of pollution in rivers first became evident in these industrial agglomerations.

All production, whether by industry or by craftsmen or traders, yields a certain amount of by-products and waste. The percentage of by-products varies from one industry to another. So-called "clean industries," such as the precision instruments industry, the machine industry, for example, yield a relatively small proportion of raw materials which cannot be turned into finished goods, whilst the chemical industry is able only to transfer one-third to one-half of the

* Presented at the 1973 Eastbourne Conference.

starting materials into saleable goods. In the more basic industries, such as mining, the percentage of raw materials which can be worked into finished goods may even be considerably lower, depending on the contents of the respective raw ores. As, in this case, the undesired part consists of natural minerals, however, the problems are ones of landscaping rather than of finite deposits of chemicals.

In the chemical industry, most reactions are carried out in the liquid phase with water or an organic solvent as the reaction medium. The desired reaction products have to be separated at the end of each process from the solvent system and from the undesired by-products. Depending on the nature of the by-products and the solvents used, different methods are utilised for the purification of the desired end-products and the elimination of the by-products.

Many people are of the opinion that industry alone is responsible for the air and water pollution. A survey made for the most industrialised countries shows that the contribution of industry towards air pollution does not exceed 15 per cent, and the most air pollution is caused by traffic. Depending on the degree of motorisation, cars, buses, trucks and planes account for 50-60 per cent of all air pollution. The second largest cause of air pollution originates from energy production (that is 25-30 per cent), of which approximately one-third is due to industry, whilst the remaining two-thirds are caused by households and municipalities.

With regard to water pollution, the following figures may be regarded as average for industrialised countries: industry 40-50 per cent, municipalities 25-30 per cent, agriculture 25-30 per cent.

Industry participates only to a minor extent in the formation of solid waste: less than 10 per cent in countries having no mining industries, although this percentage may be considerably higher in regions where "primary" industries are active. The overwhelming amount of solid waste stems directly or indirectly from agriculture, whilst households and municipalities account for approximately 25 per cent.

From these statistics it becomes clear that, although industry is responsible for a considerable part of the pollution problem, everybody as a citizen contributes in one way or another to the pollution of the environment.

Air pollution

Mineral oils, which represent the main source for energy production, contain varying amounts of sulfur. During the burning process, consequently, sulfur dioxide is formed, so polluting the air. Industry, however, shares this problem with the municipalities and households as already indicated. The replacement of coal by oil has, particularly during the last 20 years, resulted not only in a reduction of sulfur dioxide formation by some 75 per cent, but simultaneously in a drastic reduction of the emission of solid particles, such as soot. It is obvious how different the appearance of a city like London is today in comparison with years ago when coal was the main energy producer. The smog and fog problems became less severe and the centre of London is a good example of this change. But, even though the improvements are impressive, still thousands of tons of sulfur dioxide are emitted to the atmosphere every day. Although a considerable percentage of this gets into the air from high chimney stacks, it may still cause discomfort, especially during periods of temperature inversion. Considering that the consumption of energy per person is still increasing, a

better solution to this problem will have to be found in the long term. The replacement of oil by natural gas, or the reduction of the sulfur content of the present fuels (oil or coal) to negligible amounts might be the solution for the future.

The worst air pollutant is carbon monoxide, which is formed in quantities two or three times as great as sulfur dioxide. To industry, carbon monoxide causes practically no problems. It goes without saying that the car industry will indirectly aggravate this problem as long as the combustion engine is still used in all kinds of vehicles, and everyone driving them is directly generating this heavy pollution. The after-burners, adsorption devices, and so forth, which are being tested at the present time, will bring about improvements, but it is an illusion to believe that a complete replacement of the present propulsion systems of cars, coupled with an elimination of the carbon monoxide problem will be possible in such a short time as is required by some politicians, especially in the USA. It is obvious that, in this field, solutions are not possible overnight and that a steady effort is necessary to decrease atmospheric carbon monoxide, unburned hydrocarbons and nitrogenous oxides. Compressed gases, such as propane in place of gasoline, or the complete replacement of the combustion engine by electric traction, may be solutions of the future, but their realisation may take ten and more years. It should be borne in mind, however, that these alternatives are not free from disadvantages: heavier weights and higher prices for cars, higher risks in the case of compressed gases and pollution problems due to the lead, the sulphuric acid of the accumulators of the electromobility, will still remain. Therefore, new concepts for the whole transportation problem have to be found. Highly effective public transportation media may be a better solution to the traffic problem, and may solve some of the other environment problems at the same time.

Reverting to the air pollution problems of the chemical industry more specifically, many chemical processes result in gaseous by-products (such as hydrogen sulfide, mercaptans, aliphatic amines, etc) all of which may cause problems to the labour force and to the adjacent environment if they are not removed to a very high extent. Long before the problems of air pollution were seriously considered in production processes, filters, washers, and so forth were installed to improve the working conditions inside production buildings. Fortunately, this also had a positive effect on the conditions outside the production units. Today, the abatement of undesired gaseous by-products has reached a very high standard and the incidents of the population in the neighbourhood of chemical production units having reasons for complaint are generally reduced to accidents, which, even with the best installations, can never be completely eliminated.

The investment costs to achieve a high air purity in industry are relatively high, and the operational costs are very considerable. In one of CIBA-GEIGY's production units, for example, 30 per cent of the total electricity consumed is used for air purification systems of various kinds. It has to be stressed that the elimination of gases is not always the ultimate solution as very often the washing systems will transfer the pollutant from the air to the water from which it in turn has to be removed by effluent plants.

Water pollution

The most expensive pollution problem for the chemical industry is the purification of effluent. Before any effective

and economically feasible treatment of effluent is possible separation into solutions of various qualities has to be achieved. In chemical plants today, 50-60 per cent of the water consumed is used for cooling purposes. For this, no chemical or biological treatment is necessary. As a consequence the separation of the cooling water from the polluted waste water leads to some 50 per cent saving on the investment and the running costs of biological treatment plants. The slight temperature increase of a river due to cooling water from industrial plants does not usually create any basic change in the biology of most rivers, and is consequently harmless. In cases where the cooling water exceeds the permissible temperature, cooling towers will have to be built to bring the temperature down. In these cases, it may be preferable to construct a closed system to recycle the water indefinitely. With such systems the fresh water consumption is much lower.

In Western Europe, and partially also in the United States, most large chemical works produce a great variety of different chemicals. The effluent from these plants may consist of many hundreds of different compounds. Some are biodegradable, others are not. In general, the biodegradability of waste products from a complex chemical production unit does not differ very much from that of municipal waste, which is a mixture of sanitary and small-industry effluent. Roughly two-thirds of these industrial and municipal effluents are eliminated in well-functioning biological treatment plants. About one-third of the total organic carbon (TOC) and practically all inorganic materials are not eliminated. The similarity in the quality of effluent from most chemical production units and that from municipalities has often prompted building an effluent treatment plant for both industry and adjacent towns. CIBA-GEIGY, for example, has two large effluent treatment plants in operation in Switzerland in which the neighbouring municipalities participate. The effluent treatment plants were planned, constructed, and are run by the company. Under the guidance of CIBA-GEIGY and Sandoz engineers, the State of Basle-Country is at present building the largest effluent treatment plant in Switzerland several miles from Basle in conjunction with the neighbouring communities. In order to guarantee an economic waste water treatment, the industry is constructing four different canal networks. One of these is for cooling-water and one for only slightly polluted water. These two streams are discharged directly into the river. A third pipe system is for coloured effluent and a fourth for highly polluted organic waste water. In order to decrease the amounts of effluent to be treated biologically, it is necessary, for reasons of economy, that in-plant improvements be undertaken. Additional efforts are being made to reduce the large amounts of inorganic acids, especially sulfuric acid. In present processes these acids are very dilute, so they are not suitable for re-use. It is a long and tedious undertaking to work out processes giving a sulfuric acid concentration of say 40 per cent, and special units will have to be built in order to reach the concentration suitable for regeneration.

Dyestuffs production units typically cause the formation of huge amounts of inorganic salts due to neutralisation, precipitation and milling, sodium sulfate and chloride forming the bulk of these undesired by-products. As a normal biological effluent treatment plant can only handle some 6gm of salt per litre of effluent, it is imperative that the salt concentration be kept below this level.

It may be difficult for the outsider to understand why the construction of an integrated effluent treatment plant takes several years. If it is realised, however, that many parameters have to be determined before the project itself can be started,

then the time lapse is explicable. Some factors to be considered are:

1. An inventory of the tonnages of all products which are manufactured today and are likely to be produced 5 to 10 years hence.
2. A compilation of all by-products and auxiliary chemicals which are discharged as effluent today, and a prognosis of how much might be discharged in the future.
3. The planning and construction of a separation canal network.
4. To determine the effluent volumes and loads which can be handled by a biological treatment plant at optimum costs, a process improvement programme has to be initiated and then made practicable.

Two to four years may be considered to be the minimum time necessary to work out a pre-project based on the above-mentioned parameters. At least the same length of time is necessary for the construction of a large plant, which means that a total of 4 to 8 years will be required from the beginning of the planning to the start-up of an effluent treatment plant.

The most difficult part is the forecasting of future production. Therefore, assumptions have to be made.

Providing that it is possible to decrease the amount of effluent by the application of improved technology, then an increased production volume should not yield a higher amount of effluent. The operating divisions of CIBA-GEIGY were asked to keep the present amount of effluent constant for a ten-year period and to take this as a basis for their future production planning. This means that new production can only be increased to the extent to which its effluent can be at least compensated by process improvements on existing products. This decision offers an excellent challenge for the production team, and considerable economic benefits have already resulted in several instances. In Switzerland, the federal law of effluent control, which has been in force since July 1972, requires a 90 per cent reduction of all biodegradable organic materials within a ten-year period. No time can be lost, especially by all those chemical producers who may not have started their preparatory work. The Basle chemical industry, hopefully, intends to fulfil the legal requirements before the end of 1975, with the exception of the two regional plants to be built on the French and German sides of the Rhine in the vicinity of Basle. Unfortunately, the realisation of these projects will be unduly delayed for political reasons, so that they may not be in operation before 1980.

The basic technology for the construction of biological effluent treatment plants is available, but conditions are different for the next phase, the elimination of non-biodegradable organic and inorganic compounds. Although a number of methods for coping with this part of the effluent are known *per se* (such as absorption on activated coal, chemical oxidation, elimination by ion-exchange, reverse osmosis, etc), these methods have to be developed to technologically applicable procedures and have to be chosen according to the specific needs of each product or product category. It is expected that in the 1980s, legislation will require a reduction of 90-95 per cent of the total organic carbon (TOC). It is obvious, therefore, that such a goal is attainable only if a highly qualified team of chemists and chemical engineers carry out some excellent work over a long period of time.

The final objective of the industry, however, is to reduce

the formation of waste rather than to look for improved methods of eliminating already formed, unwanted products. Therefore, the second-decade objective from now towards the year 2000 is to prevent rather than to cure, to apply prophylaxis rather than to undertake treatment. There does not exist any miraculous method for achieving this goal. It can only be reached by applying a great deal of creative and hard work.

Deciding priorities to reduce the formation of pollutants must be based on the relative importance of the individual product groups. Efforts will lead, over a period of time, to a drastic reduction of the amount of waste formed. It has to be kept in mind that even the application of the best technology will yield some by-products which cannot be used. They will have to be burnt and thus reduced to cinder and ash which will have to be deposited safely. In this form they will not cause any harm to the environment.

Looking closer towards the year 2000, it seems certain that the last decade of this century will bring even more rigid legislation. Based on today's standards, this future legislation may require less than 5 per cent, probably only 1 per cent of any pollutant. It may go as far as to reach a "zero discharge." Even though some people, within the US Environment Protection Agency for example, are of the opinion that this goal may be attainable by 1985, the author believes that it will take much more time and ingenuity to reach even an approximation to this objective.

In many classical syntheses, reaction times of many hours are necessary to get optimum yields. In order to avoid decomposition, the reaction times may have to be drastically shortened by increasing the temperature or by feeding unreacted starting materials back to the reaction vessel, thus discarding the batch production procedure and employing a continuous process. Recycling of solvents with minimum losses will have to become a standard procedure.

In a chemical industry producing only one or a few products, it is relatively easy to optimise processes within a short time. In the case of a company like CIBA-GEIGY, with a complex line of organic chemicals, where many hundreds or even a few thousand products are made, it is completely impossible that all this new technology can be developed and introduced within a few years. In the case of a dyestuffs producer, a full range of products consists of several hundred individual products which have to be produced in batch processes. They cause more or less different environmental problems and solutions have to be worked out on a case to case basis. It would make the life of the dyestuffs producers much easier if they could produce only a few dozen, instead of a few hundred, individual dyes. But it must be asked whether customers and consumers are willing to renounce a great number of shades, thus enabling the dyestuffs producers to find easier solutions of the environmental problems.

This is only one problem. Consumers are responsible for a second one as well. The colours of our clothes, shirts, sweaters and ties, etc, have to be bright, brilliant and light-fast. These properties are based on very stable dyestuffs molecules. From the environmental standpoint, however, the more stable dyestuffs are, the more difficult will they be to degrade after use. This leaves a clear-cut dilemma between customer and producer.

Was dyestuffs research misled due to exaggerated desires of the consumers concerning lightfastness, stability against chemicals, etc, and should research efforts be made in the future to develop less stable, but biologically degradable

dyes? It is unlikely that the majority of consumers will ever be satisfied with dyes as unstable as those of plant origin, as they existed before Perkin invented the first synthetic dyestuff over 100 years ago. The author feels that between the two extremes there is enough room for compromise, allowing research to find new solutions to satisfy the needs of both the environment and the customer. Before such research efforts can bear fruit, short-term improvements at the production side as well as at the application end are needed. The first has already been mentioned; the following examples are more specific. They demonstrate the influence of different dyeing procedures on the amount of effluent, on the effluent load or on other pollutants resulting from different application procedures.

1. Influence on the amount of water used in processes to dye 10,000 metres of a fabric containing two-thirds polyester and one-third of cotton.

The amount of water necessary for dyeing and rinsing can be seen in the following table:

Process	Amount of water used for dyeing and rinsing (litres)
A. Winch-dyeing	270,000
B. High temperature Baum dyeing ..	90,000
C. Thermosol-exhaust	362,000
D. Thermosol-pad-steam	24,000

The amounts of water necessary vary from 24,000 litres (process D) to 362,000 litres (process C), which are in the ratio 1 : 15. The choice of the equipment and the process used may have a dramatic influence on the volume of effluent formed.

2. 30,000m² of a polyamide carpet are dyed in three different types of equipment and processes with 500kg of dispersion dye.

The following results are obtained:

Process	Unused dyestuff %	Amount of chemicals in effluent	Amount of water
A. Winch-dyeing	1.5	2,475kg	2,025m ³
B. Fluid-o-therm (Artos)	7	2,030kg	1,350m ³
C. Continuous carpet dyeing	3.5	1,350kg	600m ³

Process A is by far the best concerning unused dyestuffs. Process C produces the smallest amount of effluent chemicals and requires the smallest volume of water. The preferred procedure, therefore, can be chosen only for a given set of circumstances.

3. Elimination of chemicals hazardous to the environment.

In the sulfur-dye processes, sodium sulfide and chromium salts, which are both harmful to the environment, are used. By replacing sulfur-dyes by reactive dyestuffs, cotton can be dyed without these two chemicals.

A practical case is as follows:

In order to dye 100kgm of cotton garments, 19kgm of sodium sulfide and 3kgm of chromium salts are necessary.

If the sulfur dyes are replaced by reactive dyes, auxiliary chemicals, such as sodium sulfate, sodium carbonate and a small amount of sodium hydroxide are necessary. All three are non-toxic in the amounts needed and do not cause any harm to the environment.

4. Crease resistant finish.

Crease resistant finishes were made hitherto with formaldehyde-urea resins. At higher temperatures formaldehyde was given off and polluted the air, causing inconvenience from the hygiene standpoint. By using reactive resins of the glyoxal-urea or propylene-urea type, formaldehyde is eliminated as an air pollutant and no further rinsing is necessary, so that the formation of up to 10m³ of effluent per ton of cellulose garment can be avoided.

These examples should exemplify how, with the right choice of a dyeing process, with the most suitable equipment, and with the optimum dyestuffs, considerable improvements in dye-houses become possible.

These solutions taken individually may not mean a great achievement; however, taken collectively they represent a significant improvement from the environmental standpoint.

In the field of dye-printing analogous improvements have been realised. The conventional processes, using hydrocarbons in large amounts, have been replaced by procedures working without organic solvents. Although they offer a real advantage from the air pollution standpoint, they are not free from drawbacks as they need considerable amounts of inorganic chemicals, such as alkali, potash and salt.

An elegant new method is the transfer printing process which uses paper as an intermediate. The printed papers used to deposit the dyestuffs on the textile can be burned at the end of the process. In addition to yielding dyes of excellent colour quality, this procedure does not cause any effluent and only minor pollution of the air. Unfortunately its applicability is limited.

During the production, as well as during the application procedures of dyes, some problems occur which are typical of this group of chemicals. Some of the intermediates are coloured materials, which can colour effluent and can be deposited in the form of solid particles on the ground. This is true in a more pronounced way for the finished dyestuffs. Even today small quantities (in fractions of a percent) are visible in water and consequently give rise to concern. Fortunately, most dyestuffs have a very low mammalian toxicity, so that they do not cause problems in this respect. It must be borne in mind, however, that most dyestuffs today are produced in aqueous solutions, thus yielding quantities of effluent which are of a much higher toxicity than those of the dyestuff itself.

An arbitrarily chosen example is the production of an acid wool dyestuff:

Production of 330kgm of an acid wool dyestuff

Intermediates	516kgm	Unused intermediates	95kgm
Auxiliary chemicals	592kgm	Auxiliary chemicals	
		in effluent	515kgm
Water	15,180kgm	Effluent	15,560kgm

It is obvious that for production procedures of this nature drastic improvements are technically feasible. Those improve-

ments already mentioned in the examples of applications are equally valid for the production of many dyes. The realisation of these improvements is a long, tedious and costly process. As already stated, this process could be considerably simplified if the number of dyestuffs used could be reduced to a fraction of the products in use today. A reduction in the number would have the additional advantage of making both storage and handling easier.

A limitation on some categories of dyes may come about from an entirely different source. The competitiveness of metal-containing dyestuffs may suffer in the future due to the rising costs of metals, such as copper and chromium. Such heavy metals are toxic to the micro-organisms present in biological effluent treatment plants, so that they have to be eliminated to a very large extent. EPA, in the United States, already requires a reduction to a few pounds in the total effluent of a one-day production. Whether such values can be achieved technically today is at least questionable. The author's personal opinion is that the future technology in dyestuffs production, as well as in their application, will bring basic, new developments, resulting in considerably smaller amounts of effluent. But it is his conviction also that we shall always have to live with a certain amount of pollution from dyestuffs production and application. The order of magnitude may be taken by comparing the production figures for dyes and some other products such as polymers or fertilisers, although no direct comparison is possible between the tonnages on the one hand and the amount of waste on the other. The world-wide production of dyes is in the order of 700,000 tons per year, compared with 3,750,000 tons of synthetic fibres, 40,000,000 tons of nitrogen fertilizers, and 45,000,000 tons of phosphate rock.

Even though the production of one ton of a dyestuff may yield more waste than the production of one ton of a fertilizer, the contribution of dyes to the ecology problems of the total chemical industry is relatively small. A further indication of this statement is that in the US alone the amount of impurities in the air is 125 million tons, which is about 150 times higher than the world-wide production of dyes. This should by no means mislead us into decreasing efforts to improve the production and the usage of dyes, it should merely indicate the relative proportions.

Solid waste

A few remarks on the solid waste caused by the chemical industry in general and by dyestuffs in particular may be made. Considerable amounts of unwanted products are formed in the manufacture and use of dyestuffs. Many are inorganic compounds, either acids or salts. In nitration and sulfonation reactions, great excesses of sulfuric acid are used, which results in highly acidic wastes. If neutralised, gypsum is formed which has to be separated. Filter-cakes, although mostly consisting of harmless inorganic salts, are coloured and may cause problems when deposited. The substitution of water by organic solvents will form residues, after distillation, which cannot be recycled. The elimination of chemicals which cannot be re-used will have to be achieved by burning. The ashes can then be deposited without harm to the environment.

It should be pointed out that chemical production in the field of dyestuffs without formation of solid waste is impossible. This will continue to be true, even if all the measures indicated above (such as recycling, process improvements,

continuous processes, etc) can be put into practice by the year 2000.

Conclusion

The world-wide concern about harmful influences of any production process or product on the environment imposes an

obligation on the industry on the one hand, but provides a challenge on the other. Only by a concerted effort can the risks associated with the production and application of goods be sufficiently reduced. A contribution from everybody will be necessary to allow mankind to survive in a decent environment for a long period of time.

[Received 9 February 1973]

Discussion at Eastbourne Conference

MR D. S. NEWTON asked Dr Gysin about the possibilities for organisation for international control of pollution—for example, along the Rhine—with a view to unifying the legislation, which would hopefully increase the overall purity in rivers and atmospheres.

DR GYSIN said that there were several bodies studying this question; for example, there was the International Rhine Commission. They would never achieve any realistic

goal, it was just too slow, and there were too many different opinions. The European Council in Strasbourg had made some realistic suggestions and there was no doubt that this river basin had to be treated in a way which had been done in the UK for a long time. Dr Gysin expressed his hopes that since the UK has joined the Common Market, some of the positive steps made in this country could be applied in the new EEC, and help to bridge the different opinions which existed, especially between the German and Dutch on one side and the Italian and French on the other.

Tomorrow's packaging

By G. Scott

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Summary

Much of the litter found on the coasts of Britain has been shown to be seaborne, and some of it not even of British origin. Samples up to ten years old have been recovered and estimated, from their physical condition, to have at least a further ten years' life intact.

Owing to their lack of hydroxyl groups, many plastics are not wetted nor penetrated by water, and hence are not subject to microbiological attack.

The breakdown of many polymers is by photolysis of the hydroxyl

group with the formation of hydroperoxide. Breakdown of the latter provides free radicals which abstract hydrogen from the polymer chain leading to further scission of the chain. It is usual to incorporate ultra-violet absorbers to prevent this action.

It has been found that metallic derivatives, notably metal dithiocarbamates, are able to act as anti-oxidants during processing and to provide a useful working life, but eventually the metal acts as an activator for oxidation and makes complete biodegradation finally possible.

Keywords

Service or utility

biodegradation
photo-oxidation

Miscellaneous

pollution
polymers

Les emballages du demain

Résumé

On a montré que beaucoup du détritrus qui se trouve sur les côtes britanniques a été déposé par la marée, et que ce n'est pas même d'origine britannique. On a récupéré des échantillons qui ont duré dix ans et que l'on estimait, en raison de leur état physique, de posséder la possibilité de survivre encore une dizaine d'années au moins.

A cause de l'absence des groupements hydroxylés, beaucoup de matières plastiques ne sont pas mouillées ni pénétrées par l'eau, et par conséquent ne sont pas assujetties aux attaques microbiologiques. La désintégration de beaucoup de polymères se produit par la photolyse du groupement hydroxylé et la formation d'un

hydroperoxyde. La décomposition de celui-ci fournit les radicaux libres qui enlèvent l'hydrogène de la chaîne polymère, et qui provoque également une autre rupture de la chaîne. Afin d'empêcher cette éventualité, c'est normal d'incorporer les absorbeurs des rayons ultra-violet.

On a trouvé que les dérivés métalliques, notamment leurs dithiocarbamates, peuvent agir comme les agents anti-oxydants lors du procédé de confectionnement, et peuvent assurer la vie utile, mais où enfin le métal agit comme un activateur d'oxydation et assure la possibilité de la biogradation totale.

Die Verpackung von Morgen

Zusammenfassung

Ein grosser Teil der Abfälle, die man an der englischen Küste vorfindet, erwiesen sich als vom Meereswasser angeschwemmt und zum Teil nicht einmal aus Britannien stammend. Man fand bis zu zehn Jahre alte Exemplars und schätzte, dass diese dank ihres guten physikalischen Zustandes mindestens weitere zehn Jahre intakt bleiben würden.

Viele Kunststoffstoffe werden, weil sie keine Hydroxylgruppen besitzen, weder von Wasser benetzt noch durchdrungen und unterliegen deshalb keinem mikrobiologischen Angriff.

Der Abbau vieler Polymerer beruht auf Photolyse der Hydroxyl-

gruppen unter Bildung von Hydroperoxiden. Abbau letzterer erzeugt freie Radikale, welche der Polymerkette Wasserstoff entziehen, was zu weiterer Aufspaltung der Kette führt. Üblicherweise werden zur Verhütung dieser Reaktion Ultravioletabsorber eingearbeitet.

Es wurde gefunden, dass metallische Derivate, insbesondere Metalldithiocarbamate instand sind, während der Verarbeitung als Antioxidantien zu fungieren und für lange Verwendbarkeit zu sorgen; schliesslich aber wirkt das Metall als Oxidationsbeschleuniger und ermöglicht am Ende völlige Biodegradierung.

Будущая упаковка

Резюме

Большинство отбросов найденных на побережьях Великобритании выбрасываются морем и некоторые из них даже не британского происхождения. Найденные десятилетние образцы анализировались и обнаружено, по их физическому состоянию, что в них остается еще по крайней мере десятилетний срок жизни.

Благодаря отсутствию в них гидроксильных групп, многие пластики не обмачиваются и не проникаются водой и потому не подвергаются микробиологической атаке.

Разложение многих полимеров происходит путем фотолиза гидроксильных групп с образованием гидроперекиси. Разруше-

ние последней дает свободные радикалы, которые извлекают водород из полимерной цепи и приводят к дальнейшему расщеплению цепи. Обычно применяются ультрафиолетовые поглотители для предотвращения этого эффекта.

Найдено что металлические производные, в особенности металлические тиокарбаматы, способны действовать в качестве антиокислителей в обработке и снабжать полезную рабочую жизнь, но в конце концов металл действует как возбудитель окисления и делает полную биодegradацию окончательно возможной.

* Presented at the 1973 Eastbourne Conference.

Introduction

There is virtually no chemical pollution problem today which the scientist cannot resolve—at a price. The chemist has the ability to manipulate the chemical structure of products and by-products in a way which is bewildering and rather frightening to the layman. Indeed, the layman has some reason to be apprehensive of the chemist's activities in view of the many tragedies which have occurred in recent years as a result of the chemist's skill and nature's inability to assimilate his handiwork.

In the past, very little thought has been given to the effects of chemical technology on the environment. It has been known to the scientist for many years that the major environmental pollution problem in the world's larger cities is associated with the products of the internal combustion engine or with the manufacture of those products. Until relatively recently, however, no one was prepared even to consider the cost of having this problem rectified, although the scientific principles underlying the control of the products of the internal combustion engine are well established.

The problem of packaging litter is more recent, and its effects are primarily aesthetic rather than biological. They are, nevertheless, becoming more and more acute with time since its effects are observed by the public on the countryside and on the sea-shore in the very act of its trying to escape from the pressures and problems of modern civilisation. The very presence of discarded, apparently indestructible, plastic packaging is an untimely reminder of the rather dirty industrial world from which the normal inhabitant of that world is trying to escape.

Plastics

It is a popular fallacy—set about by some of the major manufacturers of plastics packaging and with the active connivance of the chemical industry and government departments—that the private individual, the tourist, the "litter-bug" is primarily responsible for plastic litter on the sea-shore and in the countryside. Even a casual observation of Britain's shore-line dispels this myth. Table 1 lists items collected from a stretch of shore-line in north-west Scotland, which is quite remote and inaccessible to the casual visitor.

Table 1

Plastics packaging identified at two sites on Loch Scavaig

LD—low density; HD—high density

	Site A	Site B	Material of construction
Detergent containers	15	7	Polyethylene (LD)
Bleach, sanitary fluid containers	13	15	Polyethylene (HD)
Oil containers	3	4	Polyethylene (HD)
Cosmetic containers	13	3	Polyethylene (LD and HD)
Aerosol caps	1	1	ABS resin
Buckets and washing-up bowls	7	2	Polyethylene (LD)
Food containers	—	1	ABS resin
Fertiliser sacks	3	2	Polyethylene (LD)
Thick gauge sheets	—	6	Polyethylene (LD)
Thin gauge sheets	2	—	Polyethylene (LD)
Ropes	—	6	Polypropylene
Fishing nets	—	2	Polypropylene
Miscellaneous unidentified	6	3	Mainly polyethylene

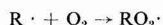
The whole of the litter identified in the Table had drifted in from the sea, and about 20 per cent of it was not even of British origin. Chemical studies indicated that much of it had lain exposed to the weather for ten years or more, and in the case of the items made of low density polyethylene (detergent containers, fertiliser sacks, etc.) their mechanical behaviour indicated that they would probably still be there in ten years' time.

No paper or glass and very little metal were found, and the reason for the remarkable difference between the quantity of plastics and paper is a consequence of their chemical structure. Cellulose and its derivatives are polymers but, unlike synthetic polymers, they contain hydroxyl groups, and this makes them very susceptible to wetting and to being swollen by water. This very fact is one of the main reasons why they are being steadily replaced in packaging by water-resistant synthetic materials. However, because water-borne bacteria can readily penetrate the cellulose structure, they disappear quite rapidly from the environment by biodegradation. The synthetic polymers, on the other hand, are quite resistant to biological attack of any sort. Moreover, all attempts to make the common thermoplastic polymers biodegradable have so far resulted in the destruction of those very hydrophobic properties which make them so useful in packaging.

Ideally, therefore, what is required is a plastic with properties identical to those of the present commercial products, but which will undergo a change under the influence of one or more of the factors encountered in the outdoor environment, leading in the first place to the embrittlement of the plastic with loss of its macrostructure and ultimately to the disappearance of the package by biodegradation.

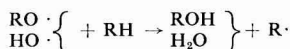
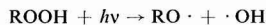
Oxidation

Fortunately, although synthetic polymers are resistant to biological attack, they are all susceptible to varying degrees to oxygen, particularly in the presence of sunlight. They oxidise by a free radical chain process which is now very well understood:



where RH is the polymer chain. The slowest step in this process is the hydrogen abstraction and the rate of this process determines the overall rate of photochemical breakdown. In the case of polyvinylchloride and polyethylene this is a very slow process, but in the case of polypropylene and unsaturated rubbery materials (including the rubber modified polymers) it is considerably faster.

The effect of sunlight is to initiate the above radical process and this occurs normally by photolysis of the hydroxide which is the main initial product of the photo-oxidation:



In the past a substantial amount of work has been done by chemists to stop this process occurring in plastics to obtain long life. This can be done by introducing an ultra-violet screening agent which acts by physically transforming the ultra-violet energy into other less destructive forms of energy.

Hydroperoxide removal

Recently, a second mechanism has been studied in detail. This involves the removal of the hydroperoxide in a reaction which does not involve the formation of free radicals. A very

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important group of compounds having this kind of anti-oxidant activity is the metal dithiocarbamates with the general structure:



These compounds are very powerful antioxidants for rubbers and plastics in the absence of light (since the hydroperoxide is also the main initiator for the free radical chain reaction in the absence of light), and some of the initial complexes (notably the nickel and cobalt complexes) are powerful ultra-violet stabilisers. In this respect they differ profoundly from simple transition metal salts (for example, the stearates, naphthenates, etc.) which are well known catalysts for both thermal oxidation and ultra-violet oxidation of hydrocarbons. Most metal complexes behave like the simple carboxylates, and ferric acetyl acetonate introduced into low density polyethylene (LDPE) at very low concentration before processing causes a very rapid oxidation during processing, with changes in its physical properties afterwards. Such oxidised films embrittle rapidly in ultra-violet light, and rather more slowly even in the dark.

The successful development of a controllable photo-activator system has resulted from the putting together of these two different kinds of behaviour of transition metal compounds. A synthesis of the anti-oxidant behaviour of the sulfur ligands, and the photo-activator behaviour of the transition metal ions, was achieved in the ferric dialkyl dithiocarbamates ($\text{M} = \text{Fe}$, $n = 3$). At high concentrations, this compound behaves in LDPE not only as an antioxidant, but also as an ultra-violet stabiliser. As the concentration is reduced, however, it changes to a delayed action activator with an induction period which decreases with concentration, whilst it retains its thermal antioxidant behaviour even at the lowest concentration.

An essential feature of a practical ultra-violet activator for plastics is that it should give a safe period before any appreciable change in the mechanical properties of the plastic occurs. In addition, it is important that it should not interfere with the normal processing operation. Both these requirements are satisfied by the present system. In outdoor tests, both in the UK and in sunnier regions, it has been found that a very rapid loss of mechanical properties of all the common packaging polymers occurs after a period of time which can be varied between a few weeks and several years depending on the concentration of the additive. The powder products of the photodegradation slowly biodegrade and become part of the natural environment.

Discussion at Eastbourne Conference

MR R. J. WOODBRIDGE asked whether there was a solution to the problem of plastic paint containers requiring a storage life of up to 3-4 years, yet giving fairly rapid decomposition after disposal.

PROF. G. SCOTT thought that there was really no problem here. The problem really had been to produce materials which would degrade fast enough for many purposes. If Mr Woodbridge was talking of something with a lifetime of 3 or 4 years, it would be necessary to say a little bit about the chemistry of the process that the author and his colleagues had been developing, since this was based on an antioxidant

Photodegradable plastics made by this process make use of the present range of cheap thermoplastic polymers which are widely used in packaging. They are only marginally more expensive than the unmodified materials and in some cases they may even be cheaper due to the replacement of expensive stabilisers by the relatively cheap antioxidant/delayed action activator. Carrier bags are now being produced commercially in Finland by this process, and no problems in operation have been found. In general, however, the polymer industry resists the introduction due to a long history in the industry of problems associated with polymer instability both during processing and in service.

It appears to the polymer technologist who has concentrated on empirical solutions to these problems that it must be a retrograde step to introduce new materials which are designed to be less stable. This suspicion springs from a lack of understanding of the capabilities of these versatile modern packaging materials. However, it is becoming increasingly apparent that the future of plastics in packaging must be limited by the problem of accumulating waste. The extraordinary pervasiveness of plastics packaging litter, which is partly a result of its high volume to weight ratio, is being viewed with increasing dislike by the public, and it is now admitted by the most forward looking packaging fabricators that the previous optimistic projections of the increase in plastics in packaging will only occur if photodegradable materials are introduced.

It is perhaps not surprising then that in those countries which have a history of innovation, notably Japan, Germany and Italy, the polymer makers are now beginning to accept this challenge as they see the major outlet for plastics, previously assured, now being threatened by consumer revolt. The plastics industry is entering a new phase in which the previous emphasis on polymer stability for its own sake as a criterion for quality is changing to one of designing polymer lifetime to meet specific consumer needs.

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system. As the Chairman had pointed out, this was the starting point of Prof. Scott's research. The antioxidant gave a lifetime to the product which could be varied over quite wide limits depending on the concentration of additives that were put into it, and a lifetime of three years was no problem at all in his view. The main objective was that after being discarded, materials should rapidly oxidise, and this it did because the antioxidant was converted to a catalyst for the oxidation process. This was the essence of the process, that it changed over very sharply from a stabilised system to an activated system.

MR T. R. BULLETT, referring to the work at Warren Springs essentially on the Kroyer process of domestic waste

pyrolysis, asked whether this was not the best way of dealing with plastic cans, particularly when, as with domestic wastes, there were enough organic bases to neutralise the hydrochloric acid. With biodegradable paint cans, the not inconsiderable amount of waste paint left in half-finished cans could be a problem.

PROF. SCOTT replied that for the reasons he had already given, he did not believe that pyrolysis was the better long term solution but rather incineration, because this did restore the carbon back to the biological cycle. Trying to obtain monomers and simple hydrocarbons by pyrolysis was not a very efficient process; neither was it going to be economical, because unless it provided a source of material which was very well segregated and homogeneous with very few impurities in it, the large number of products from pyrolysis meant that an extremely efficient distillation process of some sort would be required to separate the materials to be used usefully as chemical intermediates. Some of the products could not be used at all, and had to be burnt anyway. He was not an expert in this field, but felt that pyrolysis was not an efficient way of recycling waste materials; it was not as efficient, ultimately, as putting them back into the biological cycle.

Commenting on paint left in the can, Prof. Scott said that a lot of paint disappeared by normal oxidation processes when applied to buildings, and so on, out of doors. For a large surface area, of course, the paint would oxidise quite rapidly, particularly in the presence of ultra-violet light. Paint in a can was a different matter. He could not see that there was any problem with paint in a can which had been standing for a few years actually causing a mess on the floor, because it would probably be solid by this time anyway.

MR J. S. BOROKY asked Prof. Scott to tell him more about the combined ultra-violet stability and antioxidant action of his newly developed plastic additives. If it was correct to assume that a destruction mechanism was activated by the gradual diminution of the compound through exposure to light, then a single paper packaging of the plastic paint container would provide adequate protection against premature destruction.

PROF. SCOTT agreed that this was an interesting point. He had, in fact, brought some slides, which he had not shown because there was not time. These showed a piece of plastic which was covered by a paper label, and all the plastic had disappeared except that which was covered by the label. Mr Boroky was quite right, paper would give this preservative effect, and it was a simple way of protecting the material to last for that length of time.

MR G. A. NEWELL wondered what was preventing the widespread use of incinerators by Municipal Authorities, and asked whether the main consideration was pollution of the atmosphere or cost.

PROF. SCOTT thought that it was primarily cost, but the pollution aspect did come in, of course, because unlike the biological production of carbon dioxide, carbon monoxide was produced too in an incinerator, and if pvc were present, hydrogen chloride would also be produced in a fairly concentrated form. The question of siting the incinerator was probably the main problem. In addition, capital cost would be increased if corrosive materials like hydrogen chloride were produced.

The future for colour measurement in paint manufacture*

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Summary

Three developments in technology are likely to have a marked impact on all industries engaged in producing products in which colour is an important characteristic. These are, first the revolution in the design of colorimeters, which by the use of modern techniques such as integrated circuitry and digital display are able to combine reliability with speed and reasonable cost. Secondly, current work on colour difference measurement can be expected to result in objective methods of specifying tolerances which will be more reliable than the subjective judgment of a single expert colourist. Thirdly, powerful digital computers are now available at reasonable cost which can be linked to spectrophotometers and colorimeters so

that the complex mathematics of match prediction and colour difference calculation can easily be carried out.

These developments will make it possible, long before the year 2000, to define the shade required by twelve digits obtained from a spectrophotometer/computer combination, to predict how the shade can best be obtained, and to calculate how the first attempt to produce it must be adjusted to bring the closeness of the match within a numerically specified tolerance which will have replaced the subjective judgment of an expert colourist.

Keywords

Processes and methods primarily associated with analysis, measurement and testing

colorimetry

Equipment primarily associated with analysis, measurement and testing

colour difference computer

Les perspectives d'avenir de la colorimétrie dans le domaine de la fabrication de peintures

Résumé

Trois développements technologiques semblent destinés à exercer une influence profonde sur toutes les industries consacrées à la production des articles où la couleur est une caractéristique importante. Ces développements sont, d'abord la révolution dans la conception de colorimètres où grâce à l'emploi des techniques modernes telles que les montages intégrés et les représentations numériques, on peut unir fiabilité, rapidité et un prix raisonnable. Deuxièmement, on peut s'attendre à ce que les études actuelles sur la mesure des différences en couleur aboutissent aux méthodes objectives de définir les tolérances qui seront plus fiables que celles de l'appréciation subjective d'un seul spécialiste. Troisièmement, maintenant disponibles aux prix raisonnables sont de

puissants ordinateurs numériques capables de être liés aux spectrophotomètres ou colorimètres de façon que les mathématiques complexes entraînées par la prédiction de contretypage et par le calcul des différences en couleur peuvent à la fois être effectuées avec facilité.

Ces développements assureront, longtemps avant l'an 2000, que l'on peut définir la teinte requise sous termes de douze chiffres rendus par un ensemble spectrophotomètre/ordinateur et, d'ailleurs, que l'on peut modifier la première tentative à contretypage afin d'amener son exactitude dedans les bornes d'une tolérance définie qui aura remplacé l'appréciation subjective d'un spécialiste.

Die zukunft der Farbmessung in der Lackfarbenerzeugung

Zusammenfassung

Drei technologische Entwicklungen werden sich wahrscheinlich auf alle Industrien, in denen Güter erzeugt werden, für welche die Farbe ein wichtiges Charakteristikum ist, stark auswirken. Diese sind erstens die Revolution in der Konstruktion von Farbmessgeräten, welche durch Verwendung moderner Techniken, wie z.B. integrierte Schaltungsmethoden und digitale Sichtbarmachung, imstande sind, Verlässlichkeit mit Geschwindigkeit und erträglichen Kosten zu kombinieren. Zweitens können von den Ergebnissen gegenwärtig über das Messen von Farbtonunterschieden vorsichtiger Arbeit objektive Methoden für Vorschriften hinsichtlich verlässlicherer Toleranzen, als das subjektive Urteil eines einzelnen sachverständigen Koloristen, erwartet werden. Drittens stehen jetzt zu mässigen Kosten mächtige Digitalcomputer zur Verfügung, welche mit Spektrophotometern und Farbmessgeräten

gekuppelt werden können, sodass komplizierte mathematische Berechnungen zur Voraussage der Farbeinstellung und für Farbtonunterschiedskalkulationen leicht ausgeführt werden können.

Diese Entwicklungen werden es lange vor dem Jahre 2000 ermöglichen, den verlangten Farbton mit Hilfe von zwölf aus der Spektrophotometer/Komputer Kombination erhaltenen Ziffern zu definieren, vorauszusagen, wie der Farbton am besten erhalten werden kann und zu berechnen, wie der erste Versuch ihn zu erzeugen korrigiert werden muss, um die Farbeinstellung nahe genug innerhalb die zahlenmässig vorgeschriebene Toleranz, welche an Stelle des subjektiven Urteils eines sachverständigen Kolorists getreten ist, zu bringen.

Будущее развитие в измерении цвета в красочной промышленности

Резюме

Три направления в технологии будут повидимому играть важную роль во всех отраслях промышленности изготавлиющих изделия в которых цвет является важной характеристикой. Во первых—революция в конструкции колориметров которые с применением современной технологии, как например интегрированные схемы и цифровое воспроизведение, в состоянии совместить надежность со скоростью и умеренной стоимостью. Во вторых — можно ожидать что текущая работа по измерению разниц цвета приведет к объективным методам формулировки цветных допусков, которые окажутся более надежными чем субъективная оценка специалиста по цветам. В третьих — мощные цифровые вычислительные машины могут быть получены в настоящее время за умеренную цену, которые

могут быть включены к спектрофотометрам и колориметрам, для облегчения проведения сложной математики прогноза и подбора разниц цветов.

Эти тенденции дадут возможность, задолго до 2000-го года, определить требуемый оттенок, определяемый двенадцатью цифрами полученными из спектрофотометрического вычислителя, для прогноза наилучшего способа получения оттенка и для вычисления первой попытки его получения и регулировки, для осуществления близости подбора в пределах определенных численных допусков, которые заменяют оценку цветного специалиста.

* Presented at the 1973 Eastbourne Conference.

Introduction

The approval of the colour of a batch of paint or of a coloured pigment for use in paint manufacture is still largely an operation which relies solely on the eyes of a skilled observer, the tinter. He is responsible not only for deciding whether a match is close enough but, if it is not, for deciding how it can be adjusted to make it so. This is the only major aspect of quality control which still relies on subjective appraisal and it is difficult to believe that it will still be normal practice in the year 2000. Of course, it could be argued that, as millions of pounds have been spent on trying to achieve accurate instrumental methods since the fundamental basis of colour measurement was established in 1931, it might not be possible to do so, but this is to ignore two significant developments which have occurred in recent years—an intensive study of the problem of the quantification of colour differences and the availability of instruments capable of measuring colour differences precisely and rapidly enough to satisfy the needs of production managers and cheap enough not to worry chief accountants.

The basis of colour measurement

When a paint panel is seen, the viewer experiences a sensation of colour; exactly the same sensation can be produced by viewing a mixture of three coloured lights, the three additive primaries red, green and blue in the correct amounts. Colour measurement is basically simple: it is the calculation of the amounts of these primaries, the amounts being called the tri-stimulus values X , Y and Z .

The concept of colour space

These XYZ values can be regarded as the axes of a three-dimensional Euclidean space in which every colour can be precisely located. This space concept is particularly attractive because if one attempts, purely on the basis of visual appearance, to arrange a random selection of colours in some order, it can only be done in three dimensions, a fact first discovered by the Swedish priest and astrologer Aron Forcius in 1611 and re-discovered in this century by better known arrangers such as Munsell and Ostwald. One of the most important characteristics of the Munsell and Ostwald arrays was that the colours were intended to be equally spaced; Munsell intended that every pair of samples which differed by one hue step, for example, would exhibit equal colour differences. Such considerations never entered into the concept of XYZ space, of course, and it would have been extremely surprising if pairs of colours which were the same distance apart in XYZ space would exhibit equal perceived colour differences. In this sense, XYZ space can be described as non-uniform, and the degree of its non-uniformity is such that two greens which were considered to be on the borderline of a good commercial match could be thirty times further apart in XYZ space than two blues which were also borderline matches. The distance element in XYZ space cannot, therefore, be used to quantify perceived colour differences, and since 1936 over twenty attempts have been made to transform XYZ values mathematically into three derived values that would be the axes of a uniform colour space, so that the distance element would be a reliable quantification of perceived colour difference. These transformations have usually ended up as colour difference formulae or equations permitting the calculation of the colour difference ΔE [Δ change in, E = Empfindung (German: sensation)] from the XYZ values of the component pairs.

The best colour difference formula

Two studies have been made in the paint industry to discover the formula which agreed best with the judgments of professional colourists^{1,2} but in neither case was the number of colours adequate to permit any generalisation. However, the situation is quite different in the textile industry, whose working definition of a "good commercial match" is one that is just close enough to reduce complaints from the retail customer to negligible proportions. This is a definition which must surely be equally acceptable in the paint industry and, if so, it would seem better for the industry to accept the textile evidence rather than to carry out an investigation of comparable reliability, because this would require considerable effort: literally hundreds of sample/standard pairs would have to be prepared and assessed visually at least twice, by a number of professional colour matchers and measured; the colour differences would then have to be calculated using at least ten different formulae and the results subjected to statistical analysis.

Such evidence from the textile industry³ showed quite clearly that formulae of the Adams-Nickerson type correlated best with the mean visual judgment of professional textile shade passers. As a direct consequence of this, the best known formula of this type, generally known as the Adams Chromatic Value formula, with a scaling factor of 40, has been recommended by the Society of Dyers and Colourists and by the International Organisation for Standardisation for textiles,⁴ by BSI for plastics⁵ and by the Society of Leather Trades Chemists for Leather.⁶ This formula is more appropriately called Adams-Nickerson and as the uniform colour space on which it is based has the axes L , A and B , the space is conveniently called ANLAB and the units AN (40) units.

The reliability of the Adams-Nickerson formula

The establishment of the most reliable formula does not necessarily mean that it is sufficiently reliable to replace the subjective judgement of a professional colourist though it has been shown^{6,7} that any single visual assessment is likely to be wrong at least 20 per cent of the time and that, over a representative range of sample/standard pairs, pass/fail decisions made on the basis of a single ΔE value would not be wrong much more frequently. Moreover, there would be a built-in fail-safe mechanism, because most of the wrong instrumental decisions would be rejection of acceptable samples; this merely increases production costs, which is less serious than causing an increase in complaints of off-shade material.

However, in spite of this evidence, it would be extremely unwise for any paint manufacturer to adopt a single ΔE value for all paints produced for a specific end use. Different ΔE values must be established for different colours and one must expect individual values to cover a range as great as 4:1. This is, of course, a measure of the non-uniformity of the most uniform space available, and work is still being carried out with the objective of achieving a space which is more uniform to a degree which would be of practical importance. This may be achieved by AD 2000, but it would be most unwise for any colour-using industry to wait until this happens; instead, appropriate ΔE values should be determined for every shade being produced. For the paint manufacturer this is a much less daunting task than that which confronts the dyer, who may have as many as 5,000 standard shades in his range. The method of establishing the appropriate ΔE value is very simple though time-consuming. For each standard shade, a number of panels must be produced that differ by increasing amounts in hue, strength



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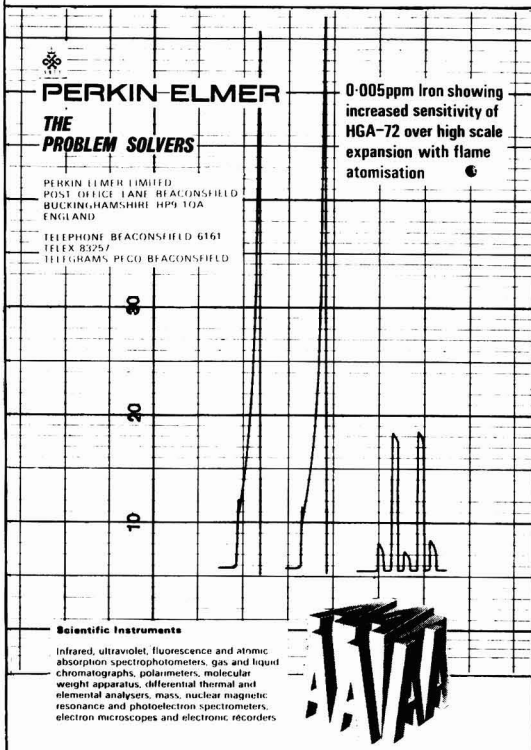
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and dirtiness or any combination of two or all three of these factors. Each is then visually compared with a standard by a number of qualified assessors working ostensibly to the same tolerance, preferably on three separate occasions. A plot of ΔE against percentage acceptability will usually permit the appropriate pass/fail value of ΔE to be determined quite readily. If this is done, then there is no doubt at all that the proportion of wrong instrumental pass/fail decisions will be much less than would occur when the decision is taken by one shade passer viewing the sample/standard pair on only one occasion.

This pre-supposes that the nature of the colour difference is unimportant compared with its size, but it might be found, for example, that the pass/fail value of ΔE when sample was dirtier than standard was less than when it was stronger. One solution to this problem would be to choose the lowest value of ΔE , but this would increase production costs and a much better solution would be to establish different values for each shade. Expressed in geometric terms, the establishment of a single pass/fail value for each shade implies the existence in ANLAB space of acceptance spheres of different radii each centred on a standard shade; different values for each shade implies acceptance ellipsoids centred on each standard shade or even with the standard nearer one focus if, for example, cleanness in a paint was more acceptable than equally perceptible dirtiness. Deduction of the nature of a colour difference is not difficult because a comprehensive study has been made⁸ into the meaning of the dyer's analogous variables of hue, brightness and strength, and it has even proved possible for one of the author's colleagues A. C. Cooper to write a computer programme to predict how a dyer would describe any perceived colour difference from the ANLAB co-ordinates of sample and standard.

Colour difference measurement

Developments in electronics, such as integrated circuitry and digital displays, have revolutionised the design of tristimulus colorimeters, so that it is no longer necessary to balance a micro-ammeter manually for each RGB value, an operation which, together with the need for frequent recalibration, meant that on average two minutes measuring time per sample was required. Today the sample is merely placed over the instrument port, a button marked *X* pushed and the *X* tri-stimulus value appears on the digital display; pushing the *Y* and *Z* buttons in succession provides the other information required, the whole cycle taking only about 15 seconds.

Instruments of this type sell for between £1,500 and £2,000 and one example of this type is the ICI digital colour monitor, now known as the ICI Digital Colorimeter (Fig. 1). These instruments, in common with all other tristimulus colorimeters, are not very accurate, nor are they very precise if used to determine absolute tri-stimulus values, but when used to determine the colour difference between two samples measured within a short space of time, their accuracy and precision is more than adequate for any industrial purpose. Using pairs of tiles from duplicate sets of NPL standard ceramic tiles whose absolute colour differences were assumed to be those obtained from measurements on a GE recording spectrophotometer (Hardy), the maximum deviation in ΔE using any modern colorimeter was 0.32 AN (40) units (0.86 compared with 1.18) and the standard deviation of repeated ΔE measurements never exceeded 0.06; a difference of 0.2 units is never more than just perceptible.



Fig. 1. The ICI digital colour monitor

ΔE values have, of course, to be calculated from *XYZ* values, an operation taking about one minute using a modern calculator such as the Hewlett-Packard HP35 and a cube root version of the Adams-Nickerson formula which gives values correct to within 0.1 units⁹ but three factors may make it worthwhile to install an instrumental set-up which will display ΔE values directly; these factors are, first, the time required to perform the calculation, second, the educational level of operator required and third, the possibility of error. The first of these colour difference meters was the Ducolor¹⁰ (Fig. 2), based on an analogue computer, which displays the components of the colour difference — ΔL , ΔA , ΔB —as well as the total colour difference ΔE ; the price of this meter is £3,415.

The second was the ICI Colour Difference Meter, based on a digital computer, which displays the same values as the Ducolor and sells at £4,500. A more sophisticated version, however, overcomes the difficulty of interpreting ΔA and ΔB values by converting them into the change in saturation or chroma (ΔC) and the change in hue angle (ΔH); this instrument will also display the *L*, *A*, *B* and *H* values of any sample. One important advantage of an instrument based on a digital computer is that it can be re-programmed at any time to take advantage of any developments in colour physics.

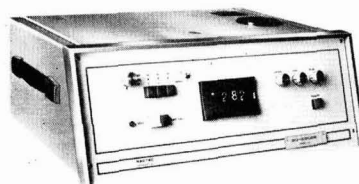


Fig. 2. The Neotec Ducolor instrument

Clearly, once the appropriate ΔE value for any particular colour for any particular end-use has been established, the tinter himself could use either instrument for making pass/fail decisions.

Shade passing against a numerical specification

The two instruments just described require the standard to be measured within a short time of measuring the sample, ideally immediately before or after. If this precaution is not

taken, the reliability of the colour difference measurement falls off badly, so that if the same sample is measured a second time an hour later there will often be an apparent colour difference between them of more than 1 AN(40) units; over several days, differences of more than 4 units can be expected.

If measurements are made on a recording spectrophotometer, these apparent colour differences are minimised but are certainly not eliminated on the GE recording spectrophotometer (Hardy). Daily measurements of the NPL pink ceramic tile were made over a year and the apparent colour differences calculated against one of the measurements in the centre of the array of XYZ values. The mean colour difference was 0.7 AN(40) units, the maximum was 1.7 and the standard deviation 0.3.

Shade passing of wet paint samples

Whilst it is unlikely that instruments will ever become precise enough to permit passing against a numerical specification unless they are prohibitively expensive, the elimination of the expensive and time-consuming step of coating and drying a paint sample before assessment is almost a certainty following the development of the fibre optics colorimeter by the Paint Research Association¹¹ which makes it operationally simple to measure a sample of paint in a container. Whilst it is true that the paint's colour will usually change significantly on drying, all batches made to the same formulation would be expected to change in the same direction and to the same extent if the quality of all the raw materials was consistent. Once this had been determined it would then be possible to measure a dried master standard and immediately afterwards to measure the paint from which it had been prepared on the same instrument. The colour difference between them would then be calculated in terms of ΔL , ΔA , and ΔB , and the colour of the batch measured against these values.

Instrumental batch tinting

If a batch of paint is outside the specified tolerance its pigment composition must be adjusted by tinting. The decision as to what adjustments should be made is generally made subjectively by the highly skilled colour matcher, but this stage may also be replaced by objective methods before the year 2000. In fact, the technique for doing so has been available for about 13 years: it is of course the correction step in instrumental match prediction and it is here, rather than in developing the initial formulation, that the cost of instrumental match prediction is more likely to be justifiable. This is even true in the textile industry, where new shades have to be matched weekly if not daily and re-formulation is frequently necessary to meet increasing fastness requirements or to use new dyestuffs which appear at the rate of 4 per week on average.

The total cost of instrumental match prediction is decreasing rapidly as a result of developments in computer technology and two examples of this will be described in some detail.

Time sharing

Time sharing is a facility whereby any operator can be linked to a powerful computer such as an IBM 370 by means of the national telephone network: all that is required is a standard teletype unit which is connected to the telephone network through a transducer called a "Modem." There are

three major advantages of such a service: first, there is no capital outlay as all the equipment can be hired for about £40 per month and additional payment depends only on the time one is connected to the computer; secondly, computer programmes can be written in the high-level language known as BASIC which is so easy to learn that once the mathematical treatment of the problem has been written down, the programme is virtually written; thirdly, the mode of operation can be "conversational" that is to say the computer instructs the teletype to type out a question or instruction so that anyone capable of typing with one finger can use the computer. The operating cost of such a computing service would be quite low: an initial prediction would cost less than 25p and the cost of each batch correction print-out, only about 5p.

Dedicated computers

A "dedicated" computer is a small computer installed for a specific purpose; the first computer match prediction system to be introduced was the COMIC in 1959. This was an analogue computer, and although match prediction using the technically superior digital computer became possible in 1963, the capital cost of the digital equipment was very much greater. Although the original COMIC is no longer manufactured, a basically similar colour computer, the Redifon is available for about £12,000. However, the cost of digital computers has fallen considerably: the first one ever used for match prediction was an Elliott 803B which cost about £30,000; today an equally powerful, but much more rapid, computer can be obtained for about £5,000. One such computer, interfaced to one of the best spectrophotometers, the Pretema FS-3A, sells for about £17,000 or can be rented for about £300 per month. One advantage of digital over analogue computing is its flexibility, because in addition to prediction and correction it can calculate costs, metameric indexes, colour differences, etc; another advantage is that it can utilise the more sophisticated "two-constant" versions of the Kubelka-Munk equation which give very much more reliable predictions for paints containing only a little white pigment and a third is that predictions can be obtained in one minute after placing the target shade over the instrument port, compared with at least ten and often as much as twenty minutes for an analogue set-up.

Colour measurement in paint manufacture

From the advances now being made in colour physics, in the design of colour measuring instruments and in digital computers, it can be predicted that, by the year 2000, it will be possible to manufacture paint without the need for anyone to assess any attribute of its colour visually: human colour vision will be required only for the initial selection of the shade to be marketed.

The sequence of operations would be as laid out below.

A sample illustrating the shade selected for manufacture would be placed over the measurement port of the spectrophotometer. The command PREDICT would then be typed on the keyboard, which would cause the computer to activate the spectrophotometer and to store the reflectances at every 10nm. The computer would then generate all the formulations which would match this shade and determine the cost of each. The shade constancy of the cheapest would be calculated—this is the change in shade that would occur when the paint was viewed under the electroluminescent panels or other domestic lights in general use at the time. If this value exceeded

a pre-set figure, the values for the second, third, etc., cheapest formulation would be determined until one below the figure was obtained.

This would then be printed out and a small quantity of paint made up and applied to a panel and dried. This would probably be near enough to the original shade to be approved by the selection committee and, if so, a number of panels would be coated and stored in a refrigerator as working standards. The "wet paint factors" would then be determined and from experience gained from manufacturing paints to nearby shades, an appropriate pass/fail value of ΔE would be specified.

When the first batch of paint was made, a working standard of the dried paint would be measured on a colour difference meter and its *LAB* values adjusted by the wet paint factor as already described. The paint would then be measured against these values and, if ΔE were below the prescribed value, the paint would be discharged to containers. If not, the *LAB* values would be fed into the computer which, using the correction matrix generated at the time of the first predic-

tion, would then print out how the batch must be adjusted. This cycle would be repeated until the colour difference was below the specified tolerance.

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Discussion at Eastbourne Conference

MR S. L. DAVIDSON asked what solution could be expected in the future for controlling other attributes of appearance. Secondly, he enquired whether the tristimulus colorimeter indicated metamerism, and what was the solution to this problem.

MR K. MCLAREN agreed that the question of measuring colour was, of course, only one aspect of appearance, but he was not familiar with the problems of measuring gloss. Whether this problem would ever be solved was questionable but, at least with a large proportion of paints, colour was an important parameter and aiming for a standard and a sample with the same gloss characteristics would minimise the problems considerably. Metamerism too was something which could be minimised: in any paint factory, the standard and the production sample should always have the same pigment composition. If a pigment were to go off the market and be replaced by something which was different, then one was faced with metamerism, but once the paint had been re-formulated then a new standard should be set up and everything passed subsequently should be checked against that standard. Problems of metamerism could be eliminated by following this procedure.

MR DAVIDSON said he realised that a spectrophotometric match, not a tri-stimulus one, was necessary to eliminate metamerism, but they were currently faced with the problem in the States of replacing all the chrome yellows and oranges with organic yellows and oranges, because there must be no more than a 0.5 per cent lead based metal in the solid content of the paint. Consequently, they had to make sure that their standards were changed accordingly. It was necessary in the paint industry to match things such as somebody's tie, somebody's dress, and without the same colouring materials. One solution was to persuade the customer to accept the match and to throw away his standard, and then to base production on the sample he accepted. There was a problem of metamerism, but Mr Davidson questioned whether the *LAB* technique would detect metamerism. He did not think so.

MR MCLAREN replied that the uniform colour space will not show it, and the only way to detect it with a tri-

stimulus colorimeter was to change the illuminant from C to A. It was of interest that work was being done at the moment at Bradford University to see if the Adams-Nickerson space was uniform under illuminant A conditions, because if this were so, it would give a reliable index of metamerism, although it would not, of course, solve the problems which Mr Davidson had so clearly described. Problems of metamerism were no more readily solved with instruments than with the human eye, because metamerism affected the human observer as well as any instrument likely to be produced. He agreed wholeheartedly with Mr Davidson's first remark, however; it is always a good idea to have a look.

MR T. R. BULLETT commented that paintmakers had the big advantage over dyers in that tinting of paint in wet bulk was a simple process amenable to feedback control by a process computer actuated by the output from, for example, the Paint Research Association's fibre-optics computer, which might be used to monitor the colour of the bulk batch of paint. Moreover, work at the PRA had shown that control of wet bulk colour could be used perfectly satisfactorily to monitor the colour of the dry film obtained from a standard product.

MR W. CARR thought that Mr McLaren had made a clear and concise survey of the sophisticated techniques now available for measuring colour and calculating colour differences. Despite these techniques, in the case of paints, the rate determining step was the time interval between application of the film and the time when it was dry enough to be presented to the instrument. The development of the fibre optics colorimeter was an attempt to overcome this time delay, but measurements on the wet paints might introduce new problem. He asked Mr McLaren to give an opinion, based either on theory or on his experience in the textile industry, on the validity of measurements on wet paints and to indicate whether comparisons between different samples determined from wet paint measurements would be the same as those determined from the corresponding dry films.

MR MCLAREN said that the problem existed in the textile industry and attempts had been made to solve it. These had been unsuccessful because as a textile was dried from its fully wet state to completely dry one, the colour

appearance changed markedly, and unless the textile was dried very precisely indeed each time, there was no hope of solving this problem.

Mr McLaren admitted that he had no experience with wet paint films; he had mentioned them because he thought they were important, particularly with the development of fibre optics. It seemed to him that if there was a persistent change on drying, then this could be allowed for, and a wet paint could be matched: this would not be a match with the shade it would be when dry, but a match with what it had been when wet. This approach was being used in the textile industry occasionally: certain dye stuffs, on completion of the operation, would change shade, and experienced dyers would match on, say, the green side if they knew the dye stuffs would become more red on drying. When using colour, measurement, the colour difference could be split into its components of lightness, hue and saturation, and such changes could, therefore, be allowed for.

MR C. MEREDITH said that Mr McLaren had mentioned the possibility of matching a wet paint sample to a dry standard, and this was precisely the problem which concerned the speaker at present at the British Standards Institution. In order to check the reprints of the standard paint colour cards (BS4800), the facilities of the Paint Research Association were being used, but it was still necessary to wait until the samples had been dried in order to assess gloss as well

as colour measurement independently, and the adoption of the ANLAB system for this purpose was increasing.

He invited Mr McLaren to hazard a guess whether by the year 2,000, international standardisation of actual colour standards could be achieved, either for the paint industry, or the wider field of textiles or other materials.

MR MCLAREN said that he was only prepared to speculate as far as textiles went, and thought the idea of a national range of colours was a complete anathema to all the interests of the textile industry. One of the marketing features of textiles was the very wide variety of colours that were available, and this was increasing every year. It was mentioned in the paper that there were dye houses with 5,000 standard shades on their range. The commission dyer would, literally, in the course of a lifetime match perhaps half a million shades, which were different in the sense that the one nearest to that which he had dyed earlier would not have been a good commercial match.

DR F. M. SMITH (Chairman) remarked that here was a connection between the papers by Dr Gysin and Prof. Scott and this one. It might very well be that the ecological problems in making dyestuffs and pigments would become so severe by the year 2,000 that there would only be a choice between two or three colours anyway.

Standardisation and the paint industry. One hundred years of standards—a personal view*

By C. Meredith

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Normalisation à l'égard de l'industrie des peintures. Un siècle de dressage des normes—un point de vue particulier

Normung und die Lackindustrie—Seit hundert Jahren Normen, eine persönliche Ansicht

Стандартизация и красочная промышленность Сто лет стандартов—Личный взгляд

Keywords

Specifications, standards, and regulations

BSS
specifications
standard procedure

Introduction

When I was originally invited to contribute a paper on the theme of standardisation and the paint industry to this Conference entitled "Towards 2000," my first inclination was to decline. I was, of course, conscious of the honour that was being done, not to me as an individual, but to the complex of organisations and activities which, for want of a better name, I call the "standards community". This consists not only, and not mainly, of the relatively few professional standardisers who, like myself, are employed by BSI, or ISO or the other standards-making bodies, but of the much more numerous technologists in industry, Government service or the academic world, who spend some, and in many cases most, of their working lives in standards-using and standards-making. If one stretches this definition far enough, I suppose every member of the Oil and Colour Chemists Association has a claim to be included, but even if one limits it arbitrarily and unfairly to those who take an active part in BSI committees concerned with the problems of the paint and allied industries, there must be at least a hundred members of this standards community for every one of us working full time in BSI—at the centre of the web, so to speak.

I hesitated about accepting your organising committee's invitation for two reasons—because it seemed to me that the task was not a possible one, and if it was possible, then I was not the man to do it.

To take the personal doubts first: I am not, and never have been, a worker in the paint industry, or indeed in industry at all. I am not, and never have been, a chemist or a physicist or an engineer. I am not even an enthusiastic do-it-yourself painter, who can discuss at length from personal experience the problems of adhesion, drying time and brushability. My only claim, indeed, to intrude upon an OCCA Conference is that for almost twenty-five years I have worked as a technical officer in BSI's Chemical Department servicing the standards community in a wide range of industries from adhesives to wood preservation, and for the past ten years or so I have been connected with, and in some degree responsible for, BSI's work of direct concern to the paint industry. I am sure that I have learned a good deal in this period, and I hope that I am still learning, but that still leaves me very much a layman when considering the technical problems of your industry and their scientific background.

The technical objection to undertaking this task struck me as even more weighty. It arises from the fact that standards-making is essentially a service—to industry, government, the professions, and the community at large—that strives to keep pace with technical advance rather than to initiate it. Now and again there may be some technical "spin off" from standards work; for example, the discipline of discussing problems round a BSI committee table may lend urgency and a concerted effort to studies already taking place, or the exchange of information through ISO meetings may lead to new lines of work being taken up more rapidly than would otherwise be the case. But these are the exceptions that prove the rule.

In general, therefore, the standards that we draft and publish are seldom completely up to date because "the only thing that is permanent is change"; they can never, in the nature of things, be ahead of their time. In trying to look ahead to present to you some picture of standardisation as it will affect the paint industry in the year 2000, I therefore have to overcome a double handicap. The other contributors to this Conference, each of them experts in their own fields, can look into their respective crystal balls and describe their visions of what the next twenty-five years or so may hold for the paint industry. My own crystal ball is cloudy in the extreme because, to change the metaphor, their output is my input. To try to express "the shape of things to come" in terms of standards is thus a second order prediction.

In spite of these very real difficulties, I finally allowed myself to be persuaded to contribute this paper; and that for two main reasons, one personal and one professional.

In the first place, I like paint people; although not one of your number, I feel at home in your company and I think I can understand what you are trying to do. Nowadays your industry, in the developed countries, is a part of big business, and employs the most advanced equipment and technological ideas. Nevertheless, to me it retains something of a human side which I find attractive. Your objectives as paint technologists, and the commercial success or failure of the firms for which you work, are directly related to the satisfaction of people's needs. It seems to me no accident that the paint industry, like relatively few others, has been involved in two major areas of interest to the consumer, by which I mean the man-in-the-street. The first is "do-it-yourself" which has blossomed so vigorously in the past

* Presented at the 1973 Eastbourne Conference.

twenty years and which will, I feel sure, continue to flourish. The second is the interest of consumers, and especially their representative organisations, in paint testing. I shall return to this theme later because I see it as one of the trends observable in our current activity which is likely to become increasingly significant in the future.

My second reason for undertaking this task was my recognition that any professional "standardiser" needs, from time to time, to stand back with a certain degree of detachment from the daily stream of paper work, committees and technical problems. He needs, if not a sabbatical year, at least a briefer respite, during which he can assess both the objectives of his work and the methods by which he is seeking to achieve them. Because of the pressures under which we operate, it is in practice very difficult to "see the wood for the trees", but the commitment to write this paper has forced me to make the attempt. I can only hope the resulting pages will prove as interesting to the reader as the effort of writing them has been to the author!

Before concluding this introductory section, some explanation seems necessary for the title "100 years of Standards" selected for this paper. It is impossible, of course, to put a starting date to the ideas and practice of standardisation; in one form or another they stretch back to the very dawn of human history. One essential characteristic of the earliest men and women—as thinking social members of the animal kingdom—was the development of spoken language as a means of communicating information and ideas. We often today refer to standards as providing "a common language" for communication between technical people or between buyer and seller. We can equally well describe language as "the first standard."

But standards organisations, unlike standardisation itself, do have recognisable beginnings. The British Standards Institution, which is the oldest national standards organisation in the world, was founded in 1901 as the British Engineering Standards Association and the first British Standard was published in 1903. As a matter of interest the first standard, BS 1, was subsequently incorporated in BS 4 Structural steel sections, but BS 2 Tramway and dock rails and fishplates, is still going strong; the current edition (non-metric I regret to say) dates from 1944.

The BSI is thus today a sprightly seventy-two-year-old, and in the year 2000 will be on the threshold of its centenary.

So as to avoid any impression of discourtesy, I must at least mention in passing that the foundation of the American Society for Testing and Materials—which, as you know, includes in its multifarious activities many of the functions of a national standards organisation—in fact preceded the birth of the BSI by about four years. There have been continuing efforts over the years to express organisationally the extensive co-operation that exists in practice between the ASTM and the American National Standards Institute—either by direct merger or, perhaps more realistically, by absorbing both bodies in a new foundation that could speak authoritatively, on the international level as well as in national affairs, for the standards community of the United States. There are substantial difficulties in the way, but if they can be overcome, which could well be before the year 2000, the fuller participation of the USA in international standards work would be much assisted. This seems to me so desirable that it would be a small price to pay if BSI, as a consequence, had to accept demotion to the status of "second oldest national standards organisation".

The remainder of this paper is divided into three sections

- (i) A description of the general purpose and philosophy of standardisation.
- (ii) An attempt to define significant trends in standards activity at the present time, and on this basis to make some forecast of likely developments in the next twenty or thirty years.
- (iii) A section in which I try to relate the first two sections to standardisation in the paint and allied industries, as it is now and as it seems likely to develop.

Purpose and philosophy of standardisation

This is a subject that does not usually receive the attention it deserves. Professional standards people may turn their minds to it, when they have a spare moment from the pressing needs of committees, drafts and co-operating organisations, but for the rest I think standards are usually taken pretty much for granted, unless they happen to conflict with something of direct personal interest. As in the case of other activities, however, the "why" and "whether" of standardisation is every bit as important as the "what" or "how".

As workers in this field, we may like to assume that our activities are worthwhile but we must not be surprised if others sometimes decline to take this on trust. We need to be able to explain our objectives and our achievements, and to justify the existence, not only of specific projects in standardisation, but of standards organisations as the chosen instruments to carry them into effect.

Accordingly, I sketched out a section of this paper and started putting down a few notes. Before I had gone very far, chance came to my aid, through publication by the International Organisation for Standardisation (ISO) of a book entitled "The Aims and Principles of Standardisation." This is one of the results from several years of work by a group of experts constituting the ISO Standing Committee for Study of the Principles of Standardisation (STACO) under the chairmanship of Mr T. R. B. Sanders, engineering adviser to the BSI. As compiler and editor of this book, Mr Sanders has presented, in my view very successfully, in only just over 100 pages, both a great deal of essential information about the work of ISO and an excellent analysis of what we may call the philosophy and methodology of standardisation. (At £1 from BSI.)

One of the basic principles of standards work is to build on what has gone before. Our Director General, Mr Feilden, frequently urges his staff at BSI, "Try to see that your Committees don't waste their energies in an attempt to re-invent the wheel!". I am sure you will forgive me if I apply this principle by making use of Mr Sanders' book instead of trying to rewrite the material in my own words.

With the author's permission, I have reproduced as an appendix his introduction and first chapter. In these he introduces the following essential ideas (among much else):

Standardisation is a theme inherent both in nature and in all human activity.

The aims of standardisation include:

- Simplification of products and procedures
- Communication
- Overall economy

- Safety, health and protection of life
- Protection of consumer and community interests
- Elimination of trade barriers

(To which I would add that the role of standardisation in education and technical training is worthy of separate mention.)

Standardisation may be described in terms of:

- Subjects (material objects, abstract concepts, symbols etc.)
- Aspects (specification, analysis, testing, sampling, inspection, code of practice, terminology etc.)
- Levels (international, regional, national, company etc.)

Standardisation may be represented in terms of:

A 3-dimensional "standardisation space"—that is a sort of honeycomb framework within which separate standards projects can be accommodated and related (see Fig. 1 in the appendix).

Although placed for convenience in an appendix, this material provides the essential foundation for the remainder of my paper. I suggest, therefore, that it should be read at this stage.

Anyone reading Mr Sanders' book, or even the few pages I have borrowed for my appendix, will not be likely to accept any of the rather facile generalisations that are sometimes made about standardisation: that it holds back technical advance and creativity; that it eliminates variety and freedom of choice in favour of uniformity and regimentation; that it discourages efforts to improve quality and depresses everything to a minimum level. From my experience, the only generalisation I feel it safe to make is that standardisation is infinitely flexible, capable of meeting a wide variety of needs and able to move with the times. Of course, standardisation is a tool, which like other tools can be misused; standardisation provides a mechanism for registering agreement, but has no power to create agreement where none exists; standardisation can be too detailed, on the one hand, or insufficiently precise on the other, so that it does not realise its potential benefits to the full. But all this really amounts to is that standardisation is a human activity and even standardisers are human!

One particular source of misunderstanding is the word itself. If we look at the definitions of "standard" in one of our leading dictionaries we find the following meanings, amongst others:

- in metrology—a basis of measurement, an established or accepted model
- in chemistry—an exemplar or substance chosen to be or afford a unit
- in religion—an accepted authoritative statement of a church's creed
- in education—a grade of classification
- in morality, or in industry—a definite level of excellence or adequacy required, aimed at, or possible.

In BSI and ISO we are concerned with all these meanings, and several others not yet found in the dictionary, as the rest of this paper may serve to indicate.

Trends and forecasts

In trying to identify what is significant in the present standards scene and to forecast what changes and developments may be expected during the next twenty-five years, I have chosen seven themes for comment:

1. The scale of standardisation activity.
2. The content of standards.
3. The organisation of standards work according to industries.
4. The use of standards by governments and other regulatory bodies.
5. The emphasis on international standards activity.
6. The concept of "standards for the consumer".
7. The concept of "standards for the community".

In the first place, then, let us consider what is now increasingly referred to as "the standards explosion". This is part of the general "communications explosion" that has become so familiar—but not, for most of us, acceptable—in the past few years. More papers, more monographs, more journals—it seems to have become a full-time task to read even the abstracts and the reviews, let alone the original work itself. In the standards world, the output of BSI levelled off somewhat after a very rapid expansion in the 1960s, and for the past few years we have published annually about 500 new or revised standards. At that rate, and allowing for a small percentage of standards withdrawn because they no longer serve a useful purpose, our total stock of standards publications of all types—at present about 6,000—will exceed 10,000 by about 1980. In fact, the rate of advance is likely to be considerably greater. Two indications are sufficient to show why: the number of projects in hand in BSI Technical Committees, including participation in international projects, increased by 55 per cent in the four-year period 1968-9 to 1971-2; and the total number of ISO publications, most of which find their place sooner or later in British Standards, is forecast to advance from 2,500 to 10,000 in about ten years.

Looking ahead, it seems evident that this increase over today's standards will not be merely a numerical expansion—"more of the same". We can foresee also the extension of standardisation into fields that at present remain virgin soil or are only sparsely cultivated. Turning back to the concept of standardisation space (illustrated in Fig. 1), we may expect substantial proliferation along the x axis, in the subjects or domains that will prove to be susceptible to the techniques of standardisation. Some increase is also probable among the aspects along the y axis, by filling in the gaps in the present coverage (on some subjects we have a standard terminology, for example, but no specifications; on others we have standard methods of sampling and test, but no guidelines as to good practice in the application of the products, etc.). Only on the z axis, listing the various levels of standardisation, may we hope to avoid unnecessary duplication, and indeed in many cases to achieve an actual reduction, for example by adopting an international standard verbatim as a regional, national or company standard.

Although I can make some guesses regarding the next ten years, I am not going to forecast what the total number of standards, whether at the national or the international level, may be in the year 2000. There are doubtless some powerful limiting factors at work, if only in the resources available to the various standards organisations, to cope with a vastly increased workload even with such expansion in finance

and staff as can reasonably be foreseen. Even if we are able to solve the problem of recruiting, paying and servicing many more full-time professional standardisers, there will remain the allied problem, which may prove more intractable, of finding and financing the standards experts to constitute the technical committees through which standards are developed. It is not always appreciated how much the drafting and approval of national and international standards, in area after area of standards work, depends effectively on the part-time efforts of a few dozen, or at most a few score, of people highly qualified by training, temperament and experience. It is not unusual for such people to come to us and say, "I like standards work and find it very satisfying, but I cannot give any more time to it, because my boss wants to know who's paying my salary, the BSI or the firm" (or the trade association, Government department, etc., as the case may be). And from our side we have to recognise that such people can fulfil their essential role in standards-making precisely because they are not employed by BSI, but have the backing of their own organisations, the daily contact through colleagues with practical objectives and achievements, and the access to laboratory facilities, library resources and so on.

I regard this contribution as the essential lifeblood of BSI, or any other standards organisation. But that is not to say that our present way of doing things is ideal and cannot be improved. We are very much alive to the fact that not all our committees are working as well as the best, that sometimes we do not get the right people nominated as members, that some of the meetings are not fully prepared, that not all chairmen are sufficiently ruthless in cutting out repetition, time-wasting or axe-grinding. We are constantly seeking ways to streamline and abbreviate the procedure without endangering our essential task, which I would describe as follows: to find, for a defined problem, what is technically the most satisfactory solution that can command general support. We are already making considerable use of what is usually termed the "Bowly procedure" (after BSI's Deputy President and former Chairman, Sir Anthony Bowly) by which the first complete draft of a standard is prepared by some individual group or association outside BSI, or by a staff officer in consultation with a few experts, and is not submitted to a representative technical committee until after it has been circulated for public comment. In some special areas, for which earmarked funds have been made available from outside sources, we have gone further, by using the services of an expert consultant, seconded to BSI on a part-time or full-time basis for a limited term, who himself makes the contacts and collects the essential information and prepares the first draft standard on this basis. It seems inevitable to me that, in these and other ways, we must impart a greater element of flexibility into our time-honoured and well-tried organisational structure, in order to handle the workload that awaits us in the future.

I do not wish to imply that the potential for standards is infinite—although I am sure this potential will not have been exhausted by the year 2000. To refer again to the concept of "standardisation space," there are a finite number of possible combinations of subject, aspect and level—that is, the number of cells in the imaginary 3-dimensional honeycomb; and within this number not all will represent standards that would be meaningful and likely to command general support. Indeed, one of the developments I expect to see during the coming period is increasing attention to standards potential. By this I mean making a careful analysis in a given subject area, of all the aspects for which standards could be produced and of all the organisations, national and international, that may be involved as either makers or users of

standards. We often do this sort of thing at present, on a limited scale, when a new committee is starting work, but I visualise a more methodical approach. Something on the same lines is involved, so I understand, in the concept of a "comprehensive standardisation programme" that has been developed in recent years in the USSR and other Eastern European countries, in which standards-making is part of the national plan for all sectors of the economy.

Starting with a particular subject or domain—let us say "aluminium pigments" or "corrosion-resistant coatings for steel"—such a programme could comprise:

1. Listing the aspects requiring standardisation, including not only properties of the product, but terminology, classification, test methods, codes of practice.
2. Identifying the government, industrial and scientific bodies capable of contributing to the work or having an interest in the results.
3. Allocating responsibility for investigating and drafting the various standards needed.
4. Co-ordinating the results of the work and arranging for them to be published and utilised.
5. Collecting and analysing data regarding the economic benefits attributable to the programme and the costs of carrying it out.

Whatever procedures are developed to handle the "standards explosion," I have no doubt at all that we must give more and more attention to establishing and maintaining priorities in our work, finding simpler and faster ways to draft, discuss and publish our standards and, in general, economising in the use of scarce resources, both within and outside BSI, so that they are used fully and to the best advantage.

My second comment refers to a feature which is not new but is acquiring greater significance: a growing flexibility regarding the content of standards. It used to be the case that a standard for a product nearly always consisted of a detailed specification with clauses covering dimensions, material, construction and so on. Similarly, a standard test method would usually specify the required apparatus in full detail, or would refer to another standard which did so. This type of standard still figures prominently in our work and has an important part to play in ensuring variety reduction; but it can also be restrictive on the processes of technical improvement and innovation which aim at achieving the same (or better) results by different means.

In recent years, therefore, a lot more attention has been paid to performance standards, in which the service required of a product is carefully specified but considerable discretion is left open as to the means by which this service is achieved. There are obvious difficulties in making sure, for example, that a plastics protective screen will not only stand up to the same tests as a glass screen at the time of installation, but will continue to do so during its expected service life; or in establishing that several different types of accelerated weathering apparatus will give comparable results, not only for one type of paint but for all the types for which this test may be required. But the more we find it possible to overcome these difficulties, the nearer we shall be getting to what most users of standards require, so that the effort to do so is definitely worthwhile.

These developments are in line with the "codes of practice" approach, long adopted by BSF in certain fields and now

spreading into others. These codes establish the principles of what should be done, in terms of the service to be rendered by a given product, assembly or procedure, but do not go into unnecessary and restrictive detail on how it should be done. Examples of particular interest to the paint industry are:

- CP 231 : 1966 Painting of buildings
- CP 2008 : 1966 Protection of iron and steel structures from corrosion
- CP 3012 : 1972 Cleaning and preparation of metal surfaces
- DD 24 : 1973 Recommendations for methods of protection against corrosion on light section steel used in building.

It is worth mentioning that both codes of practice and performance-based standards are more widely developed in the UK than in some other European countries, and our experience in this field is one important contribution we can make to standardisation discussions within the enlarged EEC. This process is taking place already in the fields of building and engineering, in which codes of practice have long been central to BSI's standards activity, and the example will doubtless be followed in other areas of work.

My third comment concerns the dividing lines between industries, and the way in which these are reflected in the scope of particular standards and standardising committees. Perhaps it may be rather a sterile exercise to ask whether there exist, in this or any other country, separate entities which can be called "the paint industry," "the pigment industry," "the printing ink industry," or whether there is really only one composite industry with three branches. But it is, nevertheless, necessary to establish some criteria in order to decide how much ground can be covered by a single group of committees or a single series of standards. One can point to some dividing lines, once distinct enough, that are now becoming blurred; but the reverse process is also taking place. Take for example the pigments industry, which not so long ago was selling its entire output to the paint industry, apart from a small quantity for printing inks. Today, for many pigments, the most important user industries are not paints, but plastics, rubbers, ceramics, and so forth and, of course, where necessary the specification requirements and test methods for standard grades of pigment should reflect this change.

In organisational terms, this changing pattern of relationships requires flexibility of several kinds: greater emphasis on co-ordination of standards activity in neighbouring fields; increased efforts to unify and harmonise whatever need not be different, including the terminology and presentation of the standards themselves; and a tendency to establish joint groups, on a temporary or lasting basis, to bring together all interests likely to be affected by a given project. BSI and ISO are firmly based on a vertical division by industries. but this must not be allowed to hinder effective co-ordination. Thus we have, in BSI, the "across-the-board" Committees C/38, C/39 and C/40 to handle, respectively, the sampling, measurement and testing of chemical products in general. A similar development in ISO, transcending industry divisions, is exemplified on the one hand by the decision to launch a broad-based study of biological testing which will cover food products, starches and perhaps also paper, wood, tobacco, textiles, etc, and on the other hand by the study recently launched in ISO/TC 47 Chemistry of so-called "general methods of chemical analysis" which may in due

course be extended to serve the needs, not only of the many different branches of the chemical industry itself, but also of the numerous other industries (steel, petroleum, foodstuffs, rubber, etc.) that are vitally concerned with chemical analysis.

My fourth comment concerns the interface between standards organisations and governments or other regulatory agencies. This is not entirely the relationship between standards-making and standards-using; BSI, for example, although primarily a standards-making body, also makes copious use of its own standards (as well as some produced by other bodies) when referring to definitions, test methods, etc. Governments also, along with inter-governmental bodies such as the Commission of the European Communities (CCE) or the International Legal Metrology Organisation (OIML) have their own indispensable role to play in standards-making.

A lot of attention has been given recently, especially in ISO, to defining and gaining acceptance for the principle of "reference to standards". This may be summarised as follows.

When any government or similar body requires, for the purpose of legislation or official regulations, to incorporate some technical standard (using this word in its widest sense) it should aim to do so by reference to an established standard, national or international, as the case may be.

If no suitable standard exists, a request to prepare one should be addressed to the appropriate national or international standards organisation.

Only if such a request cannot be met within a reasonable period of time should the Government or other authority prepare its own.

Having prepared a standard in this way, it should be offered for adoption by the appropriate standards organisation, with a view to its use for industrial as well as regulatory purposes.

The advantages of "reference to standards" are fairly obvious and apply to both sides of the interface. On the one hand, a government can secure, through the normal operation of the standards-making process, a technically valid document supported by an informed consensus and backed by scientific studies or collaborative trials as necessary. On the other hand, the official endorsement of a standard, whether on a mandatory or a voluntary basis, gives it an enhanced status which might otherwise take many years to achieve. For both parties, there is the greater flexibility which allows a separate document to be kept up to date, in terms of technological change, more readily than if it were integrated into the legislation itself. It would be wrong to represent this as a straightforward process without pitfalls or as a panacea to be applied irrespective of circumstances. Any government is, with justification, rather chary of giving its stamp of approval to a standard, however worthy, if it has had no say in drafting it, if it may not be in complete agreement with its technical provisions, and if it is uncertain as to the circumstances in which it might be amended or revised. It is the business of standards organisations to overcome these reservations by consulting the government experts at every stage, by according the priorities necessary to meet the legislative time-table and by adopting whatever safeguards may be necessary to ensure that a standard referred to in legislation will not be changed by unilateral action.

This subject is of immediate concern to BSI in the context of the UK membership of the EEC because the Commission, as the body responsible for drafting EEC Regulations and Directives, has accepted the principle of "reference to standards".* The volume of EEC "secondary legislation" is rapidly increasing and most of it will be implemented in the UK by one means or another. It is not surprising, therefore, that the BSI and the other national standards bodies in the EEC countries are giving special priority to this work. Their efforts are directed to ensuring that, in the long run at any rate, as much as possible of the technical material required for EEC legislation will be provided either through separate national standards or, more frequently, through the unified European Standards prepared under the authority of the European Committee for Standardisation (CEN).

In the field of paints we already have some examples of potential European Standards, because we are currently working on a proposal to give this status to three of the ISO Recommendations published in recent years as a result of the work of ISO/TC 35 Paints and Varnishes. The three documents in question are:

ISO/R 1512 Paints and varnishes—Sampling

ISO/R 1513 Paints and varnishes—Examination and preparation of samples for testing

ISO/R 1516 Paints and varnishes—Determination of the danger classification by flashpoint (closed cup method)

At first sight, it may appear unnecessary to have a special procedure for adopting as a European Standard a document which has already been approved by the whole standards community (including the European countries that are members of CEN) as an ISO Recommendation (which would now, incidentally, be known as an ISO "International Standard"). The explanation lies in an important difference in the degree of national commitment to the two types of document. For an ISO Standard there is a somewhat nebulous assumption (a "moral obligation") that in the course of time any existing national standard will be brought into line with the international agreement, and that no new national standard will be published in conflict with that agreement. But no time-limits are laid down and each country decides for itself what constitutes "alignment."

For a European Standard, on the other hand, there is a firm and unambiguous commitment: any CEN member country wishing to have a national standard on that subject must use the exact text of the European Standard unless it voted against the latter's adoption. For Britain, France and Germany—representing the three languages used by CEN—the commitment is even more direct, for the official text of a European Standard is published in the form of national standards of these three countries and in no other way.

In the case of the three test methods mentioned above, this means that the existing Parts A1, A2 and A8 of BS 3900 Methods of test for paints (these are technically equivalent, respectively, to ISO/R 1512, R 1513 and R 1516; they were published a few years earlier and, in fact, provided the basis for the ISO work) will be replaced by slightly amended versions issued in the BS-EN series of European Standards and will be textually identical with the corresponding French and German Standards. The advantage, from

the point of view of "reference to standards", is clear. If the EEC wishes to issue a directive detailing the safety precautions to be taken when handling or transporting products having a flashpoint below a certain level, it can specify that everyone must use the European Standard method, in the certainty that those applying the test in different countries will be following exactly the same procedure and should, therefore, obtain comparable results.

My fifth comment concerns the increasing importance, within the overall "standards explosion," of international work in comparison with purely national work. For some years past BSI has been classifying separately, under these two headings, both the total number of projects we are working on and the proportion of our technical officers' time which is spent in servicing them. Using either criterion, the relative importance of international work has increased steadily and we have no doubt that this process will continue in the future. I doubt whether we shall ever go as far as the Danish Standards Association which announced at the end of 1972 that in future its entire standards-making effort would be directed towards International Standards and it would not be publishing any more purely Danish Standards. Nevertheless, we are taking up, nowadays, fewer and fewer "proposals for new work" at the national level without there being some international counterpart in existence or in prospect, either in CEN or in ISO.

We are thus frequently faced with the problem of "working at two levels" (or even three) with the consequent danger of duplication of effort. Of course, this danger may be reduced, in the natural course of events, by the fact that the same group of experts is likely to be involved, but sometimes this is more effective in revealing duplication than in avoiding it. We are giving a lot of attention to this problem and see the need to find answers to it at two levels: technical and administrative.

The technical difficulties are fairly obvious. In seeking to reach agreement on any international standard (whether it be a weathering method, a range of safety colours, or a pigment specification) there are all sorts of national differences to be taken into account, differences in experience, tradition, level of development, availability of equipment and expertise—not to mention questions of national and personal prestige. If, in the end, complete agreement is impracticable, one usually has to settle for a partial international standard, or one written in rather general terms, to provide a basis or framework for different national standards which remain in being.

From the administrative point of view, we are trying to avoid duplication of effort by ensuring that, as far as possible, the same people (BSI staff and technical experts) have the responsibility for drafting and progressing the national and international projects on the given subject; by increasing alignment of BSI and ISO committee structure and form of publication; and by giving more attention to the timing of the key stages of national and international discussion. The decision last year that, so far as possible, all Draft International Standards circulated for ballot in ISO should be the subject of national consultation in the form of draft British Standards issued for public comment, was a very important step which has already had salutary results, I believe, in many areas of our work.

*In practice the degree of acceptance varies considerably from one department of the Commission to another, which merely illustrates the difficulty of generalising about a body which consists of such a diversity of semi-autonomous departments. This problem is not peculiar to the EEC, for similar differences in approach are found between and within Government departments in the UK.

My sixth comment relates to "standards for the consumer." Of course, the end user of an industrial product or a service, whether this be an individual purchaser or another industry, has always been a main beneficiary of standardisation, which provides an assurance that the product is of the quality claimed and is satisfactory for the use intended. But the growth of an influential "consumers' movement", both national and international, during the past twenty years or so, has had important consequences for standardisation activity as in other fields of public life. If I may refer back for a moment to the ISO book "The aims and principles of standardization," from which I have already quoted so extensively, I doubt whether this would have included a separate chapter "The consumer and standardisation", if it had been published even ten years earlier.

What do consumers want from standards and how should standards-making organisations seek to satisfy their needs? There is no single or simple answer to these questions but a few generalisations may be made, which will serve to point the likely direction of developments in the future.

A consumer wants several things when he makes a purchase, and not all of them are completely compatible one with another. I will mention only four such areas that need to be distinguished.

Firstly, he wants information so that he knows what he is buying and can judge whether it represents good value in relation to his own requirements. This requirement can be met by informative labelling on the product or in association with it, which may be supplemented by a standard specification giving fuller details of the product's characteristics or performance.

Secondly, he wants quality in the sense of fitness for purpose; this involves at least two different concepts. For example a motorist buying paint to touch up his car wants to be sure, firstly, that the type he buys is appropriate to this purpose and is not intended, for example, for painting the front door; and, secondly, that the actual tin he buys complies in all respects with the manufacturer's specification so that, for example, it matches the existing colour. The first concept may be covered in a standard, but the second requires some additional "quality assurance" which may consist in the reputation of the manufacturer, backed by his internal quality control procedures, or may be provided by some independent system of certification such as the BSI "kite mark."

Thirdly, he wants economy with a view to satisfying his requirements at the lowest possible cost. Standardisation, by encouraging variety reduction and longer production runs, may help to reduce prices; on the other hand, standardisation may also operate in the opposite direction for example by imposing requirements as to quality (which may mean more expensive raw materials or production methods) or uniformity (which entails investment in quality control procedures and withdrawal of sub-standard articles from the market). In general, however, the higher unit cost of a standard article is more than offset by the advantages of larger-scale production, reduced costs of distribution, storage and replacement, more uniform performance, and so on.

Fourthly, he wants choice, either between several different quality levels or in some other direction. For example, a consumer buying paint may want to exercise his choice in relation to type (emulsion, polyurethane, etc.), brand (competition may keep prices down), quantity (again mainly from

an economic point of view) and appearance (colour, gloss, texture).

Finally, I would like to comment briefly on "standards for the community". From its early days, standardisation has been primarily associated with industry, using this term in the widest sense to cover extractive, processing and service industries as well as manufacturing industries. More recently, the techniques of standardisation have spilled over into other areas of national and international activity, especially those concerned with health and safety, education and training, protection and improvement of the environment, and so on. Looking to the future I am sure this trend will continue. If it ever was true—which personally I doubt—that "what's good for General Motors is good for the United States", then I doubt if even the most ardent spokesman for private enterprise would regard this approach as adequate today. Many people argue, indeed, that industry cannot be healthy in a community which is ailing, and are, therefore, inclined to turn the aphorism on its head: "what's good for the community is good for industry".

It is not my intention to let this paper stray into the lush fields of political debate and economic speculation, but even if we stick firmly to the future perspectives for standardisation, we are bound to note the likely influence of what, for want of a shorter word, I will call "environmentalism". This started many years ago, in a protective way, in order to restrict or eliminate specific forms of contamination from air, water or earth. Then the discussion was given a much greater urgency, and at the same time became more generalised—the fight against Pollution with a capital P. Recently, the positive concept of maintaining or improving the quality of life has received nearly as much emphasis as the negative anti-pollution concept, and at each stage along the road we find a need for standards. In the future, BSI and ISO alike may expect increasing pressure to prepare such standards as a matter of urgency, in order that they can be referred to in national legislation. The alternative is that the legislators themselves will write the standards; this may be fully justified, and indeed desirable, when the standards involve what are essential political or economic decisions (e.g. the maximum permitted lead content of petrol), but is to be deprecated, in my view, when they deal entirely with technical matters (for example, the appropriate test methods or classification criteria for lubricants).

Standardisation in the paint and allied industries

I now come to the most difficult part of my task. I have tried to summarise, with Mr Sanders' assistance, the aims of standardisation and the principles through which these aims can be achieved. I have dealt at some length with the standards world as it is today, the changes that have already come about and the likely trends of future development. Now I must try to relate these general ideas to the particular case of the paint and related industries, in the hope that I may be able to make some comments on standards today, or some predictions regarding standards for the next twenty-five years, that will be of interest in contributing to your picture of the industry in the year 2000.

A useful starting point—and an appropriate one, as this paper is intended for an OCCA Conference—is to consider the organisations of technical co-operation in the field of paint technology. Here again I am fortunate, for I am able to refer to the work of an acknowledged expert in the field.

Hans Raaschou Nielsen, Director of the Scandinavian Paint and Printing Ink Research Institute, was invited to the USA to deliver the Joseph J. Mattiello Memorial Lecture on 26 October 1972 in Atlantic City. This was a very special occasion—the Golden Anniversary of the Federation of Paint Technology Societies. He chose for his theme “Co-operation—national and international—do we realise its potentialities?”. In the introduction to his lecture he quoted—almost by way of a text—some words which I am very glad to borrow because I feel they help to place all our efforts at international standardisation in the wider context of humanity’s need for international understanding.

“Technical men have a distinct advantage in their approach to international understanding and co-operation. Basically, they speak a common language. Practically, they must deal with the same problems. Their common ground has an expansive area. Their fundamental training tells them that science and technology do not progress on a single track or in a single mind. Co-operation is their most potent motive power.”

These words were first used twenty-five years earlier by J. J. Mattiello himself, in a lecture he gave in October 1947 to the first international paint congress in Paris when proposing the formation of a triple alliance between the paint technologists of the USA, Great Britain and France, which he hoped would expand to include the rest of Europe.

The contacts made on that occasion, in the period when the threads of European life were being woven together again after the disruption of war, were very important in setting the pattern for subsequent co-operation between the American-based Federation of Paint Technology Societies (FPTS), the British-based Oil and Colour Chemists’ Association (OCCA) and the various national associations in Europe. From the latter there were formed in 1950 the Federation of Technical Associations of the Paint, Varnish and Printing Ink Industries of Continental Europe—better known as the FATIPEC—and in 1953 the Federation of Scandinavian Paint and Varnish Technicians (SLF) in which Raaschou Nielsen himself has played such a leading part.

I shall not attempt to summarise this Mattiello Memorial Lecture. The full text has been published in the January 1973 issue of the *Journal of Paint Technology* and I urge those who have not already read it to do so. Mr Nielsen explains the network of organisations that have been developed—on the national, regional or international level—for technical co-operation, and singles out for special mention four specialised fields in which this co-operation can take practical effect:

1. Research, both fundamental and applied.
2. Standardisation, especially of test methods.
3. Information retrieval and documentation.
4. Training and education.

His conclusion is refreshingly outspoken: “It seems to me that national co-operation in many countries is today at a high level. International co-operation, on the contrary, is still plagued by doubts, fears and worries.” This is not stated in a negative way, however, but rather as an indication of the urgency to improve matters in the future.

This then is my first forecast for the year 2000. Looking back from that vantage point another lecturer will doubtless trace the progress made in twenty-five years by paint tech-

nologists, the advances made in technical co-operation of all kinds. Because there is so much leeway to make up, so many “doubts, fears and worries” to dispel, I can safely guess that he will stress particularly the advances in international co-operation. I cannot say, of course, whether he will be addressing a conference of OCCA or one of the other organisations I have mentioned—indeed it is entirely possible, as one result of this international co-operation, that all of them will have joined together by then in a truly worldwide body!

I am tempted to think that this future lecturer will look back in amazement at the situation we have today, where groups of experts, on both sides of the Atlantic (and, for that matter, on both sides of the Channel), can be working away devotedly at all the technical problems of the industry—researching, standardising, classifying, training—but with little more than sporadic and almost accidental contacts between them.

Improved contact and co-operation, whether it takes an organisational form or not, will greatly assist the development of a really international system of standards, but it is important to realise that the efforts now being put into achieving such standards will bear fruit in those other fields of international co-operation. Not only do standards themselves, when completed, provide a common technical language, but the very procedures of standardisation constitute a means of communication between quite different and even opposing interests, a meeting place on neutral ground where sectional points of view can first be analysed into their essential components and then combined into a new synthesis.

This process is evident at the national level but, above all, in international standards work. Many of the ISO Technical Committees have now been functioning more or less actively for ten or twenty years or even longer, and it has been fascinating to watch them grow and develop a character of their own. There is, of course, a continuing turnover of membership, but there is also a strong element of continuity, assisted by increasing mutual confidence and understanding on the basis of shared experience and common effort to reach agreement. To the outside world, the results achieved may appear rather meagre, at least in the early years, but to the participants even an incomplete agreement is worthwhile if at the start it seemed there was likely to be none at all. Each such step along the standards road represents a point of departure for new advances in the future.

My second forecast concerns these new advances and of course I am thinking here in particular of international developments within ISO Technical Committee 35—Paints and Varnishes. ISO/TC 35, which now includes 19 participating countries and 25 observer countries in its membership, started work on a much smaller scale in 1950. The total of ISO Recommendations or Standards published as a result of its labours was: 1950-59, none; 1960-69, 13; 1970-72, 23. There is no doubt in my mind that the next ten or twenty years will see not only the virtual completion of the work currently receiving the larger share of attention in ISO/TC 35—the harmonisation of methods of test and analysis for paints and for the raw materials of the paint industry—but will also see the emergence of international standards in areas where at present they play only a minor part. I will mention three such areas, where standards-making is mainly at the national level for the time being, but where international activity may follow in due course.

Firstly, standard test methods specifically intended to provide the type of information required by the individual

consumer, who is interested not primarily in the properties of a paint as a material but of how it will behave on his windowsill or his car. Attention is thus focused on performance, which is not that of a paint as such, but of a whole system involving up to seven different factors: substrate, preparation, primer, undercoat, finish, application, exposure. With so many variables to allow for or to control, the problems of standardisation are naturally more complex, but I fully expect them to be overcome. As you know, many studies are in hand at the present time on tests to assess the combinations of properties which determine applicability (spreading rate, levelling, sagging), adhesion (paint-to-paint and paint-to-substrate), resistance to weathering, and other important aspects of performance. I hope I am not being over-optimistic in predicting that the tests we have today in these areas will be refined and improved, to the stage where the performance of a paint in practice, at least under certain well-defined conditions of substrate, application and exposure, can safely be predicted on the basis of short-term trials in the laboratory.

Secondly, performance-based specifications are emerging for paints, as in other fields of standardisation. I will take only one example—the Public Authority Standard now in preparation for building paints (undercoat and gloss finish) of the alkyd resin type. This has been drawn up by a technical sub-committee of Product Group 16, Paints, of the Public Sector Standardisation team (PSST), on which were represented government departments, nationalised industries, local authorities and the BSI, and in which representatives of the paint industry also took part. In its draft form, it proposes submission of paint systems for type approval by an Approving Authority—expected to be the Ministry of Defence Quality Assurance Directorate (Materials)—on the basis of the stated requirements and test methods for consistency, brushing properties, opacity, drying time, gloss, resistance to yellowing, mechanical properties (bend test and cross-cut test), durability (outdoor weathering), storage properties and volume solids. It is also likely to require that certain general information on the composition of the paints shall be disclosed, in confidence, to the Approving Authority, in order to make possible an intelligent assessment of their quality and to facilitate monitoring by the Authority's inspectors to whatever extent this is considered necessary.

It is no secret that the technical basis for this specification had earlier been proposed within BSI's Pigments, Paints and Varnishes Industry Standards Committee but did not attract the support from the manufacturing side that would have justified pursuing it as a British Standard project. It remains to be seen whether, and within what period, this position may change, in the light of experience gained in operating such a standard in the public sector.

Thirdly, for at least certain specialised types of paint, which nevertheless represent in all a significant proportion of the total consumption, I believe that product specifications of the more usual type will be accepted as serving a useful purpose. Examples might be fire-resistant paints, mould-resistant paints, marine paints, metallic or other corrosion-resistant paints, and vehicle paints. These are all areas where the service required from the paint is clearly defined, in spite of the variation in climatic or other conditions that may be involved. Moreover, the demand for such paints tends to be fairly stable, they are sold mainly to large-scale customers, and competition between paint manufacturers for the contracts is likely to be acute. In my view, all these factors are conducive to the use of standard specifications and/or classification of paints, according to type and service.

It used to be argued that standardisation in the field of paints would impede technological improvement because there would be little incentive for a go-ahead firm to produce a better quality of paint than the minimum level established by the standard. I do not hear this sort of comment so frequently today, perhaps because wider experience with standardisation in other fields has shown it to be a very flexible instrument, which is perfectly capable of "moving with the times".

My third forecast concerns the shape of the paint industry itself, and its relation with allied industries. I think we can say with assurance that some existing demarcation lines will become blurred or disappear, while others may assume more importance. Let me illustrate what I mean by an example from the last quarter-century, which may help us to extrapolate into the next.

The emergence of the plastics industry as a major force since the second world war has affected the paint industry in at least two vitally important ways. First, there has been a great expansion in the properties, the performance and above all the versatility of paints, resulting from the use of resins as basic paint media, in addition to the oils and the water-soluble or water-dispersible media of earlier periods; I shall come back to this subject later on. Second, there has been the proliferation of coloured and patterned materials, as a result of the development of self-coloured plastics, which along with paints and textiles now constitute the main vehicles for importing colour into our environment.

Looking to the future, I see paints grouped with, and competing against, on the one hand, other types of coatings for the basic constructional materials such as steel and other metals, wood and manufactured boards, and concrete; and, on the other hand, other types of coloured material such as plastics, ceramics and dyed fibres, both natural and man-made.

Have standards a role to play in these developments? I would say undoubtedly, "Yes." Standard methods of measuring performance enable us to compare not only like with like, but also chalk with cheese, to the extent that they have at least some significant properties in common. Standards thus provide a framework of reference, so that alternative products or systems can be slotted in and defined in such a way that comparison between them is made easier. Freedom to choose remains, but it can be an informed choice.

It is commonplace knowledge that paint serves two functions: protection and decoration. Whichever of these we seek (or, as is more usual, a combination of both), paint is in competition with other materials, such as metallic and plastics coatings, and self-coloured materials. Standards can help us, firstly to distinguish and then to measure and compare, each of the major factors involved in this process of competition, such as:

1. Suitability for various substrates.
2. Preparatory work required.
3. Applicability, and skill required.
4. Appearance, in its many facets.
5. Resistance to damage of various kinds.
6. Service life under various conditions.
7. Ease of replacement.

Standards cannot do the whole job, nor should they. There remain various economic considerations to be taken into

account—costs of materials, labour, maintenance and replacement—and also an additional subjective factor, the way we individually look at a problem and arrange the objective factors in a personal order of importance. In some cases the subjective factor will outweigh all the other data in determining our choice but at least if we do this we should do it with our eyes open!

My fourth forecast concerns paint as a vehicle for colour, a role it shares with many other materials. The recent developments in colour co-ordination for building purposes are well known, and those who seek detailed information on the subject will find it in our BS Draft for Development DD 17*, in an article in *BSI News* (January 1972) and in the very valuable *Building Research Digest* 149 (January 1973) "The Co-ordination of Building Colours". The latter publication sets out at some length the scientific basis for the co-ordination project and the way it is intended to be applied, through the standardisation of so-called "satellite ranges" for each of the main groups of materials to be found in buildings. For paints, the satellite range is BS 4800†, which came into effect at the beginning of 1973 as a replacement of, and improvement on, the previous BS 2660‡. Other ranges are being proposed for vitreous enamels, for external colours of farm buildings and caravans, and for ceramic sanitary ware. Consultations to the same end are in progress in relation to plastic wall coverings and other components, ceramic wall tiles, hard and soft floor coverings, and so on.

Originally it was intended that DD 17 should have a life of two years from January 1972, after which it would receive full British Standard status, subject to any modifications suggested from experience in using it. I should not be surprised if, in the event, it proves necessary to allow some slight extension of the probationary period. It is only natural that the advantages of colour co-ordination—the flexibility that it affords to manufacturers and designers within the discipline of a comprehensive framework of colour—should be more rapidly recognised in some industries than in others. The rate at which a traditional colour range can be adjusted to fit in with the co-ordination scheme likewise varies from industry to industry, for valid economic reasons.

One major decision still to be taken is whether—and, if so, how far—the co-ordination scheme should be extended to textured materials used in buildings; not only to carpets, but also to curtains, soft furnishings, and so on. The argument for doing so is very strong, because any designer or decorator is concerned with colour in the whole of the human environment and not only in part of it. The difficulties are also considerable, for example:

A whole new range of industries would be involved.

There are substantial technical problems in comparing and matching colours of different surface textures.

Multicoloured and patterned materials are of greater importance in this field.

The economic significance of rapid changes in "fashion colours", especially in clothing textiles, may prove a barrier to even a flexible range of standard colours.

In view of these difficulties, it was perhaps wise of those who worked out the scheme embodied in DD 17 not to set out from the start to include textured materials in general, or textiles in particular, within its scope. This does not alter the

fact that, with the principles of colour co-ordination fully established in relation to paints, and with firm prospects in ceramics, plastics, and so on, there is a strong case to apply the same principles to the wider field. The flexibility of the scheme is such that this could be done without insisting that precisely the same standard colours must be used; it seems feasible, therefore, that colour ranges could be selected for carpets, curtains and furnishings to fit within the framework established by DD 17, with the result that they would automatically be co-ordinated with the colour ranges for paints and plastics materials.

The other major development I see coming in relation to colour is that the principles of co-ordination and standardisation will be taken up at the international level. My friends in the paint industry tell me that BS 4800 is already widely known and used in several European countries, which is only to be expected in view of the economic links on the manufacturing side and the substantial international trade both in paint and in the expertise of architects and designers.

I have no wish to suggest that what London decides today, Europe and the world will necessarily copy tomorrow; international standardisation activity seldom operates in such a straightforward manner. When working on a larger canvas, whether European or world-wide, there are important factors of climate, tradition and temperament to be considered which did not receive attention at the national level because they were implicit in the whole colour co-ordination exercise. I remember a lady correspondent from South America who made some outspoken comments at the BSI Press Conference in January 1972 when DD 17 was published; she clearly thought that the colours had been selected by people without much experience of strong sunlight!

Even within the EEC countries of western and southern Europe, it is hardly likely that the DD 17 range, or the paint range in BS 4800, will carry the day just as they stand. But I do expect the advantages of colour co-ordination, and the principles on which DD 17 has been constructed, to be readily appreciated. On this basis, a constructive discussion could develop, taking into account also the response of designers and customers when paints from the BS 4800 range are put on the market.

The idea of co-ordination in building operations, especially as expressed in modular dimensions, is currently being applied in many areas of international standards work. As a result, largely, of pioneer efforts by the UK during the past ten years, much attention is being given to this by ISO Technical Division 3 which is responsible for advising and co-ordinating the work of all the ISO Technical Committees concerned with the building industry. If not through this channel, then through others, I feel confident in forecasting that colour standards and colour co-ordination will become the subject of active study at the international level within the next few years.

There only remains one more area of potential standardisation activity that I would like to discuss at this time. It is, however, a very important one, because it concerns the whole process of innovation within the paint industry during the next 25 years, and the standards that will accompany this process.

First, there is the question of substrates. I expect that by the year 2000 we shall be well on the way to completing the

*DD 17 : 1973 Basic range for the co-ordination of colours for building purposes.

†BS 4800 : 1972 Paint colours for building purposes.

‡BS 2600 : 1955 Colours for building and decorative paints.

process, started long ago, of replacing homogeneous timber, metal, brick, and stone as the main load-bearing components in all forms of construction. The newer composite materials—whether they be blockboard or laminated board, reinforced concrete, plastics-coated metal or fibre-reinforced plastics—are less wasteful of scarce natural resources and far more flexible in their potential variety to suit differing applications. As mentioned earlier, some of these developments enter directly into competition with the paint industry as we know it today; but taken together I see them as a real challenge to the industry to adapt to new opportunities and I have no doubt that this challenge will be met.

Second, there is the question of raw materials: paint media, pigments and extenders.

Media. I think it inevitable that the process will continue of displacing the traditional vegetable oils by the synthetic products of the plastics industry, which can be "tailored" to virtually any combination of requirements and which, for the most part, are already competitive in price.

Pigments. A similar process has been taking place for many years and will doubtless continue: synthetic pigments have replaced or are gradually replacing the natural product. The reasons are obvious: the synthetic product can be supplied to a more consistent quality, and its properties adjusted to suit requirements; and there is increasing demand for purity and strength of colour that are attainable with difficulty if at all, from natural pigments. The cost differential that used to favour natural pigments has been reduced considerably in recent years and soon may well be negligible in cases where the workable reserves are localised or require more processing than formerly.

Extenders. I foresee that the trend towards synthetic materials in place of natural products will proceed more slowly. The last twenty years or so have seen the establishment on the international market of synthetic silica and calcium silicate, precipitated calcium carbonate and various surface-treated extenders which, if not synthetic materials in the true sense, have nevertheless quite different characteristics from the corresponding natural products. I fully expect some new synthetic materials to come on the scene during the next twenty years, perhaps in the form of by-products from other industries which will find a commercial outlet in the paint field, but I think most of the naturally occurring materials will remain in use.

Third, there is the question of formulations. You will not expect me to reveal the exciting new products that are under study in research and development departments today, much less those of the 1980s and 1990s. I think we can be certain of one thing, the inter-penetration of the paint and plastics industries, to which I have already referred briefly, will undoubtedly develop further in the future. We have seen new materials introduced in rapid sequence, most of which are still in use today:

- the earliest types of modified natural resins, for example ester gums
- phenolic resins
- urea formaldehyde and melamine formaldehyde resins
- alkyd resins of various types, including polyesters
- polyurethanes
- epoxy resins
- silicone polymers
- acrylic and vinyl polymers

In the course of time, some of these materials—and others which have yet to be introduced—will doubtless fail to stay the course and will be dropped from the repertoire of the paint industry, except possibly for particular specialised purposes. But the process of innovation will clearly continue. Some of the more traditional products will be squeezed out by these developments but, in general, I see the future of the industry as one of fewer, larger firms making a wider variety of products. As in the past, however, I think we shall still be able to distinguish two categories of paints or paint systems: (a) general purpose materials intended for use under rather diverse conditions and tolerant of less well prepared substrates and less standardised application procedures, and (b) special purpose materials giving optimum service only under strictly controlled conditions.

Fourth, there is the question of application procedures, with which I include substrate preparation. As far as domestic paints are concerned, the industry has made great strides in recent years by providing products which depend much less than formerly on the experience and skill of those using them, whether professionals or enthusiastic amateurs. I feel sure this trend will continue, because "do-it-yourself" has come to stay in this country, and will certainly spread to others where it is not yet significant.

At the same time, however, there is a contrary trend to be noted. Many of the modern paint systems, especially for industrial purposes, are relatively expensive in terms of first cost, but their durability is such that they more than compensate for this by their effective service life. Maximum durability can only be obtained, however, if special attention is paid to substrate preparation and to conditions of application. This is particularly true of some of the newer techniques of application such as electrodeposition.

When one realises the economic and political pressures that will develop during the next twenty-five years in favour of conservation of scarce resources (including under this heading some metals and minerals that are now regarded as abundant), it seems obvious that the need for corrosion-resistant coatings will be far greater even than it is today. Perhaps we shall look back with amazement at the days of primitive mass-production, when built-in obsolescence was a characteristic feature of what were nevertheless described as "consumer durables".

Special mention should be made in this connection of the technique of powder coating and other methods of applying thick coatings as a single operation. Much progress has already been made in the continuous coating of steel strip and sheet, which finds application for external cladding on buildings and for domestic appliances. This technique can provide a very desirable coating for heavy duty applications or where regular maintenance is inconvenient or impossible.

Such processes are especially suited to the coating of standard articles or components produced on a continuous mass production basis and it seems safe to predict that strenuous efforts will be made to apply them more widely, for example in the vehicle and construction industries.

Under each of these four headings—substrates, raw materials, formulations and application procedures—there will be an essential role for standards. You will not expect me to forecast with any confidence which of our present standards will remain valid in the year 2000, and which of them will have been replaced by others developed to meet the new requirements. But if I am nevertheless expected to

hazard some predictions, I will content myself with the following:

Terminology. BS 2015 Glossary of paint terms, will be maintained up to date and expanded, possibly even extended to cover surface coatings in general. A comprehensive ISO counterpart will also be prepared.

Raw materials. The BS and ISO series of test methods for pigments (BS 3483 and ISO/R 787) will be completed and updated in the light of technical improvements, as will the corresponding specifications. The similar work on extenders and on paint media will likewise be built up into a comprehensive coverage.

Codes of practice. Much greater attention will be devoted to the subjects of substrate preparation, application procedures, maintenance schedules, and to prevention of corrosion in general. The existing codes of practice, already mentioned, will be maintained and similar codes prepared in the field of industrial and marine paints.

Test methods. The BS 3900 series, which currently includes some thirty-five standard methods, will have extended to perhaps twice as many and the corresponding series of ISO methods will be nearly as numerous. Special attention will be given to tests relating to application procedures, corrosion resistance, and assessment of defects in painted surfaces, and to accelerated weathering and exposure tests of all kinds.

Product specifications. Performance-based specifications will be developed for most of the categories of decorative and industrial paints of major importance, supported by quality assurance schemes involving type approval, testing and quality control surveillance by an independent authority. Some of these specifications and quality assurance schemes will be operating on an international basis, at least in Europe. BS's Hemel Hempstead Centre will play a significant part in testing and inspection, and in the field of quality assurance generally.

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Appendix

A reproduction from the book "The aims and principles of standardization" by T. R. B. Saunders (Editor).

Introduction

Standardisation is not new; it relates to an activity which is "as old as the hills," an expression which may be interpreted literally since nature itself has shown the path for standardisation discipline. For example, nothing is more perfectly standardised than the atom of oxygen or the molecule of water; also, on a higher level, the suns and their planets, or proteins which make living material; finally, beings themselves. Turnips are standardised, so are ducks. Nature, as it assembles particles, fits celestial bodies into space, peoples the earth with human beings, carries everything out according to predetermined rules.

What more wonderful example is there of a precise industrial standard than the swallow's nest or the bee's honeycomb—or of the discipline of standardisation than the work of bees, ants or beavers.

What is new about standardisation is the twentieth-century approach to the subject. In an ever enlarging civilised world, demanding better communications, more and more trade between nations and an insatiable demand for manufactured goods and appliances, standardisation has emerged both as the key to open many doors and also as a discipline which must be accepted by any civilised community if it is to enjoy the goods and services which it is now demanding. This has led in the twentieth century to a whole new science of standardisation and to the development of product standards, firstly at national level and later at international level.

Any improvement in the life of man rests on the possibility of his being able to give the necessary time and thought to the cultivation of his spirit and his heart. For this, the three-fold needs of man—food, lodging and clothing—must require from him and his fellow men less and less time, and the constant improvement of his equipment must afford him more and more effective means to make both his individual surroundings and his public life more beautiful. Production is at the root of this problem in all countries and in all climates. If this production is not disciplined, the looked-for results are not obtained and the economy may suffer. Standardisation is one of the most efficient methods of furthering the harmonious and beneficial development of production sought for in the general interest. But to achieve this aim, standardisation must itself rest on the scientific foundations of efficacy.

Standardisation saves trouble in thousands of everyday matters. Every man's working day depends to an increasing degree on the interaction of typical solutions consciously chosen and established, and on mutual adaptation of one to the other. It depends on the normal appearance of an object and the parts of such, on the normalcy of recurring situations. The degree to which our physical—and perhaps to an even greater extent our psychological—forces are impaired and exhausted depends on the operation of the factor of normalcy. Standardisation is therefore one of a group of factors comprising the general state of the culture of a society. It was once indispensable in the formation of language and the art of writing—a highly perfected means of expressing thought and therefore of the development of science. It played no small role in the development of such an art as music, and it contributed to the beauties of architecture.

The present development of international sport would be unthinkable without standardisation. Rules must be established and equipment standardised, so that chances are equal for all in competitions, and so that results may be compared.

Standardisation has eliminated and continues to eliminate the chance and uncertainty which characterise primitive relationships and hamper the creative human mind. Such an important element as confidence is acquired from standardisation which gives a solid foundation to repetition and disciplined procedure. Standardisation facilitates mental work, introduces order, simplifies and clarifies. It is a factor which assists the profitable exploitation of material wealth and the wealth of the mind already accumulated over various ages and in various fields.

Safety is also to a large extent dependent on the establishment of order and on defining the characteristics of environment, on the elimination of chance and the prevention of the occurrence of new situations in circumstances in which diversity of phenomena and conditions have not been mastered. The same is true of safeguarding—by means of standardisation—manufactures and products, as well as entire

buildings, machinery and equipment, since it is in standards that the appropriate requirements are defined.

One of the indications of a society's material culture is the degree to which success has been achieved in such matters as the control of corrosion or the limitation of damage in transit by means of sophisticated packing. Experience has shown that an important condition for cutting down losses is the understanding and use by the community of standardisation methods, which give many general advantages in the same way as does the application of other principles of rational and effective procedure.

The aims of standardisation

The principal aims of standardisation were defined some years ago by the ISO committee for the Study of the Principles of Standardisation (code name ISO/STACO) as the promotion of:

1. Overall economy in terms of human effort, materials, power etc. in the production and exchange of goods.
2. The protection of consumer interest through adequate and consistent quality of goods and services.
3. Safety, health and protection of life.
4. Provision of a means of expression and of communication amongst all interested parties.

This definition of the aims was fairly widely accepted at the time and is still valid, but it now calls for examination and considerable amplification in view of the massive development of standardisation at all levels during the past decade.

For example, there is now a much wider recognition of the value of standards as a means of communicating ideas and technical data, in creating order out of disorder and offering simplification in place of complexity. Moreover standards are now seen to play an essential role in the elimination of "trade barriers" between nations.

It is apparent that there can be no hard-and-fast division between the various aims of standardisation since they are all interdependent on one another. Where safety and health are concerned, for example, it is seldom possible to adopt the most economical solution.

Where quality is specified the aim of communication is of the utmost importance since the particular conditions must be so expressed as to be clearly understood by all parties concerned.

It is important also to consider standardisation as an activity, and to distinguish clearly between the aims of the activity on the one hand, and the methods and means employed for achieving them on the other: and also to distinguish between the methods employed and the effects which result from the activity.

We shall now take a careful look at the present-day aims of standardisation and attempt to identify them.

Simplification

Modern standardisation should perhaps first be considered as a process of simplification, combating the ever-increasing complexity of human life: Complexity may be compared to a flood tide surging relentlessly forward, which, if uncontrolled, will engulf all before it. Standardisation is one

of the primary means by which mankind is able to control the flood, to gather and disseminate information about it and to discipline its waters, directing them into approved channels for the benefit and safety of mankind.

Simplification is therefore perhaps the first and most important aim of standardisation but communication, safety and economy follow closely behind.

Interchangeability

A very important aspect of simplification is the limitation of variety of manufactured goods and components. This is dealt with at some length in chapter 4 under the heading of "Variety reduction." It can be applied at all levels of standardisation but is particularly beneficial in terms of overall economy to the individual company, where it is the most direct and immediate means of effecting cost savings at the manufacturing stage.

Variety reduction presumes the principle of interchangeability—that is the ability of the manufacturer to produce a large batch of parts which are sufficiently identical in size, shape and performance to enable any one part to be substituted for another, to give the same performance.

No two parts can be absolutely identical and it is the duty of the standard to specify the degree of tolerance (departure from the theoretical conditions) which can be permitted without losing the advantage of interchangeability. A good example of dimensional interchangeability is the ordinary bolt and nut. Screw threads are now so highly standardised that, although vast quantities of bolts and nuts are made all over the world, those of a given diameter and pitch manufactured in one country are completely interchangeable with those manufactured in another.

Sometimes it is not necessary that the internal construction of one article shall be identical in all respects with another, so long as each complete article is dimensionally interchangeable and able to perform identical functions. Examples of this are the standard for ball bearings, where it is sufficient to specify the external dimensions of the complete ball race, together with its performance as regards load and speed, while leaving to the individual manufacturer the choice as to the size and exact number of balls to be used in the assembly. Or again, in the case of an electric motor, essential dimensions and electro-mechanical characteristics may be specified while leaving to the manufacturer the choice as to the number and arrangement of wires in the winding.

In such cases it is usual to talk of "Functional Interchangeability" a term which is defined in Chapter 2.

Standards as a means for communication

We cannot make anything of our social, political or working environments unless we have adequate means of communicating about our needs, opinions and ideas with others. Man's concern, self-preservation apart, has always been essentially to communicate, whether through literature, art, philosophy or scientific discovery. Indeed, the leaps forward in technical and scientific knowledge have very often been milestones in the history of communications: the invention of printing, the development of newspapers, the discovery of radio waves, which have opened up entirely new cultures in radio and television and boundless possibilities in telecommunications, on this earth and in space.

A primary function of standards is to provide a means of communication between the manufacturer and the customer, to list the things which are available, their size and performance and to inspire the customer with confidence that if he orders goods which comply with a standard he can rely on their quality and reliability. As international standards come in, harmonizing and in some cases taking precedence over national standards, the aim of communication becomes even more self-evident.

A great many national and international standards now give a considerable amount of design data as well as advice on how to use the standard and on how to select from it the article most suitable for the particular requirement. This can exercise a powerful influence on customer demand and can assist the overall economy by channelling the demand into certain recognized lines. It has very great advantages but it has its dangers too, if the committees who prepare standards are too much dominated by manufacturing interests. An adequate strength of user opinion and of independent experts and professional men is essential if the standard is to reflect the best and latest practices and achieve its widest usefulness.

Symbols and codes

In international affairs differing languages are always a problem, but in some cases this can be overcome by the use of internationally agreed symbols and codes. Some important examples which may be quoted are the ISO Recommendations on Engineering Drawing Practice (ISO/R 128 and 129); and on the SI units and their use (ISO/R 31 and 1000). The former enable designs to be submitted all over the world, both simplifying the process and minimizing the language problem. The latter provides a means of communicating dimensions and physical quantities which is world-wide.

Similarly, in the electrical technology, communication between engineers throughout the world is facilitated by the standard letter symbols and graphical symbols given in IEC publication 27 and by the recommended graphical symbols given in IEC publication 117.

Overall economy

Some persons may claim that economy in its broadest sense is the first and ultimate aim of all standardisation activity; and that, apart from standards directed towards safety, where the most economical solution can seldom apply, all standards should show clear economic advantages if they are to be promoted at all. But the problem is not quite so simple as this.

In the standardisation of products, the achievement of overall economy is bound to be a compromise in that it will not be attained when all its individual components are each one at their optimum, because they are interdependent one on another. For example, the greatest economy in labour may preclude the greatest economy in materials, and vice-versa. Or again, the greatest economy in design and manufacture may give rise to a product which is not the most economical in running expenses. Moreover, it is necessary to pay equal regard to the economy of the producer and that of the consumer.

The economic effects of a particular standard are generally so complex that, until very recently, standardisers at all levels have tended to neglect them altogether, concentrating their attention only on the technical aspects. But this attitude

is changing very rapidly and many attempts are now being made to assess the economic advantages and to bring them to the notice of producers and consumers alike. The subject is discussed more fully in Chapter 5.

Safety

There are many product standards prepared solely for the protection of human life and health. Examples are safety belts for motorists or airline passengers, industrial protective clothing of all kinds, life-belts for use at sea. Many countries make these standards mandatory in use. There are other standards solely concerned with safety which are more in the nature of Codes of Practice. They would include such items as fire regulations to be observed in the construction of buildings, or regulations dealing with the installation of electric wiring. In addition, a vast number of national, and a growing number of international standards have safety requirements written into them as one aspect of the particular standard.

More now than ever before it may be said that safety and protection of human life are one of the principal aims of standardisation.

If the primary aim of the standard is to ensure safety then this aspect will take precedence over everything else. Goods must be manufactured with the utmost care to ensure a very high degree of reliability and in addition reinspection and check testing will be called for at intervals during the life of the goods. All these requirements will need to be set out in the standard and compliance with the standard is frequently made enforceable by law. This naturally tends to make the goods more expensive but it must be remembered that the cost of accidents or of breakdown of vital equipment can be very much greater. Economy must always take second place where safety is concerned.

Consumer interest

Almost all standards are prepared for the ultimate benefit of the persons who are going to use the products and so the consumer should be equally concerned with the manufacturer in preparing them. Unfortunately the majority of consumers are not very well organised for presenting a collective opinion, and in most cases are not technically qualified to do so. Nevertheless the implementation of the majority of standards rests ultimately with the consumer, since if he does not have confidence in the standard, he is unlikely to buy the product.

The protection of consumer interest is undoubtedly one of the most important aims of standardisation, and it is clear that the notion of quality of goods comprises their properties both at the time of purchase and in the process of their subsequent use (e.g. durability, reliability etc.). As proof of the growing recognition of the importance of protecting consumer interest through the medium of national standards it may be stated that 37 countries now operate a certification system in connection with their national standards and many more countries are contemplating one. By such a system the conformity of products to the relevant standard is certified by the national standards body.

Community interest

Nowadays it is not only the manufacturer and the consumer who are concerned with standards. There is a wider community interest which has to be catered for; this is exemplified

very forcibly in relation to environmental aspects to which our attention is turned so dramatically at this time. Unless this broad community interest is fully provided for, the work for standards at both the national and international levels will fall progressively short of what is wanted for living standards. So we have to bring into the consensus these views also, i.e. those of Governments, of the medical profession, of research centres, of social organizations and the like.

Trade barriers

The rapid advances in technology which are taking place all over the world and the vast increase in volume of manufactured goods now passing between one country and another have created a demand for new and up-dated standards bearing international status to a degree which was never conceived until very recently. It is not really desirable that standards, be they national or international, should be applied with the force of law unless this is necessary for reasons of public safety, health or environment, or occasionally for avoidance of gross deception. But the policy of legislating by "reference to standards" instead of attempting to issue separately devised technical regulations, is becoming more and more frequent, and more and more necessary, as technology develops and trade expands. The aim of standardisation must therefore be: firstly to reach agreement in a forum of international experts, such as is provided in the technical committees of the ISO and IEC, on the technical content of standards, including the quality of goods and the methods of ensuring it and on the codes of good practice for putting the goods into service and utilizing them; secondly to apply the principle of "reference to standards" in drafting laws and regulations in individual countries. Only in this way can the right of independent nations to frame their own rules and regulations be made compatible with the universal desire to eliminate trade barriers. Only in this way can we avoid cumbersome legislation and make the best use of scarce technical resources; and at the same time provide the optimum solution in the dynamic circumstances created by the pace of technological progress.

The recognition of this comparatively new role for international standards accentuates the *urgency* in providing them, since there are many areas in which they do not exist at present and the mere absence of an approved standard may lead to conflicting regulations in different countries which can be a far more effective barrier to trade than any tariff laws which existed in the past.

Summary of the aims

To conclude this discussion, we may summarise the modern aims of standardisation today under the six headings:

1. Simplification of the growing variety of products and procedures in human life.
2. Communication.
3. Overall economy.
4. Safety, health and protection of life.
5. Protection of consumer and community interests.
6. The elimination of trade barriers.

The principles of standardisation

There is evidence that knowledge in the physical sciences has been growing at an exponential rate, doubling itself every fifteen years or twenty years. With the advent of mass

production and more recently of automation in industry, the variety of articles becomes more and more abundant and complex. Anxious for a more efficient life, man has consciously worked to reduce the variety and number of types in his commodities and even in his manner of life. The conscious effort of reduction to manageable proportions is the beginning of standardisation. Thus—

Principle 1. Standardisation is essentially an act of simplification as a result of the conscious effort of society. It calls for a reduction in the number of some things. It not only results in a reduction of present complexity but aims at the prevention of unnecessary complexity in the future.

This conscious effort of society towards simplification can succeed only through the mutual co-operation of all concerned. The method of establishing a standard should be based upon general consensus. A *consensus* in standardisation practice is achieved when substantial agreement is reached by all the interests concerned, according to the judgement of a duly appointed authority. Consensus implies much more than the concept of a simple majority but it does not necessarily imply unanimity. Thus—

Principle 2. Standardisation is a social as well as an economic activity and should be promoted by the mutual co-operation of all concerned. The establishment of a standard should be based on a general consensus.

The final objective of standardisation activity is to bring about the conditions of efficient and comfortable life of the people. The effect of standardisation can be appreciable only if standards are implemented. Formulating or publishing a standard is merely a means to approach the goal. Even though the published standards were of excellent content they would be of no value if they were not widely implemented in every field of practical activities of production and consumption. Implementation generally calls for sacrifice by some because more often than not a standard which involves no sacrifice by anybody will prove to be of only limited value. It will be no more than a reiteration of practices already established and accepted. Therefore, the co-operation of all persons concerned is essential, and for obtaining such co-operation strong propaganda or public relations is indispensable. Thus—

Principle 3. The mere publication of a standard is of little value unless it can be implemented. Implementation may necessitate sacrifices by the few for the benefit of the many.

The selection of standardisation subjects and aspects should be made carefully from various viewpoints. The order of priority should be considered according to the particular situation; and since the direct object of standardisation is to change complexity into simplicity and superfluity into adequacy the course of action may be as follows—

- (1) to select rationally the most appropriate things from many alternatives;
- (2) to make the selected ones firm, or secure from change, for a certain period. Thus—

Principle 4. The action to be taken in establishing standards is essentially one of selection followed by fixing.

Notwithstanding what has been said above, all standards need to undergo periodic review and revision. The interval between revisions will vary quite widely, depending on individual circumstances. It should not be too short, for

the reason explained in principle 4. But standards can never remain static for long. For most standards it is desirable that there should be a check every five years to see whether revision is needed. At the other end of the scale, nearly all standards are likely to need substantial revision within ten years of publication. Thus—

Principle 5. Standards should be reviewed at regular intervals and revised as necessary. The interval between revisions will depend on the particular circumstances.

When drafting product standards it is usual to specify the main characteristics of the product as well as the performance to be expected from it in service and, where appropriate, the properties of the materials from which it should be constructed. For each of the characteristics which are specified, means must be found for a clear and non-ambiguous determination to be made as to whether a particular product or batch of products does comply with the standard or not. Therefore the standard should include the methods of test to be adopted and if necessary a description of the test apparatus.

If sampling methods are adopted (see Chapter 9) the method of sampling should be specified. Thus—

Principle 6. When performance or other characteristics of a product are specified, the specification must include a description of the methods and tests to be applied in order to determine whether or not a given article complies with the specification.

When sampling is to be adopted the method, and if necessary the size and frequency of the samples, should be specified.

The question of whether legal enforcement of a standard is desirable needs to be considered very carefully with due regard to all the circumstances. The decision will depend on the nature of the standard and the level of industrialisation of the society, as well as on the constitution and laws of the country or countries in which the standard is intended to operate. There are many cases of standards legally enforced—standards of measurement for example (in French “*étalon*”). Where safety and health are involved some legal enforcement will frequently be desirable. Sometimes this will be done internationally, by agreement between nations. Examples are traffic regulations (on land, sea and in the air) or standards needed for the control of pollution.

Codes of practice may also call for some legal enforcement, but most product standards rely on implementation by consent which is much better if it can be achieved. In many cases legal enforcement would prove impracticable and if the customer always insists that the goods which he buys shall comply with the appropriate standards, this can be a much more powerful sanction against sub-standard goods and services than a law which is difficult to enforce. However, in the developing countries, where the accumulated practices in industry have not firmly taken root, some additional step about legislation may be worthy of consideration. Thus—

Principle 7. The necessity for legal enforcement of national standards should deliberately be considered, having regard to the nature of the standard, the level of industrialisation and the laws and conditions prevailing in the society for whom the standard has been prepared.

Subject, aspect and level of standardisation

The terms subject, aspect and level have already been used in describing the aims and principles of standardisation. We

now propose to consider more precisely what is meant by each of them.

Standardisation subjects

The majority of standardisation subjects are material objects such as bolts and nuts, copper tubes, domestic appliances, dental instruments and there are many hundreds of these. But there are a great many more abstract subjects also such as limits and fits, grading or sampling of minerals, noise assessment: or again there are letter and graphical symbols like the electrical ones, or those used to denote surface texture. Because there are so many standardisation subjects it is convenient to group them together into “domains”. A standardisation domain is a group of related subjects and the following are a few examples: engineering, packaging and transport, food, agriculture, textiles, chemicals.

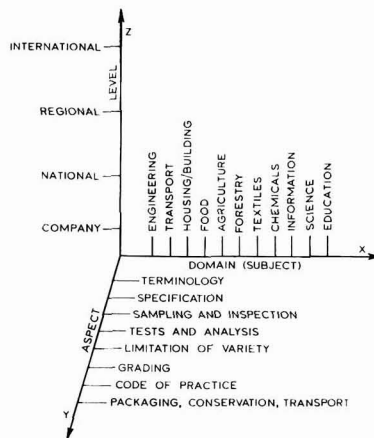


Fig. 1. Diagrammatic representation of standardisation space

In the orthogonal system of three axes, illustrated in Fig. 1, denoting “standardisation space” subjects and domains are presented along the X-axis: and, since there are a very great number of standardisation subjects, for convenience only examples of domains are indicated on the figure.

Standardisation aspect

A standardisation aspect is a group of requirements or conditions which must be satisfied by a standardisation subject if that subject is to be regarded as conforming to a standard. There are many aspects and to name only a few of them: specification, analysis, testing, sampling and inspection, code of practice.

These are presented along the Y-axis in Fig. 1.

Standardisation level

Standards can be promulgated at different levels, the four most important levels being:

- (1) *The International level*—standards such as those of the ISO and IEC, resulting from co-operation and agreement between a large number of independent sovereign nations having common interests. Such standards are intended for world-wide use.

- (2) *The Regional level*—standards initiated by a limited group of several independent nations, or by a regional standards body, for their mutual benefit. Examples of the latter are the European Standards Committees CEN and CENEL, the Pan American Standards Commission COPANT and the Eastern European Group CMEA.
- (3) *The National level*—standards promulgated after consulting a consensus of all the interests concerned in a country, through a national standards organisation which is recognised as the proper authority for the issue of such standards.
- (4) *The Company level*—standards issued by an individual company (or in some cases a group of companies), prepared by common agreement between various departments of the company for guiding its purchases, manufacture, sales and other operations.

The levels of standardisation are presented along the Z-axis in Fig. 1.

A "Standard" may be regarded as a document containing a solution of a standardisation problem: and the problem, which may be concerned with one or more subjects, generally with several aspects and handled at a certain level, will

Discussion at Eastbourne Conference

MR D. S. NEWTON asked whether a BS standard represented the best that could be obtained or was it the minimum acceptable level of quality for a particular product. He also enquired whether the developing nations were making use of established standards or, due to nationalistic tendencies, issuing their own.

MR C. MEREDITH replied that these were two very broad questions. First, he rejected as a generalisation, the concept of a Standard representing a minimum acceptable level. There was a sense in which this was true in that a Standard represented a consensus and a consensus did mean compromise if there were conflicting views; if there were no conflicting views, there would not be much point in having a Standard. There was a sense, therefore, in which the concept of a minimum acceptable level was correct, but it was not as simple as that. There were many cases of a Standard including grades to meet the needs, perhaps, of more specialist usage. The aluminium pigments, for example, had a very complex system of grading in the Standard to meet the future needs of industry. Of course, there was nothing to prevent somebody manufacturing and advertising additional qualities, not in the uniform standard, which might represent a selling point for that very reason, but there was still a basic acceptance that nothing would fall below the consensus of what was desirable.

On the second point, Mr Meredith again thought that it was not possible to generalise. The increasing spread of ISO standards meant that there was much more acceptance of these by the less developed countries. It had been necessary previously to choose ASTM, British Standards, or DIN, and this might well have created difficulties, but the general advance towards single international Standards through ISO gave these a considerable edge in acceptability.

MR A. G. HOLT commented that the new highly flammable liquids regulations had come into force only yesterday.

occupy a defined volume of "standardisation space"* in Fig. 1.

It is obvious that the "standardisation space" as described above cannot be taken as a mathematical space of either continuous or discrete variables; it is to be regarded merely as a convenient device to illustrate the three important attributes of standardisation problems.

From the above description of the standardisation space, it will be clear that the field of standardisation today has become much more extensive than it was, let us say, about half a century ago, when it first began to develop as an engineering activity aimed chiefly at simplification and limitation of variety. In particular, the multiplicity of variables along the aspect axis of standardisation space shows the growth of this complexity during the past several decades, and there is no indication that this growth has reached a saturation point. On the contrary, judging from the rate of progress of present-day science and technology, there is every reason to believe that a great many new variables will continue to be added to the subject as well as the aspect axes of the standardisation space, although we may take it that the level axis will remain, more or less as now conceived subject to regional variations.

There were in the EEC and United Nations pipe line, regulations covering storage and transport by road, rail and sea of a number of unpleasant materials and flammable liquids. Flash points varied from 21, 22 and 23°C at the lower end to 32, 55 and 61°C at the other end. Each piece of legislation involved the paint industry in an enormous amount of work in changing its records and ensuring compliance. He felt that standardisation of all the regulations and legislation was essential, and wondered whether this was something ISO could be doing.

MR MEREDITH said that this was a very important suggestion and certainly one he would welcome, although there were serious difficulties in the way. Where fairly elaborate structures of control had been developed, on, for example, transport of hazardous materials by air, sea and road, all with separate international bodies developing these codes, and where alongside this, there was the diversity arising from studies undertaken for a particular industry, such as the petroleum control legislation and that for the chemical and other industries, there was a very complex picture. Within the last few years and partly as a result of UK membership of the Common Market, he had discovered an increasing realisation of the need to do something about this situation. He was sure that the people who were actually responsible for preparing the legislation and the regulations now shared the views of those in the industry and perhaps this was the first step towards a solution to the problem. It was possible that ISO would provide a meeting place, as it had in so many other fields, for all the interested parties to get together.

DR F. M. SMITH asked who had the biggest influence on the setting of Standards. He suggested that it should be the Trade Associations and other official bodies as they did not have the right to complain about what they received.

MR L. J. BROOKS said that Mr Meredith would recognise a dilemma in as much as the very act of codification implies fixation and fossilisation. It was quite extraordinary

*This concept of "Standardisation space" as a logical means of presenting standardisation problems was first proposed by Dr Lal Verma, Director General of the Indian Standards Institution from 1947 to 1955.

for how long certain standards or specifications had outlived their usefulness or validity. The necessity for recognised parameters would be accepted with much greater willingness if a built-in process of periodic review, say every 5 or 10 years, were discernible. His next comment might seem on the other hand a contradiction of this. People had over the years become accustomed to certain British Standards for colours, the two most familiar ones being 381 C and 2660, and these were very acceptable, but no sooner than the customers had been persuaded to accept them, were they abandoned in favour of a relatively small group of *avant garde* colours which nobody in industry really cared for. This applied particularly to the marine industry, where the interest of colour was much more functional.

MR MEREDITH, replying to the first point on the question of revision, said he thought that every Standards organisation in the world accepted the need to keep standards up to date and to revise them. Of course, what was not always appreciated was that as the general corpus of standards grew, so the proportion of time and effort—which meant money—needed to keep that corpus up to date had to increase. The British Standards Institution was well aware of the necessity, and Mr Meredith asked those using out-of-date standards, not to put them “on the shelf,” but tell the Institution, or the body concerned, that they were out of date and in what way they needed to be modified. One of the greatest difficulties encountered by a standardising organisation was that there was no feedback. There was, in fact, no way of finding out whether a published Standard was being used. There were cases of feedback, one of which had concerned Mr Meredith personally. One was in relation to the grading of petrol; BS4040 could be found on every petrol pump in the country, and this was evidence that the standard was being applied universally. He sometimes heard that a standard was out of date, more usually that it was out of date five years ago, but he did not hear it five years ago. There were real difficulties in keeping Standards revised, but the need to do so was very well understood.

On the second point about colours, he pointed out that BS381C which was the Standard on colours for specific purposes, remained unchanged; there were approximately 100 standard colours here which still were standard. The one which had been changed was the Standard for decorative paints BS2660, which had been replaced by BS4800. This had been at the request of designers, architects and other users who said they needed a more rationalised approach to architectural paint colours. There was the problem of publishing paint colours as drafts for comment; unless the standard colours themselves were published—which would be nearly as expensive as the final standard—the lists of colour references might not attract very much attention.

The Institution did what it could to advise people that changes were coming, and there was an overlap of a year before the previous tender was withdrawn. This had not been long enough; moreover, some colours which had now ceased to be standard were found to be very popular, and ones which should have been retained. There had been some kind of breakdown in feeding information to the Technical Committee drawing up that Standard.

DR G. W. WENDON referring to Mr Holt's contribution said first that trade Associations were made up of individuals who, when serving on committees and so forth, did not

simply represent sectional interests; secondly, efforts to obtain representation of potentially conflicting interests, for example of the paint industry on committees discussing pigments were not always successful. He asked whether CEN would be more successful than ISO had been in the past, in preventing member countries from going back on the usually unanimous decisions reached in ISO committees and working groups, and framing their subsequent national standards in flagrant contradiction of the ISO recommendation.

MR MEREDITH said he could only agree with Dr Wendon that it was most undesirable, although the likelihood of it happening in the future was decreasing. It could not be excluded because standardisation was an activity by agreement, and agreement worked through individuals representing or assumed to represent their countries. If having reached agreement, it was proved in practice that a particular individual did not represent his country, and his country did not follow the policies decided upon, there were no direct sanctions which the international standards community could apply. Pressure could be brought to bear indirectly, but there was no centrally imposed discipline and this was the problem. It applied, of course, in other fields such as the governmental agreements reached through the United Nations. The advent of CEN in a rather limited range of subjects would help. It meant that a stronger discipline could be applied because voting for a European Standard not only implied an intention or wish, but the European Standard could, in fact, take shape only in the form of uniform national standards. This increased commitment was a disadvantage too, because it was more difficult to reach agreement in a discussion where everybody knew that they were going to be bound by what they were agreeing to.

MR A. R. H. TAWN returned to the matter of updating. He had not had occasion to consult BS 684 (Methods of analysis for oils and fats) for some years and realised that it might have been amended but he recalled that it had specified benzene as a solvent in the acid value test for years after benzene had been condemned on account of its toxicity. It did appear that feedback was lacking in this case.

Of real concern to him was the interface between Standards and legislation. The Toys (Safety) Regulations SI 1157:1967 set out limits for toxic elements and detailed methods of test; so did the BS Code of Practice which followed. He wondered what was the role of the Standard in this situation. An unkind view would be that it merely presented industry with another document to be read and complied with, but having no real advantage over what was already there.

MR MEREDITH replied that he was not sure whether BS684 still involved the use of benzene,* but there was a general directive that where an acceptable alternative could be found, benzene would not be included as a solvent in a British Standard. Of course, there was always that caveat “where an acceptable alternative is available.”

As far as the Toys Regulations were concerned, the interface between regulations and Standards was occupying a lot of his attention at the present time. The particular British Standard on (BS3443) Toys was not one which came under his direct responsibility, and he did not know the sequence of events which led to the situation. There was increasing

* BS684 was published in 1958 and the method for the determination of acid value specified, as alternative reagents, either neutral benzene or diethyl ether; thus, no one need use benzene in order to comply with the Standard. A complete revision of the Standard is in progress, but this is inevitably a lengthy process as nearly 50 methods are involved and there is corresponding ISO work to be taken into account. It is extremely unlikely that benzene will be retained, even as an alternative, in the revised edition—C. Meredith.

support for the principle mentioned in my paper of what was termed "Reference to Standards," whereby the detailed technical requirements of a particular test method, for example, were better placed in a Standard which was available to the public and regularly open to review and revision rather than enshrined in a statutory instrument, or a law, like the Abel test for flash point had been enshrined in the Petroleum Act. Although this principle was gradually being accepted, some legislative authorities still insisted that their statutory instruments had to be comprehensive and complete in themselves, and this inevitably involved duplication of a Standard. In such cases, it might be justifiable to say there was no need for a Standard. Again I am not sure that the contents of the two documents are in fact identical, I believe there in addition, there might be some aspects dealt with in the Standard which did figure in the Toys Regulations at all.

MR D. S. NEWTON asked whether Mr Meredith saw the extension of the "Draft for Development" concept as

a means of allowing advances in technology to be incorporated more readily and rapidly in the British Standards system.

MR MEREDITH confirmed that this was his opinion. The Draft for Development idea had been introduced rather sparingly and in a tentative fashion, but it was becoming accepted as a very useful weapon. The BSI took its responsibilities fairly seriously, and he liked to feel that something issued by the BSI represented a firm statement.

There was a role for the Draft for Development type of publication to align national with international Standards, because finalising an international Standard might take many years. If a draft which had received a fair amount of backing from international discussion were published as a Draft for Development in the UK, a lot of valuable practical experience in the use of that Standard could be gained, and probably the resulting final document would be very much better because of this. It was quite a hopeful line of advance.

Next month's issue

The Honorary Editor has accepted the following papers for publication, and these are expected to appear in the December issue:

The characterisation of the mechanical properties of paint films by micro-indentation by *R. L. J. Morris*

Finish first—fabricate later. The continuing story of coil-coating by *D. S. Newton*

Powder coatings by *S. T. Harris*

Review

Organic Photochemistry, Vol. 3

By Orville L. Chapman (Editor)
New York: Marcel Dekker Inc., 1973.
Pp. VIII + 311. Price \$18.75

This is the third volume of the work, the second of which was reviewed in *JOCCA*, 1970, 822. Since this time there has been increasing interest by the paint industry in photochemical processes, particularly in photo-initiators for irradiation curing. A more detailed knowledge of this complex field is, therefore, becoming essential. This third volume continues to deal with reaction mechanisms and although not offering information of immediate utility in the industry, builds up the fundamental background of the subject.

There are three chapters, the first of which originates from Florida State University under the title *cis-trans* Photoisomerisation of Olefins. This deals with stilbenes, 1,3-dienes

and alkenes, but the treatment is restricted to a limited range of olefin pairs.

The second, from Louisiana State University, is a review of the photochemistry of the three-membered heterocyclics. This covers the excited-state chemistry of the inherently strained oxirane (epoxide) compounds, together with the corresponding three-membered nitrogen and sulphur ring compounds.

The last chapter, from Iowa State University, is concerned with the photochemistry of the cyclic ketones. This describes reactions of the α - β unsaturated cyclic ketones and non-conjugated cyclic ketones, including the cyclic keto-sulfoxides, many of which are governed by restrictions of ring size.

The high standard of production of the previous volume is maintained and references are abundant. Expanded introductory and concluding sections to the chapters would have given a better picture to those not specialising in this field.

L. A. O'NEILL

Information Received

Degussa supplies glycidol

The Chemicals Division of Degussa, Frankfurt am Main, has developed a new process for economical production of glycidol (2,3-epoxypropanol). Glycidol of high purity and good stability is now available from a pilot plant. In addition to the 98 per cent product, 50 to 70 per cent solutions of glycidol in inert solvents can be supplied.

Lagor represent Laporte in Italy

Laporte Industries Ltd. has appointed Lagor SpA, of Milan, to represent its titanium dioxide interests in Italy. The agency is owned by the Lamberti Group.

New products

Curing agent for paint applied to wet surfaces

A new high-performance curing agent for epoxy resins being marketed in the UK by Jacobson van den Berg under the trade name "Sur-Wet R", enables surface coatings to be applied to wet, water-soaked or even submerged surfaces. The product can be used with an epoxy resin as a 100 per cent solids system. Sur-Wet R owes its outstanding properties to the fact that it is hydrophobic. In combination with a suitable epoxy resin, the new product displays outstanding adhesion and a high degree of surface wetting. When brushed or sprayed on to a substrate, the coating penetrates to displace other liquids present. Properly applied and cured, the product shows excellent resistance to hot and cold water, sewage, chlorinated and salt water, detergents, oils and strong alkalis and dilute acids.

Electrospray Mark 2 from DCA Electronics Ltd.

In addition to its existing "Electrospray" range of conventional electrostatic paint spraying equipment, DCA Electronics Ltd. has introduced a new air-atomising low-cost electrostatic model suitable for both manual and automatic use. The new equipment, "Electrospray Mark 2," features an extremely lightweight and well-balanced gun with a noval spray-head incorporating a combined recessed external-mix type atomising system and ionisation chamber made from solvent-resistant nylon.

New gas chromatograph from Perkin Elmer

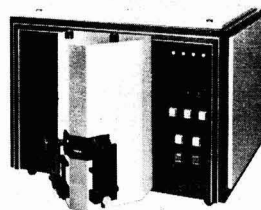
Perkin Elmer Ltd. has announced a versatile new gas chromatograph, Model F17. Digital front panel controls ensure precision and are logically grouped for ease of operation. An integrated range of modules allows instruments to be supplied to specific requirements, ranging from isothermal units with a single detector to the fully automatic, sub-ambient programmed version equipped for the simultaneous use of up to three detectors. A wide range of accessory modules is available, and the flexibility of the design allows future developments to be incorporated.

New range of flexo water-based inks from Fishburn

Fishburn Printing Ink Company has launched "Hydroplus," a range of flexo water-based inks for the case and sack industry. Hydroplus inks were developed to replace the "Hydroflex" range, because of the difficulties in the availability and the soaring costs of the naturally-occurring shellac resin used.

Spectrophotometer/colorimeter from Diano

A fully automatic, dual-beam spectrophotometer/colorimeter, the "ChromosCAN TM," has been introduced recently by the Diano Corporation, Mass., USA. Several models are available, and the makers claim that the instrument has the lowest price amongst the computer-compatible instruments in its price range.

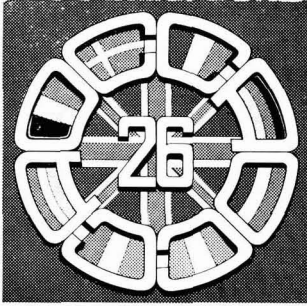


A dual-beam spectrophotometer/colorimeter available from the Diano Corporation

What could you do with a zero—hardness rubber?

Compounding Ingredients Ltd. has been marketing the Monothane "Heat-Pour-Cure" polymer range for approximately 12 months, and during this time a most unusual material has been developed in the same series, which registers zero hardness and 1,200 per cent extension.

The recovery of this material, "Monothane A-O," is excellent; the rubber resists abrasion and is impervious to many chemicals. Its ability to absorb impact without breaking down and return to its original shape, has already suggested that it may well be of interest for seals and certain energy absorbing applications.



The motif adopted for the Association's 26th Technical Exhibition, showing the flags of the enlarged EEC, has aroused world-wide interest, and amongst the enquiries from new sources which are being received at the Association's offices are many from Eastern Europe. Already applications have been received from organisations which have not shown previously at the Association's Exhibition, as well as from previous exhibitors.

Venue

As already announced in the August issue of the *Journal*, OCCA 26 will take place at the Empire Hall, Olympia, London, from 23 to 26 April 1974.

Invitation to Exhibit

Invitations to Exhibit were despatched in July to those organisations in UK and abroad who have exhibited at previous Exhibitions or have requested information on the 1974 Exhibition. Any organisation which has not received an Invitation to Exhibit, but wishes to do so, should apply at once to the Director & Secretary of the Association at the Association's offices.

International character

The Exhibition, which has long been known as the forum for technical display and discussion for the surface coatings industries, in 1973 attracted visitors from more than 50 overseas countries, and there was direct contribution by exhibitors from 14 overseas countries. The motif chosen for this year's Exhibition shows the flags of the enlarged European Economic Community and, by converging on the flag of the UK, symbolises the welcome extended for many years to exhibitors and visitors not only from these countries but from farther afield to the OCCA Exhibitions in London, one of the capital cities of the European Economic Community. To further the aim of a truly international character, the Exhibition is widely advertised in technical journals both at home and in 18 technical journals overseas. Furthermore, it has been the practice for many years to issue information cards in six languages (English, French, German, Italian, Spanish and Russian) and these are widely distributed to firms and individuals in many countries. Interpreters are available at the Exhibition without

World-wide interest in OCCA 26—the European Economic Community's forum for technical display and discussion in the surface coatings industries

charge to help both exhibitors and visitors alike.

Hours of opening

On this occasion the Exhibition Committee has decided to dispense with the Monday opening and to concentrate on four full days as follows:

Tuesday 23 April	.. 09.30 to 18.00hrs
Wednesday 24 April	.. 09.30 to 18.00hrs
Thursday 25 April	.. 09.30 to 18.00hrs
Friday 26 April	.. 09.30 to 16.00hrs

Exhibition Dinner

Following the success of the Exhibition Dinner on the opening day in 1973, the Committee has decided to hold a Dinner at the Savoy Hotel, London WC2 on Tuesday 23 April at 19.00 for 19.30hrs. At the request of some exhibitors a cash bar will be made available after the function for those visitors wishing to use this facility. Full details of the Dinner will be announced in this *Journal* from time to time and an application form for tickets will be enclosed in each copy of the *Official Guide*.

Official Guide

The *Official Guide* will be prepared well in advance of the dates of the Exhibition so that copies can be circulated widely, both to members and non-members, thus allowing visitors an opportunity to plan their itineraries. As well as maintaining the Exhibition's unique position as a purely technical display, manned by technical personnel, the Exhibition Committee has for many years followed the successful policy of encouraging visitors in this way, and by making no charge for admission so that the maximum flow of communication between exhibitors and visitors can take place.

Aims of the Exhibition

The Exhibition Committee wishes the aims of the Exhibition as stated in the Invitation to Exhibit, to be as well known as possible and accordingly these are reproduced below.

The aim of the Exhibition is the presentation of technical advances in those industries supplying the paint, varnish, printing ink, colour, linoleum and other allied industries. The technical advances

may relate to: new products, new knowledge relating to existing products and their uses, or in suitable cases, existing knowledge which is not generally available in the consuming industries.

The Committee stipulates that exhibitors present a technical theme—that is display in a technical manner the technical developments in raw materials, plant or apparatus illustrated by experimental evidence. It is essential that a technically or scientifically trained person, who has full knowledge of the products displayed, be available on the stand throughout the official hours of opening.

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.

Charge to Exhibitors

The OCCA Exhibitions have for many years been planned to keep costs as low as possible for exhibitors. The charge (which includes stand space, floor, walls, muslin ceiling, fascia with coloured felts and pine trims, and painted name plaque), will be £110 (plus Value Added Tax) per unit of 4.32m², and exhibitors receive a free supply of *Official Guides*, six language cards, badges, folders, and so forth. Since there is no charge made for admission to the Exhibition, no "special facility" tickets are issued for distribution by exhibitors. Each visitor is given a copy of the *Official Guide*, together with a folder for technical literature, showing the location of the stands, upon arrival at the hall.

Travel Agents

The Wayfarers Travel Agency Ltd., Cranfield House, 97/107 Southampton Row, London WC1B 4BQ., will be allocated a stand adjacent to the OCCA Information Centre at the Exhibition and will be prepared to advise on, and arrange, hotel accommodation and travel facilities to the Exhibition. They will also be able to make theatre ticket reservations for the evenings of the Exhibition.

Please address all enquiries to The Wayfarers Travel Agency AT THE ADDRESS SHOWN ABOVE, and not to the Association.

Optional Professional Grade for Ordinary Members

The Professional Grade Committee has issued a further list of admissions to the Professional Grade. The full list showing the Sections to which the Members are attached is given below.

Associate in the Technology of Surface Coatings (ATSC)

Bentley, Major Gordon (*West Riding*)
 Clement, Donovan Harry (*Midlands*)
 Drew, Harold Henry Lennox (*Midlands*)
 Stubbings, Alec Walter George (*London*)
 Topping, George David (*London*)
 Wheatley, Kenneth Valentyne (*Irish*)

Course for LTSC

As announced in the August issue, students who have fulfilled the necessary examination requirements can complete the requirements for Licentiate status by taking a one-year part-time course at the Polytechnic of the South Bank, Department of Chemistry and Polymer Technology. *The Associa-*

tion understands that this course is now under-way, and several people are preparing their dissertations.

Full details of the requirements for the three optional Professional Grades for Ordinary Members were last published in the September issue.

Register of Members

The following elections to Membership have been approved by Council. The Section to which new Members are attached is given in italics

Ordinary Members

BELSHAM, BARRY MICHAEL, 24 Egypt Street, Limassol, Cyprus.
(General Overseas)
 CORR, PATRICK JOSEPH, "Deo Gratias", 26 Central Avenue, Hullbridge, Hockley, Essex.
(London)
 CROMBIE, ALAN, 32 Deepdale Close, Clavering Grange Estate, Whickham, Newcastle upon Tyne.
(Newcastle)
 DU TOIT, THEODOR GUSTAV, BSc, SA Titan Products (Pty) Ltd., Private Bag 4, Umbogintwini, South Africa.
(South Africa)
 EASTLAKE, THOMAS HERBERT, PO Box 510, Duncanville, Vereeniging, Transvaal, South Africa.
(South Africa)
 JANSEN, HENDRIK J. P., Akzo Zoutchemie Nederland BY, James Wattstraat, 100 Amsterdam, Holland.
(General Overseas)
 MILESI, MASSIMO, via Varese 2, Bareggio, Milan, Italy.
(General Overseas)
 OLDRING, PETER KENNETH, BA, 29 Sunfield Avenue, Moorside, Oldham, Lancashire.
(Hull)

PRENTIS, RICHARD BASIL, SA Oil Mills (Pty) Ltd., PO Box 208, Randfontein, South Africa.
(South Africa)
 SCHOONENBURG, PANCRAS JOHAN, Rupert International, PO Box 456, Cape Town, South Africa.
(South Africa)
 SEN GUPTA, KAMAL KUMAR, BSc, 185 Maharaga Wanda, Kumak Road, (South) Calcutta 700036, India.
(General Overseas)
 SOMAN, C. A., BSc(Tech), MS, 6030 Milburn Road, Pensacola, Florida, USA.
(General Overseas)

Associate Members

PEDERSEN, FREDDY INGVAR, W. H. Rosenmeyer & Co. (Pty) Ltd., PO Box 72, Rondebosch, Cape, South Africa
(South Africa)

Registered Students

RUSHTON, ANTHONY JOHN, "Westwood", 48 Kenwood Road, Stretford, Lancashire M32 8PT.
(Manchester)

Forthcoming Events

Details are given of meetings in the United Kingdom up to the end of the month following publication, and South Africa and the Commonwealth up to the end of the second month.

Thursday 1 November

Bristol Section: "Future trends and requirements for automotive finishes" by Mr W. Dabbs of Pressed Steel Fisher Ltd. Joint Meeting with the Birmingham Paint Varnish and Lacquer Club, at the Imperial Hotel, Birmingham.

Newcastle Section: "Acrylic emulsions in maintenance paints" by Dr R. N. Washburne, Rohm & Haas Ltd., to be held at the Royal Turks Hotel, Grey Street, Newcastle at 6.30 p.m.

Thames Valley—Student Group: "Printing and Printing inks" by Mr B. Ellison, of Winstones Ltd., Harefield, to be held at the Main Lecture Theatre, Slough College at 4.00 p.m.

Tuesday 6 November

Hull Section: "Some aspects of personnel management" by Mr K. Yates, of Laporte Industries Ltd., to be held at the Haven Inn, Barrow Haven, Lincs. at 6.30 p.m.

Wednesday 7 November

London Section: "Newer analytical techniques and their application to the surface coatings industries." One day joint meeting with the Society for Analytical

Chemistry, Analytical Division, Chemical Society, to be held at the Thames Polytechnic, Woolwich at 9.30 a.m.

Scottish Section—Eastern Branch: "Marketing" by Mr G. Mandel, of Thomas & Green Ltd., to be held at the Carlton Hotel, North Bridge, Edinburgh at 7.15 p.m.

Thursday 8 November

Midlands Section—Trent Valley Branch: "Solvents and safety" by Mr K. W. Smith, HM District Inspector of Factories, Derby, to be held at the Birmingham Chamber of Commerce and Industry, 75 Harborne Road, Birmingham B15 3DH at 6.30 p.m.

Friday 9 November

Manchester Section: "Industrial relations and communications" by Mr W. Davies, Manchester Business School, to be held at the Manchester Literary and Philosophical Society, 36 George Street, Manchester, at 6.30 p.m.

Saturday 10 November

Scottish Section—Student Group: "Powder coatings" by Mr M. P. Stanley, Shell Chemicals UK Ltd., to be held at St. Enochs Hotel, Glasgow 10.15, a.m.

Monday 12 November

London Section: "Optical methods in colloid and surface chemistry." Joint Meeting with Society of Chemical Industry, Colloid and Surface Chemistry Group, to be held at 14 Belgrave Square, London SW1X 8PS at 11.30 a.m.

Tuesday 13 November

West Riding Section: "Water-based metal primers" by Mr K. A. Safe, Vinyl Products Ltd., to be held at Griffin Hotel, Leeds at 7.30 p.m.

Thursday 15 November

Irish Section: Annual Dinner Dance at Clarence Hotel, Dublin.

Friday 16 November

Midlands Section: "Recent progress in organic pigments" by Mr E. R. Inman, of CIBA-GEIGY (UK) Ltd., to be held at the Birmingham Chamber of Commerce and Industry, 75 Harborne Road, Birmingham B15 3DH at 6.30 p.m.

Tuesday 20 November

Scottish Section: "Colour difference—the measure of the future" by Mr M. McLaren ICI Organics Division. Joint

Forthcoming Events—continued

Meeting with the Society of Dyers and Colourists, Scottish Region, to be held at the Whitehall Restaurant, West George Street, Glasgow at 7.30 p.m.

Thursday 22 November

London Section—Southern Branch: "Webb offset printing" with a film, by Mr J. D. Freeman, the News Centre, Portsmouth, to be held at the Pendragon Hotel, Southsea at 7.00 p.m.

Thames Valley Section: "New modified hydrocarbon resins for paint and printing inks" by Mr K. Gilkes, of Berger Chemicals Resin Division, to be held at the Beech Tree Hotel, Maxwell Road, Beaconsfield, Bucks at 7.00 p.m.

Friday 23 November

West Riding Section: Annual Dinner Dance at the Crown Hotel, Harrogate.

Friday 30 November

Bristol Section: "Water pollution—legislation, case study and one answer" by Mr B. Cryer and Mr Shepherd of Berger Paints, Mr Hunt of Bristol City Engineers Department, and Mr R. Evans, of Pollution Technical Services, to be held at the Royal Hotel, Bristol at 7.15 p.m.

London Section: Ladies' Night.

December

Monday 3 December

Hull Section: "A review of the current and future trends in industrial finishing" by Mr R. McD. Barrett of BIP Chemicals Ltd., to be held at the Dorchester Hotel, Beverley Road, Hull at 7.00 p.m.

Tuesday 4 December

West Riding Section: "Flame retardant coatings" by Mr F. C. Adams of Building Research Establishment, to be held at the Griffin Hotel, Leeds at 7.30 p.m.

Thursday 6 December

Thames Valley Section—Student Group: "Electrostatic application" by Mr Mounce, of Henry W. Peabody Ltd., at the main Lecture Theatre, Slough College at 4.00 p.m.

Newcastle Section: "Determination of the dispersibility of organic pigments in paints" by Mr Hafner, Hoechst Cassella Dyestuffs Ltd.

Friday 7 December

Manchester Section: "Are we at risk with chemicals?" by Mr K. B. Butterworth, of the British Industrial Biological Research Organisation, to be held at the Manchester Literary and Philosophical Society, 36 George Street, Manchester 1 at 6.30 p.m.

Irish Section: Ladies Night. A Lecture on "Old Dublin" by Mr F. Dixon to be held at the Clarence Hotel, Dublin.

Tuesday 11 December

London Section: Ladies' Invitation Lecture. "Driving the Police way" by Chief Inspector N. A. M. Ferguson of the Metropolitan Police, to be held at Great Northern Hotel, King's Cross, London N1 9AN at 7.00 p.m.

Thursday 13 December

Hull Section: "The Humber Bridge construction" by Mr J. A. Hyatt of Freeman Fox and Partners. Joint meeting with the Chemical Engineers—South Humberside Group at 6.30 p.m. at the Haven Inn, Barrow Haven, Lincolnshire.

Thursday 13 December

Scottish Section: "Review of plastics" by Prof. N. Grassie, University of Glasgow. Joint meeting with the British Paper and Board Manufacturers Association, Technical Section, at 7.30 p.m.

Saturday 15 December

Scottish Section—Student Group: "Marketing techniques." Speaker to be announced.

Wednesday 19 December

Scottish Section—Eastern Branch: "Newer modified hydrocarbon resins for paint and printing inks," by Mr A. Laws and Mr K. B. Gilkes, Berger Chemicals, to be held at Carlton Hotel, North Bridge, Edinburgh at 7.30 p.m.

Section Officers 1973/4

London—Southern Branch

Chairman: J. R. E. F. Coates, Captains, Red Lane, Limpsfield, Oxted, Surrey.

Vice-Chairman: B. A. Richardson, BSc., Penarth Research Centre, Penarth House, Otterbourne Hill, Winchester, Hants.

Hon. Treasurer: R. A. Brown, BSc, Vanguard Paints Ltd., Cranleigh Road, Porchester, Hants.

Hon. Secretary: W. H. Morris, 4 Sandi-splatt, Paul's Hill, Fareham, Hants.

Hon. Publications Officer: T. R. G. Cox, BSc, Penarth Research Centre, Penarth House, Otterbourne Hill, Winchester, Hants.

Hon. Auditor: J. R. Marchant, 19 Ash Close, South Merstham, Surrey.

Section Programmes 1973/4 Session

Midlands—Trent Valley Branch

Venues for meetings of the Trent Valley Branch were not available at the time when the booklet giving Section Programmes went to press. It is now known that all meetings for the present session will be held at the British Rail School of Transport, London Road, Derby.



Oil and Colour Chemists' Association

President: L. H. SILVER

General

The Oil and Colour Chemists' Association was formed in 1918, to cover paint, printing inks, pigments, varnishes, drying and essential oils, resins, lacquers, soaps, linoleum and treated fabrics, and the plant, apparatus and raw materials useful in their manufacture. In 1924 it absorbed the Paint and Varnish Society. The stated purpose of the Association is to promote by discussion and scientific investigation the technology of the industries concerned with the above-mentioned products, and to afford Members opportunity for the interchange of ideas. This is achieved by the regular holding of ordinary meetings at which papers are presented, and the organisation of annual technical exhibitions, biennial conferences, educational activities and practical co-operative experimental work. Details of these activities are given in the *Journal of the Oil and Colour Chemists' Association*, which is published monthly, and whose pages are open to receive communications and other pronouncements on scientific and technical matters affecting the Members of the Association and the industries concerned. The Association's meetings also afford opportunities for Members to meet informally and socially.

Sections

There are Sections of OCCA in Auckland, Bristol, Hull, Ireland, London (with a Southern Branch), Manchester, the Midlands (with a Trent Valley Branch), Newcastle upon Tyne, Scotland (with an Eastern Branch), South Africa (with Branches in the Cape, Transvaal and Natal), Thames Valley, Wellington, and the West Riding, and these are responsible for the conduct of their own local affairs. There is also a General Overseas Section. There is also a close alliance between the Association, the Federation of Societies for Paint Technology in the United States, and the Fédération d'Associations des Techniciens de l'Industrie des Peintures, Vernis, Emaux et Encres d'Imprimerie de l'Europe Continentale (FATIPEC). The Association also maintains cordial relations with the Scandinavian Federation of Paint and Varnish Technicians (SLF).

The five Sections previously maintained by the Association in Australia formed (1.1.68) the Oil and Colour Chemists' Association Australia, having the same aims and activities as, and working in close liaison with, the parent body.

Membership

Ordinary Membership is granted to scientifically trained persons, and Associate Membership to others interested in the industries covered. An optional Professional Grade, conferring designatory letters, is open to Ordinary Members. Student membership is open without restriction to persons under the age of 21 and to those up to 25 who are following a course of technical study. An entrance fee of 50p is payable by all members. Applications for membership are invited from suitably qualified persons who are engaged or otherwise interested in the industries noted above. Applications, which should be supported by two Members of the Association (one of whom must be an Ordinary Member), should be forwarded to the Director & Secretary at the address given below. Application forms and full details of membership may be obtained from the offices of the Association.

Professional Grade

The Association recently introduced (1971) an *optional* professional grade for its Ordinary Members, giving the designatory letters FTSC (Fellow in the Technology of Surface Coatings), ATSC (Associate in the Technology of Surface Coatings), and LTSC (Licentiate in the Technology of Surface Coatings). Full details are available upon request from the Association. Where Membership has lapsed, previous periods of Ordinary Membership count towards the total required under the regulations, as set out in the January 1973 issue of *JOCCA*.

Exhibitions

A technical exhibition is held annually at Olympia; Members are sent copies of the *Official Guide* several weeks in advance, in order to plan their itineraries. Non-members should apply, in writing, to the Director and Secretary for copies of the *Official Guide*.

Conferences and Symposia

The Association organises large, biennial technical conferences, the papers for which (together with discussions) are published in the *Journal*. Sections of the Association, in the UK and abroad hold symposia and these, too, are reported in *JOCCA*.

Publications

Journal of the Oil and Colour Chemists' Association (JOCCA) is published monthly and includes a yearly index in the December issue. The subscription rate to non-members is £12.00 p.a. (\$31) post free; payable in advance. Single copies may be purchased for £1.25.

Introduction to Paint Technology (Second Edition with additional chapter). With illustrations, 187 pages and index £1.00 (including postage).

Paint Technology Manuals (Parts 1, 2, 4, 5 at present out of print).

Part 1 "Non-convertible Coatings"

Part 2 "Solvents, Oils, Resins and Driers"

Part 3 "Convertible Coatings," Second Edition, pp. 350, £2.80

Part 4 "The Application of Surface Coatings"

Part 5 "The Testing of Paints"

Part 6 "Pigments, Dyestuffs and Lakes, pp. 340, £2.00

Part 7 "Works Practice," pp. 218, £2.40

Director & Secretary: R. H. Hamblin, MA, FCIS,
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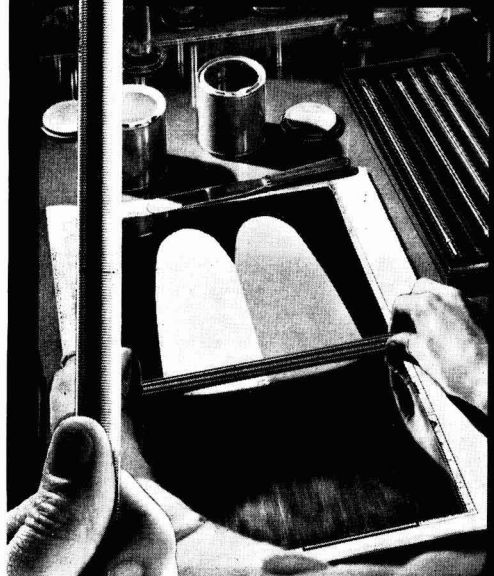


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