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14 May 1976 at the Savoy Hotel, London—See page 37

Ecological coatings: the theory and the reality

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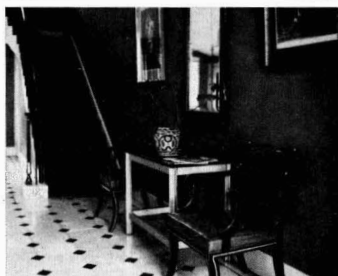
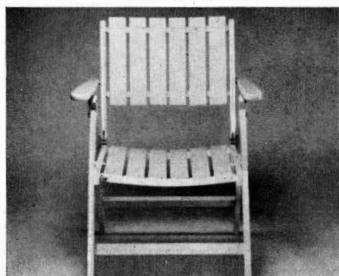
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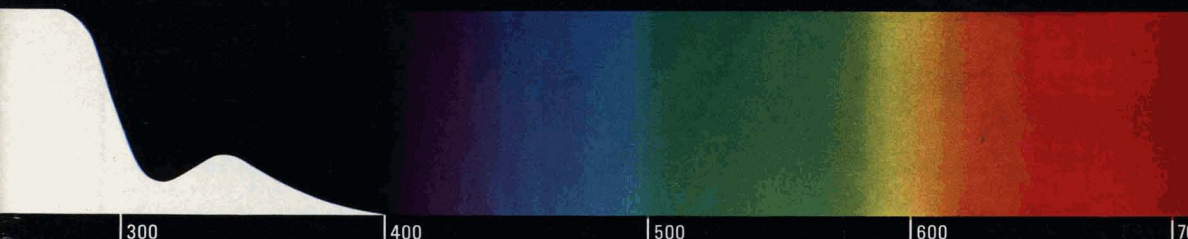
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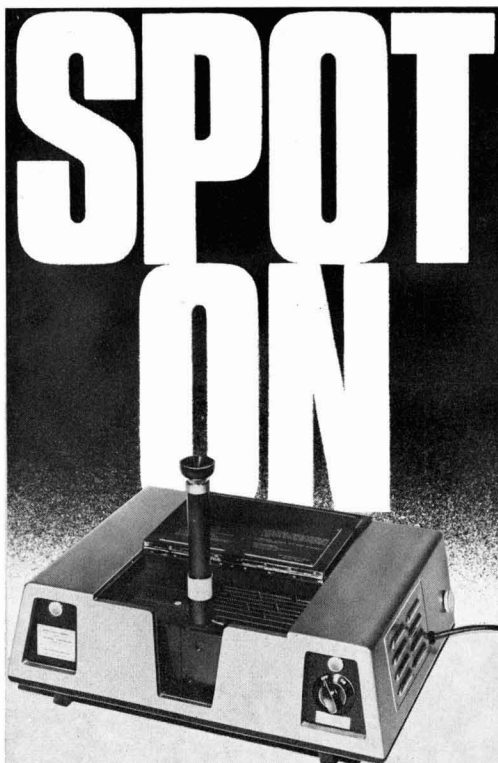
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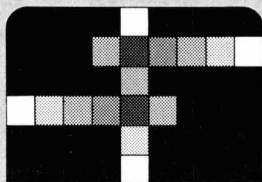
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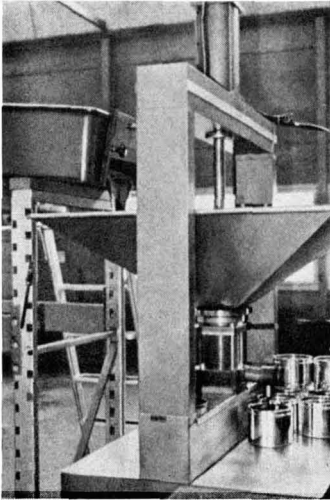
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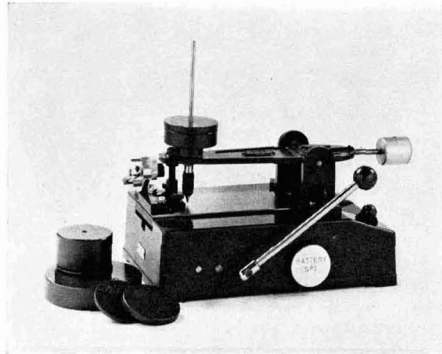
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Transactions and Communications

Ecological coatings: The theory and the reality*

By A. G. North, J. L. Orpwood and R. Little

Cray Valley Products Limited, St. Mary Cray, Kent

Summary

A variety of coatings have been compared for performance regarding the quantity of organic material released into the atmosphere during cure and the energy required to obtain cure. The coatings, with two exceptions, are white enamels designed for producing decorative coatings on mild steel and they have sufficient performance to be used as general industrial coatings. Resin systems used include a range of alkyds and thermosetting acrylics, high solids and conventional oil free polyesters, water based acrylic and alkyd, polyester and acrylic powder coatings and a two-component

acrylic/isocyanate system. In the comparison of energy requirements, a white, electron beam cured coating and a clear ultraviolet-cured coating have been included.

From the results obtained, it is possible to select the best system to meet particular performance requirements and to give either minimum atmospheric pollution or minimum energy for curing, depending on the relative importance of these factors.

Keywords

Types and classes of coatings and allied products
enamel

Types and classes of structures or surfaces to be coated
steel

Properties, characteristics and conditions primarily concerned with dried or cured films
performance

Miscellaneous terms

cost
energy requirements
pollution

Revêtements écologiques: la théorie et la réalité

Résumé

On a fait comparer une gamme de revêtements au point de vue de la quantité de matière organique qu'ils dégagent à l'atmosphère au cours de leur durcissement et également la quantité d'énergie nécessaire pour effectuer le durcissement. Tous les revêtements, sauf deux, sont des émaux blancs pour la finition d'acier doux, et ils sont aptes à être utilisés comme revêtements industriels en général. Les systèmes de résines comprennent une gamme d'alkydes et d'acryliques thermodurcissables, de polyesters soit de forte teneur en matière sèche, soit exempte d'huile, d'alkydes et d'acryliques à base d'eau, de revêtements en poudre polyester ou acrylique, et d'un système acrylique/isocyanate à deux emballages.

D'ailleurs en faisant la comparaison des besoins d'énergie, on a utilisé un revêtement blanc durcissable par faisceaux d'électrons et un revêtement clair durcissable par rayons ultra violet.

A partir des résultats obtenus au cours de cette étude, il est possible de choisir le système qui mieux répond au rendement exige par les besoins spécifiques, et qui donne naissance à la pollution atmosphérique minimale ou, à mesure de l'importance relative des deux facteurs, qui exige la quantité minimale d'énergie pour achever le durcissement.

Umweltsbedingte Anstrichmittel: Theorie und Wirklichkeit

Zusammenfassung

Verschiedene Anstrichmittel wurden hinsichtlich der mengenmässigen Freisetzung in die Luft von organischen Stoffen während des Härtungsvorganges sowie der zur Härtung erforderlichen Energie verglichen. Ausser zwei anderen Sorten wurden weisse Malerlacke für Blechanstrich, die aber auch als Universalindustrielacke genügen, benutzt. Die verwendeten Harzsysteme schliessen eine Reihe von Alkydharz- und wärmehärtbaren Akrylharzlacken, Polyester mit hohem Festgehalt und konventionelle ölfreie Polyester (wassergetragene Akrylharz- und Alkydharzlacke, Polyester-

und Akrylharzpulverlacke, sowie ein Zweikomponenten-Akrylat/Isozyanatsystem ein. Beim Vergleichen des Energieverbrauchs wurde ein weisser, durch Elektronen- und ein transparenter durch Ultraviolettbestrahlung härtender Lack mitgeprüft.

Die Ergebnisse zeigten, dass es möglich ist, das beste für eine besondere Aufgabe erforderliche System auswählen zu können, welches entweder, je nach Wichtigkeit der Faktoren, die geringste Luftpollution oder den minimalsten Energieverbrauch aufweist.

Introduction

Ref.1

The term "ecological" or "environmental" coating has no precise meaning, but it is convenient, and most paint chemists immediately have a concept of the intention even if in reality the coatings are far from perfect. The authors are concerned not only with what polluting products enter the environment when the coating is made, applied or cured, but also with the concepts of the total energy usage and the amount of oil used as a petrochemical feedstock.

It is apparent that in industrial coatings in particular there will be a change from conventional solvent based finishes to coatings that reduce pollution and require less energy for conversion, but most of the articles dealing with the newer coatings make comparatively limited comparisons of the alternatives. The work described in this paper was designed to make a comparison of a wide variety of coatings in an attempt to resolve the relative importance of the newer coatings. Inevitably in such a comparison it is not possible to deal with every alternative, either in terms of the potential use of the finish being examined or in terms of maximising a particular type of coating in terms of, say, minimum solvent content or

*Paper presented at the Association's Biennial Conference held at the Grand Hotel, Scarborough, Yorks, England, from 17 to 21 June 1975.

minimum curing temperature. A comparison has, therefore, been made using commercially available resins converted into white enamels for application to metal. Two coatings have been included to provide comparisons in terms of energy and pollution, although neither coating is comparable in terms of performance. The first of these coatings is a white, electron beam cured coating mainly designed for wood or plastic substrates and with inadequate adhesion on metal, whilst the second coating is an ultraviolet (UV) cured material which at the current stage of development cannot be cured in pigmented form at the film thicknesses needed to make a valid comparison.

Past experience in the paint trade indicates that few new types of coating which have real merit fail to achieve some permanent place, but the volume ultimately achieved may not be commercially attractive in terms of the research and development work carried out; most companies, therefore, attempt to concentrate their work in those fields of development which will ultimately achieve the biggest share of the market. In order to establish the relative importance of, say, powder, water based and radiation cured coatings, it is necessary firstly to look at the technical comparison to establish the performance that can be achieved, but by definition at the start of a research programme it is assumed that there will be an improvement in performance and that specific requirements can be achieved. The next stage is to look at constraints on the type of coating which can limit the market, although this can be subjective if subsequent developments take place which invalidate current ideas. A good example is the use of electron beam (EB) curing, which is at its most attractive when a flat substrate is being coated. To estimate the eventual share of the market for EB coating, it is necessary to calculate both the current percentage of paint finishing on flat

stock and the extent to which this percentage will increase, as a result, possibly, of the economy of electron beam cure.

Once the coating performance which can be achieved and the constraints which could control the size of the market have been established, then economics are the next consideration. These can be studied separately for the paint, the application and the cure, but since the object of the exercise is to decide which type of coating has the best long-term potential and which warrants the most "R&D" effort, it is obviously not sufficient to make a comparison on the basis of current prices. Rather a basis, such as crude oil required both as a petrochemical feedstock and as a source of energy, should be used; then subsequent changes in crude oil price can be used to predict relative costs as oil prices change—although costs associated with multiple processing are currently more relevant than the oil cost.

Capital costs of equipment for alternative processes are certainly in the short term of great significance in influencing the choice of coating. Whilst in many cases the advantages of new processes allowing full amortisation of the equipment can be readily demonstrated, the rate of introduction is in inverse proportion to the capital cost since a large expenditure involves not only financing problems, but also considerably more risk to the paint user in achieving the volume of coated production required for economic operation, and in allowing for equipment obsolescence which may occur if better processes are introduced. In this respect, the industry faces a similar situation to that experienced with computers, where the rapid rate of evolution made potential customers hesitant in purchasing equipment. This effect is seen particularly in the case of UV curing where major advances in the rate of cure have enabled new installations to speed up the processing,

Table 1
Summary of odour-threshold data

Compound	Absolute (ppm)	50% recognition (ppm)	100% recognition (ppm)	Odour Index* 100% recognition
Acetic anhydride	<0.14	0.36	0.36	14 611
Acetophenone	0.30	0.60	0.60	2 183
Acetone	20.0	32.55	140	1 742
<i>p</i> -Amyl acetate	0.067	0.15	0.21	25 047
<i>p</i> -Amyl alcohol	0.12	1.0	1.0	13 150
<i>n</i> -Butylamine	0.08	0.24	0.24	4 491 666
Butyl cellosolve acetate	0.11	0.20	0.20	6 550
Butyl cellosolve	0.10	0.35	0.48	2 729
<i>n</i> -Butyl chloride	8.82	13.3	16.7	6 377
Butylene oxide	0.07	0.71	0.71	260 563
Butyraldehyde	<0.0046	0.0092	0.039	2 984 615
Carbitol solvent	<0.21	1.10	1.10	600
Cellosolve acetate	0.056	0.138	0.250	10 520
Cellosolve solvent	0.30	0.55	1.33	3 909
Cyclohexanone	0.12	0.12	0.24	10 958
Diethylethanolamine	0.011	0.04	0.04	33 000
Diethylamine	0.14	0.498	0.498	512 000
Di- <i>n</i> -butylamine	0.08	0.27	0.48	5 479
Diisobutyl ketone	<0.11	0.31	0.31	4 258
1-4, Dioxane	0.8	1.8	5.7	6 228
Ethyl acetate	6.3	13.2	13.2	7 575
Ethyl acrylate	0.00024	0.00036	0.00036	113 000 000
2-Ethyl hexanol	0.075	0.138	0.138	1 000
Isobutanol	0.68	1.80	2.05	5 131
Isobutyraldehyde	0.047	0.141	0.336	766 949
Isopentanoic acid	0.005	0.015	0.026	9 615
2-Methyl 1-butanol	0.04	0.23	0.23	17 130
Methyl cellosolve acetate	0.34	0.64	0.64	4 109
Methyl cellosolve	<0.9	0.22	0.40	19 725
Methyl methacrylate	0.05	0.34	0.34	119 705
Morpholine	0.01	0.07	0.14	65 857
Styrene	0.148	0.148	0.148	44 391
Toluene	0.17	1.74	1.74	16 609
Vinyl acetate	0.12	0.40	0.40	302 500

*Odour index = Vapour pressure, ppm/odour recognition threshold (100%) ppm.
(Source: Union Carbide Corporation).

reduce investment in UV lamps and, in some cases, in equipment for inert gas.

The final study that should be made is one of current and future legislation. This varies not only by country but also in the US by State, and decisions made may be relevant only to specific parts of the world. Thus, the frequently quoted Rule 66 legislation in California relates largely to the combination of temperature inversion and high UV intensities, in that area, which produce lachrymatory and toxic by-products from certain organic solvents. Even where legislation is of a more general nature, it may not be too logical. Thus, for example, a water based paint may be considered "non-polluting" if the organic solvent content of the volatile material does not exceed 20 per cent, but a specially formulated high solids, solvent based paint may emit no more organic solvent into the atmosphere, but may not achieve the same legislative advantage. Under UK conditions, it can be readily demonstrated that the emission of solvent vapours into the air from paint coatings is of a very small magnitude compared with emissions from road transport and so it can be argued that a more serious concern is public nuisance which relates to local concentrations of solvent vapour and particularly of those volatile materials which are more readily detected. Possibly, therefore, attention should be paid as much to detectability as to toxicity and as an indication of one approach to this matter, Table 1 reproduces some previously published figures¹ of volatility and detectability, which lead to an index.

After the parameters that need to be studied in arriving at conclusions on the relative importance of various types of industrial coatings have been decided, then the work presented in this paper gives at best a partial answer to the questions. A great deal of interest is being shown, for example, in the energy required to produce certain organic chemicals and derived resins, but at present this information is incomplete and in some cases contradictory. This is not surprising since there are many ways of calculating energy requirements for producing a product, ranging from a simple study of direct energy production to one which includes all associated energy inputs and even makes an allowance for recoverable energy when the product is finally scrapped. This may be relevant in packaging, for example, but is not of significance in the present study.

Experimental

Formulations have been kept as basic as possible, that is, flow agents, anti-gas checking agents and other additives have not been used. Solvent blends have been kept simple and the same blends used wherever possible. Except for the powder coatings and radiation cured paints, the paints have been formulated for conventional spray techniques. In practice, many of the resins would be applied by some method other than spray.

In general, a pigment:binder ratio of 0.8:1 has been used, but there are some slight variations. A single chloride process titanium dioxide has been used wherever possible (Runa RH472—Laporte Industries Limited), but for the EB cured paint a different pigment (Runa RO676—Laporte Industries Limited) has been used for improved rheological properties.

Neither of the radiation cured paints is suitable for metal substrates and general mechanical and corrosion resistance properties have not, therefore, been examined.

Preparation and application

Paints were made by ball milling the pigment in part of the

resin and solvent, letting down in the mill with more resin and then running for a further hour before adding the remainder of the resin on a shaker.

Paints were thinned to a viscosity suitable for spinning and 0.1kg of paint thinned to spraying viscosity.

The paints were applied using an ICI spinner, flashed off for 10 minutes and stoved for the recommended schedule. The powder coatings were applied by electrostatic spray. The two-component acrylic/isocyanate system (system J) was air dried for one week before testing.

Mechanical tests were carried out on degreased, scuffed 25 swg mild steel. Salt spray, humidity, stain and detergent resistance tests were carried out on panels treated with Bonderite 197.

The systems compared were as follows:

- A An oxidising alkyd-amino resin combination designed for low temperature stoving and thinned in aliphatic solvent.
- B A short oil oxidising alkyd-melamine resin system in aromatic solvent.
- C A short oil saturated acid alkyd-melamine resin combination thinned in aromatic solvent.
- D An oil free polyester-melamine resin combination thinned in aromatic solvent.
- E A high solids oil free polyester-melamine combination thinned in aromatic solvent.
- F A low temperature curing thermosetting acrylic-melamine resin combination thinned in aromatic solvent.
- G A high temperature stoving thermosetting acrylic-epoxy resin combination thinned in aromatic solvent.
- H An acrylic non-aqueous dispersion resin-melamine combination thinned in aliphatic solvent.
- J A two-component acrylic isocyanate system thinned in aromatic solvent.
- K A water soluble alkyd-melamine combination thinned in mixed water and hydroxylic solvent.
- L A water soluble acrylic resin-melamine combination thinned in mixed water and hydroxylic solvent.
- M A thermosetting polyester powder coating.
- N A thermosetting acrylic powder coating.
- P A 100 per cent curable unsaturated acrylic.
- Q A 100 per cent curable unsaturated acrylic-polyester combination.

The formulations used are detailed in Tables 2, 3 and 4.

Table 2
Alkyd and oil free polyester coatings

Composition	Paint				
	A	B	C	D	E
Pigment					
Rutile titanium dioxide	23.68	28.42	25.60	27.55	33.83
Alkyd resin					
Medium oil length linoleic alkyd 55% non-volatile content (NV) (eg Synolac 78S ^a)	48.16	—	—	—	—
Short oil length linoleic alkyd 60% NV (eg Synolac 6012X ^a)	—	38.08	—	—	—
Short oil length saturated acid alkyd, 70% NV (eg Synolac 6184X ^a)	—	—	34.30	—	—
Oil free polyester, 60% NV (eg Synolac 9130S ^a)	—	—	—	45.84	—
High solids oil free polyester 80% NV (eg Synolac X8313 ^a)	—	—	—	—	42.68
Amino resin					
Hexamethyl methoxy melamine resin (eg Beetle BE670 ^b)	—	—	—	6.92	8.48
Butylated melamine formaldehyde resin 60% NV (eg Beetle BE645 ^b)	—	14.82	13.34	—	—
High reactivity melamine formaldehyde resin 55% NV (eg Maprenal RT ^c)	5.45	—	—	—	—
Solvent					
Xylol	—	14.01	20.07	14.11	10.57
<i>n</i> -Butanol	—	4.67	6.69	4.71	3.52
Aliphatic solvent (eg SBP6 ^d)	20.34	—	—	—	—
Additives					
Driers, catalyst etc.	2.37	—	—	0.87	0.92
% weight, non-volatile (theoretical)	54.30	60.16	57.61	62.05	75.90
% weight, non-volatile (determined)	53.00	58.92	56.20	58.33	70.75
% volume, non-volatile (theoretical)	34.83	42.31	40.29	45.10	61.17

Note: Theoretical non-volatile for paints D and E assumes hexamethyl methoxy melamine is 100% non-volatile.

(a) Synolac: Cray Valley Products Ltd.

(b) Beetle: British Industrial Plastics Ltd.

(c) Maprenal: Hoechst Chemicals Ltd.

(d) SBP6: Carless Capel & Leonard Ltd.

Table 3
Thermosetting acrylic coatings

Composition	Paint			
	F	G	H	J
Pigment				
Rutile titanium dioxide	22.43	21.65	26.56	25.66
Acrylic resin				
Thermosetting hydroxy acrylic, 55% non-volatile (eg Synocryl 823S ^a)	38.29	—	—	—
Thermosetting acrylamide acrylic, 53% NV (eg Synocryl 830S ^a)	—	45.60	—	—
Non-aqueous dispersion thermosetting acrylic, 50% NV (eg Synocryl X.7489 ^a)	—	—	47.53	—
Hydroxy functional acrylic (eg Synocure 867S ^a)	—	—	—	40.20
Cross-linking resin				
Butylated melamine formaldehyde resin, 60% NV (eg Beetle BE645 ^b)	11.69	—	—	—
Epoxy resin solution, 75% NV (eg Epikote 1001 ^c)	—	4.53	—	—
Aliphatic tolerant melamine formaldehyde resin, 60% NV (eg Dynomin MI-11 ^d)	—	—	16.62	—
Hexamethylene di-isocyanate adduct, 75% NV (eg Desmodur N ^e)	—	—	—	10.58
Solvent				
Xylol	20.70	18.99	—	11.78
Butanol	6.89	6.34	—	—
Aliphatic solvent (eg CAS.17/10 ^f)	—	—	9.29	—
Ethylene glycol mono ethyl ether acetate	—	2.89	—	—
Methyl isobutyl ketone	—	—	—	11.78
% weight non-volatile (theoretical)	50.84	49.22	60.29	58.12
% weight non-volatile (determined)	49.08	47.18	57.20	57.92
% volume non-volatile (theoretical)	34.95	40.29	41.89	42.44

(a) Synocryl, Synocure: Cray Valley Products Ltd.

(b) Beetle: British Industrial Plastics Ltd.

(c) Epikote: Shell Chemicals Ltd.

(d) Dynomin: Dyno Industrier A/S.

(e) Desmodur: Bayer Chemicals Ltd.

(f) CAS: Carless Capel & Leonard Ltd.

Table 4
Water soluble, powder, cold cured and radiation cured coatings

Composition	Paint					
	K	L	M	N	P	Q
<i>Pigment</i>						
Rutile titanium dioxide	20.11	20.00	28.93	21.14	42.78	—
<i>Resin</i>						
Water soluble acrylic/melamine formaldehyde resin, 50% non-volatile (eg Synocure 841S ^a)	—	40.02	—	—	—	—
Water soluble alkyd, 80% NV (eg Resydrol 473S ^a)	20.11	—	—	—	—	—
Acrylic powder coating resin (eg Everclad 5400 ^b)	—	—	—	77.84	—	—
Polyester powder coating resin (eg Everclad 4110 ^b)	—	—	70.26	—	—	—
Acrylated epoxy resin (eg Synolac X.8157 ^a)	—	—	—	—	26.74	47.50
Neopentyl glycol diacrylate	—	—	—	—	30.48	47.50
Hexamethyl methoxy melamine, 100% NV (eg Beetle BE670 ^c)	4.96	—	—	—	—	—
<i>Solvent</i>	6.70	4.67	—	—	—	—
<i>Water</i>	46.11	35.31	—	—	—	—
<i>Additives</i>	2.01	—	0.81	1.02	—	5.00
% weight, NV (theoretical)	41.24	40.00	100.00	100.00	100.00	100.00
% weight, NV (determined)	40.01	39.22	98.3	98.5	99.0+	99.00
% volume, NV (theoretical)	21.91	26.18	100.00	100.00	100.00	100.00

(a) Resydrol, Synocure, Synolac: Cray Valley Products Ltd.

(b) Everclad: Kansai Paint Co. Ltd.

(c) Beetle: British Industrial Plastics Ltd.

Results

Testing of the coatings is listed in Tables 5, 6 and 7.

Table 5
Performance of alkyd and oil free polyester coatings

	Paint					
	A	B	C	D	E	E
Stoving (stoving time 30 mins) temperature (°C)	80	130	150	150	150	150
Film thickness (µm)	29	30	29	25	29	47
Gloss (45°), %	100+	99	99	99	100+	100+
(20°ASTM.D523) %	81	64	62	63	78	80
<i>Mechanical properties</i>						
Impact, mm	F1.25	F1.25	F.125	P5.0	P6.25	F1.25
Bend (ASTM.522) mm pass	3.2	6.3	25	3.2	3.2	3.2
Slow indentation (Erichsen) mm	8.6	6.4	4.6	7.1	8.3	8.5
Cross hatch adhesion (Erichsen DIN.53151) %	80	98	30	95	98	94
Pencil hardness	HB	2H	H	4H	2H	2H
<i>Solvent resistance</i>						
60 sec Xylol swab	3	3	1	0	0	0
60 sec Methyl ethyl ketone swab	4	3	1	0	1	1
<i>Stain resistance</i>						
Lipstick, 2 hrs/4 hrs	2/3	1/1	1/2	0	0	0
Boot polish 5 min/2 hrs	4/5	2/3	4/5	0	0	0
1% detergent at 60°C						
24 hrs	1	2	1	0	0	0
48 hrs	3	3	2	1	3	3
<i>Spot tests, 24 hrs</i>						
40% sulfuric acid	0	1	1	0	1	0
4% acetic acid	4	4	4	0	0	0
40% sodium hydroxide	5	3	2	0	0	0
Salt spray resistance 1 000 hrs						
5% salt/35°C (ASTM)						
Blistering	1	1	2	0	0	0
Creepage, mm	1-3	5	2-6	3-4	2-5	2-5
^f Humidity cabinet, DEF/1053, ^f Method 25. 500 hrs	2	2	0	0	0	2

Key: F = Fail, P = Pass.

Solvent resistance, stain resistance, spot tests, detergent, salt spray, humidity on an arbitrary scale 0-5 (0 = No effect, 5 = Severe effect).

Table 6
Performance of thermosetting acrylic coatings

	Paint				
	F	G	H	H	J
Stoving temperature (°C) (stoving time 30 mins)	120	150	120	120	Room temperature for 1 week
Film thickness (µm)	29	25	30	45	29
Gloss (45°), %	99	100+	93	96	100+
(20° ASTM.D523), %	64	84	57	63	85
<i>Mechanical properties</i>					
Impact, mm	F1.25	P1.25	F1.25	F1.25	F1.25
Bend (ASTM.522) mm pass	19.0	9.5	12.7	25.0	12.7
Slow indentation (Erichsen) mm	6.0	6.5	4.5	2.8	4.3
Cross hatch adhesion (Erichsen DIN.53151) %	98	98	98	12	90
Pencil hardness	2H	2H	H	F	2H
<i>Solvent resistance</i>					
60 sec Xylol swab	1	2	1	1	1
60 sec Methyl ethyl ketone swab	3	3	1	1	1
<i>Stain resistance</i>					
Lipstick, 2 hrs/4 hrs	0/0	0/0	1/1	1/1	0/0
Boot polish, 5 mins/2 hrs	2/3	1/1	3/4	3/4	0/0
<i>1% detergent solution 60°C</i>					
24 hrs	2	0	0	1	2
48 hrs	3	1	2	2	3
<i>Spot tests, 24 hrs</i>					
40% sulfuric acid	1	0	1	1	0
5% acetic acid	0	0	1	1	0
40% sodium hydroxide	0	0	2	2	0
<i>Salt spray resistance 1 000 hrs 5% salt/35°C (ASTM)</i>					
Blistering	0	0	1	1	1
Creepage, mm	6-8	2-3	3	2-6	2-3
<i>Humidity cabinet, DEF/1053, Method 25, 500 hrs</i>					
	2	0	0	0	0

Key: F = Fail, P = Pass.

Solvent resistance, stain resistance, spot tests, detergent, salt spray, humidity, on an arbitrary scale 0-5 (0 = No effect, 5 = Severe effect).

Table 7
Performance of water soluble, powder and cold cured coatings

	Paint					
	K	L	M	M	N	N
Stoving temperature (°C) (stoving time 30 mins)	140	150	200	200	180	190
Film thickness, (µm)	30	25	30	60	30	65
Gloss (45°), %	100	87	100	96	93	93
(20° ASTM.D523) %	52	55	64	54	66	72
<i>Mechanical properties</i>						
Impact, mm	F1.25	F1.25	F1.25	F1.25	F1.25	F1.25
Bend (ASTM.522) mm pass	6.35	6.35	3.2	37	3.2	25
Slow indentation (Erichsen) mm	5.0	6.5	>10	9.8	9.0	9.1
Cross hatch adhesion (Erichsen DIN.53151) %	98	98	100	100	100	100
Pencil hardness	2H	2H	2H	2H	3H	3H
<i>Solvent resistance</i>						
60 sec Xylol swab	1	2	2	2	2	2
60 sec methyl ethyl ketone swab	3	1	2	2	2	2
<i>Stain resistance</i>						
Lipstick, 2 hrs/4 hrs	1/2	0/0	0/0	0/0	0/0	0/0
Boot polish, 5 mins/2 hrs	4/5	2/4	0/0	0/0	0/0	0/0
1% detergent solution at 60°C						
24 hrs	3	5	0	0	0	0
48 hrs	3	5	0	0	0	0
<i>Spot tests, 24 hrs</i>						
40% sulfuric acid	1	5	0	0	0	0
5% acetic acid	2	2	0	0	0	0
40% sodium hydroxide	2	2	0	0	0	0
<i>Salt spray resistance 1 000 hrs</i> 5% salt/35°C. (ASTM)						
Blistering	0	4	0	0	0	0
Creepage, mm	2-3	Bad general rusting	2	2	1	1
Humidity cabinet, DEF/1053, Method 25, 500 hrs						
	3	0	0	0	0	0


Key: F = Fail, P = Pass.

Solvent resistance, stain resistance, spot tests, detergent, salt spray, humidity, on an arbitrary scale 0-5 (0 = No effect, 5 = Severe effect).

It will be seen from Tables 5, 6 and 7 that certain of the systems, particularly those which can be applied at high solids, have been examined at two film thicknesses. This is to allow some comparisons to be made of film performance against the powder coatings which cannot easily be applied at low film thicknesses.

Calculations of the energy requirements have been made by considering a hypothetical production line in which steel is coated at the rate of 4 500m² per hour at a coating rate of 0.04kg m⁻². Curing takes place during 30 minutes in all the systems, with the exception of the two-component room temperature cured acrylic isocyanate finish and the EB and UV cured coatings. The temperature is varied to achieve a satisfactory degree of cure in the time available. In Table 8 the results are summarised in terms of the energy required to

cure (in Megajoules per square metre) and additional data are given where available on the energy required for the resin manufacture. A further calculation has been carried out in Table 9 of air volumes required for most of the stoving systems. One of the main requirements in oven design is that sufficient air be introduced to ensure that solvent vapour does not reach the lower explosive limit. Oven designs vary in the exact percentage required, but a commonly used figure is such that the volume of air passing through the oven should ensure that the average concentration of solvent in the oven does not exceed 25 per cent of the lower explosive limit. This restriction does not apply, of course, to coatings which cure with effectively zero emission of organic material and the situation can also be more complicated in the case of water based systems where higher solvent concentrations can be tolerated.



**OBERFLÄCHENSCHUTZ
SURFACE PROTECTION
PROTECTION DE SURFACE**

Dynamit Nobel
CHEMIKALIEN

DYNAPOL®

P DYNAPOL P co-polyesters on the basis of terephthalic acid are best suited for electrostatic powder coating and fluidized bed coating.

Electrostatic Powder Coating

We offer for this application saturated polyesters, containing hydroxyl groups, for the production of decorative, elastic and weather resistant coatings.

Typical Fields of Application:

- apparatuses
- metal window frames
- garden furniture
- household appliances
- automobile accessories

Technical Data:

Coating thickness 50–70 μm
 Erichsen depth test (DIN 53156)
 8–10 mm
 Pendulum hardness (DIN 53157)
 157–185 sec.
 Impact test > 50 inch · lbs
 Gloss according to Lange 45°
 depending on grade 80–130°
 Salt spray test (ASTM B 117) 600 hours
 Adhesion (DIN 53151) GT 0
 Kesternich test 30 cycles

Fluidized Bed Coating

For this application we have a partly crystalline co-polyester available, which is best suited for the production of elastic, heat and weather resistant coatings.

Depending on the type of cooling process applied, bright or matt coatings may optionally be produced, having very good electrical insulating qualities in addition to a decorative surface.

The fields of application are those requiring a high quality protection against corrosion and a decorative surface.

Typical Fields of Application:

- sign posts
- garden chairs
- wire mesh
- valve handwheels
- household appliances

Technical Data:

Coating thickness about 250–500 μm
 Erichsen depth test (DIN 53156)
 > 10 mm
 Impact test > 80 inch · lbs
 Hardness (DIN 53153) about 85–90
 Gloss (Lange), depending on the kind of cooling 80–125
 Kesternich test 40 cycles

DYFLOR®
2000

Polyvinylidene fluoride for powder coating.

DYFLOR 2000 WS for fluidized bed coating.

DYFLOR 2000 ES for electrostatic powder coating.

Powder coatings made with this fluoropolymer show some outstanding properties, e. g.:

- smooth surfaces
- very good resistance to chemicals
- wide range of service temperature
- high elasticity
- high impact strength
- high flame resistance

DYFLOR 2000 combines excellent resistance to chemicals with good physical properties. DYFLOR 2000 is giving an optimal protection, even at higher temperatures.

Because of its properties DYFLOR 2000 is recommended for the coating of such parts, which are exposed to strong chemical and corrosive influences, as for instance in the chemical industry construction and in chemical apparatuses.

DYFLOR 2000 can be processed safely and problem-free on the usual coating lines.

Coating properties:

Coating thickness	approx. 200 μm
Indentation test (DIN 53153)	85
Pendulum hardness (DIN 53157)	143 sec.
Erichsen depth test (DIN 53156)	10 mm
Impact test	8 mm
Adhesion	GT 0
Working temperature	–40° C to +150° C

DYNAPOL®

L DYNAPOL L-resins are high-molecular, linear, saturated polyesters containing terephthalic acid, which may be processed to physically drying binders and, combined with amino resins to extremely adhesive, highly elastic coatings.

DYNAPOL L are available in different degrees of elasticity.

DYNAPOL L-coatings are distinguished by an optimally balanced behaviour regarding flexibility and hardness. Due to their excellent weather resistance they are also suited for outdoor use.

In specific formulations DYNAPOL L-coatings can be composed to be sterilisation-proof. These coatings comply with the recommendations of the BGA (German Ministry of Health) and are, according to FDA-Regulations, generally recognized as safe in food.

Typical Fields of Application:

- packings
- sterilisation-proof packaging for foodstuffs
- prefabricated building and constructional elements for the architectural field (sidings, wall-panels, ceilings)
- apparatus construction

Technical Data:

(on pre-treated aluminium)	
Gloss (Gardner)	approx. 95–100%
Pencil hardness	H
Impact test	approx. 80 inch · lbs
T-bend-test	T 0-2 depending on the type
Salt spray test	min. 400 hours, unaffected

These data comply with the ECCA Test Specifications (European Coilcoating Association, Brussels).

New modified polyesters with intensified reactivity, good forming properties and excellent weather resistance are specially recommendable for coilcoating lacquers.

DYNAPOL®

H DYNAPOL H-Types are thermosetting, branched polyester resins containing hydroxyl groups, having suitable stamping and deep-drawing properties,

as required for the production of automobile stoving and repair lacquers as well as for the coating of aluminium, steel or galvanized steel for the packaging field.

Technical Data:

(on pre-treated aluminium)
Gloss (Gardner) 95%
Pencil hardness 2 H
Impact test approx. 60 inch · lbs
T-bend-test T 2-3
Salt spray test min. 500 hours, unaffected

These data comply with the ECCA Test Specification.

DYFLOR[®] L 90

DYFLOR L 90 is a polyvinyl fluoride, which is to be processed in form of a

dispersion. It is preferably used where an especially high life expectancy, resistance to chemicals, weather resistance, and a good forming property within a large temperature range (-50° C up to +130° C) is of importance.

Above all, dispersions based on DYFLOR L 90 may be processed on coil coating lines. But they are just as well suited for the spray coating. Metals, ceramics and other materials are suitable substrata, as long as they endure a heat treatment of about 250° C during the stoving process. The lacquer films may range from a semi gloss to matt as desired; they are dirt repellent and may be pigmented in many colour shades.

DYFLOR L 90 is being applied where the conventional coating will give an insufficient protection against corrosion.

Main Fields of Application:

- Building elements in an-aggressive industrial atmosphere
- sidings, roofings and other structural parts on the architectural field
- high quality coatings for corrosion protection for machine parts which are applied to extremely aggressive media.

Technical Data:

(on pre-treated aluminium)
Gloss (Gardner) about 70%
Pencil hardness F - H
Impact test 80 inch · lbs
T-bend-test T 0
Salt spray test more than 1000 hours, unaffected

These data are in accordance with the ECCA Test Specifications.

DYNASIL[®] 40

Ethylpolysilicate.
Rawmaterial for zinc dust paints.

for industrial processing. They can be welded over, they can be applied either by air or airless spraying, brush or roller painting, and can be used as a one-coat layer or priming. They may be recoated with all conventional colour systems.

Main Fields of Application:

- shipbuilding
- industrial plant construction
- power plant construction
- bridge building
- large steel constructions
- building elements on a large scale production basis

DYNASIL[®] H 400 / H 400 LL*

H 450 / H 450 LL*

H 500 / H 500 LL*

Test results of zinc dust coatings on the basis of DYNASIL:
Salt spray test (DIN 50021) unaffected after 1000 hours.
Adhesive strength, grating (DIN 53151) Grating value 0
Temperature resistance:
Permanent load max. 400° C.
Short term load max. 600° C.

* Binding agents on the basis of silicate ester with a shelf life of more than one year.

DYNASIL[®] EFP

Binding agent on the basis of silicate ester having an increased flash point (34° C/93° F)

DYNASIL[®] Li 20

DYNASIL Li 20 is a modified, specially stabilized

lithium silicate. It serves as a binder for coatings, mainly for zinc-rich corrosion protective paintings. It doesn't contain any organic solvents, is dilutable with water and noncombustible.

Wherever is depends on a corrosion protection of iron and steel — even at temperatures up to 400° C — zinc dust paints with DYNASIL as a binder excellently satisfy expectations. Zinc dust paints on the basis of DYNASIL are particularly suited

Dynamit Nobel
CHEMICALS

Other tried and tested products for the surface protection:

Electrically insulating lacquer resins

ICDAL® TE/TI

Ester and esterimide resins. Wire lacquer resins for the production of insulated conductors, resistant to permanent temperature loads. Resins for insulating impregnating lacquers.

Titanic acid esters

Reactive cross-linking agents for paint and lacquer resins, binders for high temperature lacquers.

Vandyl alcoholates

Catalysts for the polyurethane coatings with variable adjustment of the setting times.

Nitrocellulose

COLLODION COTTON
PLASTICIZED NITROCELLULOSE

Plasticizers

WITAMOL®

for different lacquer applications. Special plasticizer heat-sealing and physiologically unobjectionable aluminium coatings.

Chlorinated paraffins

WITACLOR®

To get flame resistant lacquers, for the production of facade paints.

Chlorophenoles

WITOPHEN®

Additive to oil and dispersion paints in order to prevent the formation of fungi and the decomposition during storage. For the production of fungus-resistant wall paints.

Chlorinated hydrocarbons

DYNATRI® LQ, trichloroethylene
Solvent for paint and lacquer resins for hot and cold dip coating processes.

For the de-greasing of metals:

DYNAPER® perchloroethylene

(tetrachloro ethylene)

DYNATRI® trichloroethylene

MECLORAN® 1,1,1-trichloroethane

MECLORAN® D 1,1,1-trichloroethane (vapor type)

For the de-greasing of light metals:

DYNATRI® LM trichloroethylene

Special hard aggregates

TROCOR®

Electro-corundum as an aggregate for high-stress concrete pavings and for abrasion coatings on the basis of synthetic resin.

Blast material, not giving cause to silicosis

REWAGIT®

Standard corundum, economical is use, low dust content, rust proof. To clean and roughen material surfaces.

Please, get yourself informed about our extensive delivery program. Ask for our leaflet "Basic and Auxiliary Materials for the Surface Treatment Technology".

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CHEMICALS

Table 8
Energy requirements

System	Energy to cure (MJ m ⁻²)	Stoving temperature (°C)	Energy contribution from resin manufacture
A	0.60	80	0.12
B	0.93	130	0.08
C	1.18	150	0.09
D	1.03	150	0.11
E	0.70	150	0.11
F	1.11	120	0.03
G	1.49	150	0.04
H	0.96	120	0.04
J	Air drying		0.03
K	0.76	140	0.15
L	0.81	150	0.04
M	0.49	200	—
N	0.46	190	—
P	0.14	—	0.03
Q	0.40	—	0.03

30-minute stoving schedules
4 500m²/hour, 40.5 g/m² solid paint (= film specific gravity 1 645)
Oven 45 m long × 1.5 × 1.5
Thermal efficiency 70% (Gas fired ovens)
Electrical efficiency 28%

In Table 9 the calculations are listed for the appropriate coatings and a second figure is given relating to the volume of air that would be required in the oven to ensure that the air/vapour mixture emitted does not give concentrations of solvents exceeding the maximum allowable concentration in the atmosphere. This, of course, is an extreme situation, since normally the effluent gas will be immediately diluted with large amounts of air from the atmosphere, but obviously if the effluent gas has concentrations of solvent such that the maximum allowable concentration figures are not exceeded, then the effluent gas is essentially non-polluting in terms of legal requirements. The ratio between the volume of air needed to keep at a satisfactory concentration below the lower explosive limit and that needed to achieve what may be thought of as a "breathable" oven effluent is shown in the third column of Table 9.

Table 9
Air requirements

System	Air volume (m ³) to achieve 25% lower explosive limit (I)	Air volume (m ³) to achieve threshold limit value (II)	Ratio II/I
A	1.2805 × 10 ⁴	7.5624 × 10 ⁴	5.91
B	1.0209 × 10 ⁴	9.7488 × 10 ⁴	9.55
C	1.1375 × 10 ⁴	1.0798 × 10 ⁵	9.49
D	0.9370 × 10 ⁴	2.5603 × 10 ⁵	27.32
E	0.4836 × 10 ⁴	1.3094 × 10 ⁵	27.08
F	1.5012 × 10 ⁴	4.2660 × 10 ⁵	28.42
G	1.5665 × 10 ⁴	4.5520 × 10 ⁵	29.06
H	1.2455 × 10 ⁴	9.5745 × 10 ⁴	7.69
J	(0.6291 × 10 ⁴)	2.7715 × 10 ⁵	28.60
K	0.3870 × 10 ⁴	2.3586 × 10 ⁵	60.95
L	0.3274 × 10 ⁴	(8.0887 × 10 ⁴)	21.72

Discussion

Non-volatile content

The theoretical non-volatile contents compare well with the experimentally determined figure, being slightly lower in most

cases, due undoubtedly to a combination of volatile matter from the pigment and other additives and, in the case of the coatings containing hexamethyl methoxy melamine, to the loss of methanol that occurs when curing in the presence of hydroxyl and acidic groups—the latter can account for the differences observed.

Paint performance

Detailed comparisons can be obtained from the tabulated results and it is sufficient to note some general trends.

The oil free polyesters probably show the best combination of performance in that they have the stain, humidity and salt spray resistances of the best acrylic coatings together with better flexibility, and they suffer only in alkali resistance as exemplified by detergent solutions. The powder coatings are, of course, limited to thicker coatings, but have exceptional resistance characteristics. The cold cured acrylic is noteworthy as the only low temperature cured coating that has sufficient performance for more arduous requirements.

Energy requirements

In order to make a final choice of system to conserve energy it is necessary to know more about the energy and crude oil equivalent of all constituent chemicals, but it is apparent that vegetable oil containing alkyds will have the lowest oil feedstock requirement and addition polymers, such as the acrylics, the lowest energy requirement in the resin-making stage. One of the paradoxes of any study of energy use is that an exothermic process, such as vinyl polymerisation, cannot be negative in energy requirement because of the cooling and stirring requirements and the impossibility at reasonable capital cost of utilising the waste heat of reaction. It is apparent that in the curing stage the room temperature cured acrylic is best with electron beam, with UV systems close behind. What is not so obvious is that the need for multiple air changes with solvent based paints makes powder coatings competitive with regard to energy, even though high temperatures are required. Similarly, the high specific heat of water is more than compensated by lower demands for air. A point that is not often realised is that some aliphatic solvents have lower explosive limits than aromatic solvents of comparable volatility, so that whatever their merits in reducing toxic hazards, they are not particularly beneficial with regard to the energy necessary for cure.

Conclusions

The work presented is still in progress and forms part of a longer study to choose the best buy for a variety of industrial products that require finishing. The relative use will ultimately depend only on the system that produces adequate performance at minimum cost. To establish the position of each type of coating further study is needed of capital cost, space, oil equivalents, energy used in intermediates as well as the likely impact of legislation on solvent vapour emission. This is the only logical way to steer R&D effort towards the system of greatest potential.

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Mr A. King, Stein Atkinson Stordy Ltd, Wombourne.

Reference

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Discussion at Scarborough Conference

MR G. H. HUTCHINSON asked the authors whether they had considered impulse radiation curing (IST) as a contender for their studies. This method of using rapid impulses of ultra-violet energy might be used for curing the more conventional (for example, alkyd) type of coatings on metal substrates and was currently being studied in Germany. It might be useful to consider the energy and other requirements of this method by the very useful approach to the design of ecological coatings which had been adopted in this paper.

MR NORTH said that impulse radiation had not been studied in this particular work and from limited tests carried out by his company, no advantage to impulse curing had been demonstrated. There might well be specific systems, however, where impulse curing could give rise to lower energy requirements.

MR A. N. MCKELVIE thought that in such a speculative paper dealing with long-term forecasts, it might be pertinent to consider priority values as well as scarcity values. He was thinking, in particular, of vegetable oils and similar materials, which had a replacement factor, but which might be required in the future wholly for human consumption.

MR NORTH replied that whilst in a study of this type it would be highly desirable to consider long-term availability and desirability of using specific raw materials, this tended to be a subjective judgment. For example, some years ago it had been considered that entirely synthetic resins, such as acrylics, would have potential advantage over alkyds because stable pricing could be foreseen and because the vegetable oils used in alkyds would be increasingly required as foodstuffs.

Recent events, however, had demonstrated both the instability of pricing, based on petroleum, and the apparent advantage of using natural products, such as vegetable oils, in that these were a renewable resource.

MR P. WHITELEY asked whether the authors had any information on the disadvantage of increased costs when adopting coatings for the ecological benefits which they might offer.

MR NORTH replied that one of the aims of the study was to obtain sufficient data so that for any end use, it would be possible to calculate the economic attractiveness of a particular system. There was usually, but not necessarily, an increased cost in applying a coating, which gave ecological benefits. The increased cost could range from unnecessary extra film thickness in the case of powder coatings, to the relatively expensive co-solvents often needed in aqueous coatings. Comparison might be carried out, however, both with straightforward solvent-based finishes and applications where disposal of solvent by, for example, after-burners was required. Ideally, once sufficient facts were available, it would be possible to make a choice based on current raw material and energy prices and the specific end application.

MR K. TUUKKANEN wondered whether the authors could choose a particular system from their list (A) to (Q), which might be the best choice for further development in the future.

MR R. LITTLE said that no single choice could be made since it would depend on the end application, but he thought that two systems which showed particular promise and which might be studied in more depth were the high solids, oil-free polyester and the room temperature catalysed acrylic types.

Some factors affecting the water absorption of films from synthetic latices. Part II: Particle size and latex stability

By J. Šňupárek, Jr.

Research Institute for Synthetic Resins and Lacquers, 532 07 Pardubice, Czechoslovakia

Summary

The water absorption of polymeric films prepared from butyl methacrylate/butyl acrylate/acrylic acid copolymer latices has been investigated. The effects of particle size and dissociation of carboxylic

groups have been studied, and the dependence of water absorption on particle stability has been demonstrated.

Keywords

Types and classes of coatings and allied products

latex coating

Binders (resins, etc)

acrylic resin

methacrylic resin

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

water absorption

Quelques facteurs qui exercent une influence sur l'absorption d'eau par des feuillets de latices synthétiques

Résumé

On a fait une investigation sur l'absorption d'eau par des feuillets polymères à partir des latices copolymères tels que méthacrylate de butyle/acétate de butyle/acide acrylique. Les effets de la granulométrie et de la dissociation des groupements carboxyliques ont été étudiés et l'on a démontré la manière par laquelle l'absorption d'eau se dépend de la stabilité des particules.

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Einige Faktoren, die eine Wasserabsorption von synthetischen Latexfolien beeinflussen

Zusammenfassung

Untersuchungen über die Wasserabsorption polymerer Filmen aus Butylmethacrylat-Butyl-acrylsäureester-Akrylsäure-Kopolymer-Latex wurden angestellt. Die Einflüsse von Teilchengröße und Dissoziierung von Karboxylgruppen wurden untersucht, und die Abhängigkeit der Wasserabsorption von der Teilchenbeständigkeit wurde nachgewiesen.

Dissoziierung von Karboxylgruppen wurden untersucht, und die Abhängigkeit der Wasserabsorption von der Teilchenbeständigkeit wurde nachgewiesen.

Introduction

Refs. 1-9

Homogenous polymeric films are formed from latex by the coalescence of discrete polymer particles. The origin of the coalescence forces was attributed to the surface tension¹ of spheres, to the capillary forces² and to the mutual interdiffusion of macromolecules during later stages of the process³. At the same time, the complementary effect of these factors, as well as the effect of the radius of curvature of the coalescing particles⁴ has some effect. Polymer particles do not lose their identity in the film. Consequently, the structure of films deposited from a latex differs from the structure of those prepared from solvent vehicles. In addition, the latex films contain a certain amount of water-soluble ingredients, which affects their water sensitivity. A latex film undergoes several changes upon exposure to water. Whitening and swelling of the film may be accompanied even by the destruction of film continuity. Water is absorbed into the film by diffusion through the polymer and by capillary flow in the channels arising from imperfections within the film⁵. Water enters the polymer, in which it is soluble to a slight extent and diffuses into small pockets formed by salts and other water soluble materials. This penetration is driven by osmotic pressure, but is opposed by the increasing hydrostatic pressure of the water cells produced in the film, this force being due to the resistance of the polymer to deformation.

It was shown previously⁶ that the amount of water absorbed by the latex film depended on the elasticity of the polymer and the polarity of the emulsifiers, as well as on the stability of polymer particles. It was proved that increased latex stability, achieved by the addition of secondary emulsifiers, decreased the water absorption in spite of the hydrophilic character of the emulsifier. Other authors^{7,8} have found that the water absorption of films depends also on the particle size of the latex. On prolonged immersion, the water uptake of films with latices of fine particle size increased continuously, whilst a maximum was reached at an early stage with corresponding films based on coarse-particle latices.

It is suggested that the higher absorption of latex films of small particle size could be ascribed to incomplete coverage by emulsifier of the surfaces of larger particles and that this causes their lower stability. During film formation from latices of low stability, premature flocculation of particles occurs, and this results in a "spongy" film⁹ with higher water absorption⁶. The validity of this suggestion has been verified in this work.

Experimental

Ref. 10

The latices used were produced in the author's laboratory by semi-continuous emulsion copolymerisation of butyl metha-

crylate, butyl acrylate and acrylic acid (weight ratio 82:15:3). Various particle sizes were obtained by adjusting the distribution ratio of emulsifier between the initial reactor charge and the emulsion of monomers¹⁰. The anionic emulsifier "Etoxon AF-5" ($C_9H_{19}C_6H_4(OCH_2CH_2)_2OSO_3Na$) (Spolchemie, ČSSR) was used for polymerisation, and "Lutensol AP-9" ($C_9H_{19}C_6H_4(OCH_2CH_2)_2OH$) (BASF, Germany) was used for secondary stabilisation. The water absorption was measured after 10 days of immersion in water on films 300–350 μm thick (aged for three and 30 days at room temperature before immersion). The mechanical stability was evaluated by means of a high-speed stirrer (3 000 r.p.m.) for 30 minutes. If a coagulum appeared, the latex was classified as unstable. Surface tension was measured by the stalagmometric method. A portion of each sample emulsion was neutralised with ammonia to pH 8.

Results and discussion

The films were prepared from latices with particle diameters (d) of 0.11 and 0.56 μm . The cumulative particle size distributions are shown in Fig. 1. The product with coarse particles

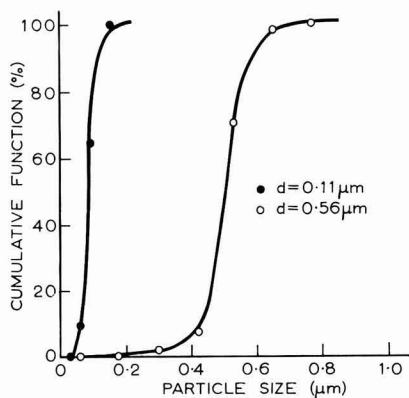


Fig. 1. Cumulative particle size distributions

was mechanically stable, whilst the fine particle latex was unstable. Mechanical stability was obtained by post-addition of a non-ionic emulsifier. The effect of secondary stabilisation, as well as the effect of dissociation of carboxylic groups on the surface tension and mechanical stability, are demonstrated in Fig. 2 and Table 1.

In the cases where latices without post-stabilisation were used, the normal type of water absorption into the films was found. Water uptake of films based on the latex with particles 0.11 μm in diameter continuously increased, whilst for the

corresponding films based on latex particles 0.56 μm in diameter, a limit of absorption was reached (Fig. 3). In films from a post-stabilised, small particle-sized latex, however, a lowered and limited absorption was found.

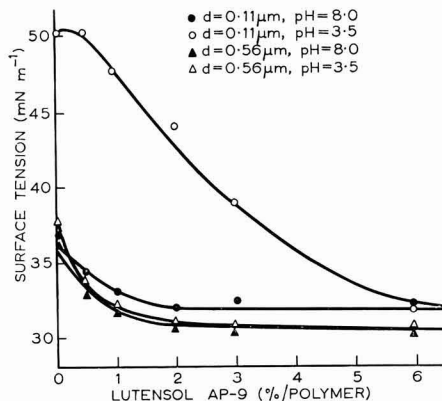


Fig. 2. Surface tension of latices in relation to the amount of post-added Lutensol AP-9

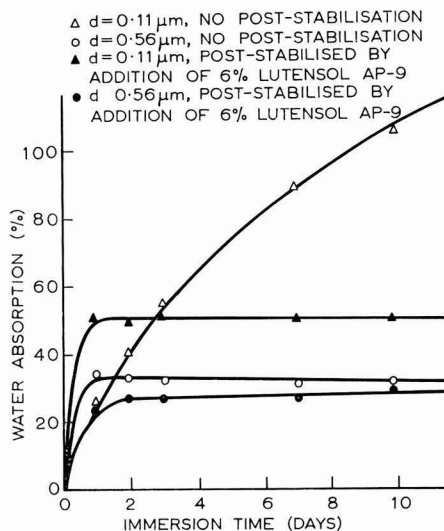


Fig. 3. Absorption of water in relation to immersion time

Table 1
Mechanical stability of the latices used

Lutensol AP-9 Per cent added, based on polymer	Stability after stirring for 30 min			
	$d = 0.56 \mu m$		$d = 0.11 \mu m$	
	pH = 3.5	pH = 8	pH = 3.5	pH = 8
0	+	+	Unstable after <5 min	+
1	+	+	" " <5 min	+
3	+	+	" " <5 min	+
6	+	+	+	+

+ = Stable

The stabilising effect of dissociated carboxylic groups is evident from Table I and Fig. 4, in which the amount of secondary emulsifier, necessary for decreasing water absorption of films from acid and alkaline latices, is shown. Water absorption of films from the latex with particle size $0.56\ \mu\text{m}$, which was stable even without post-stabilisation, was found to be practically independent of the amount of post-added non-ionic emulsifier (Fig. 5).

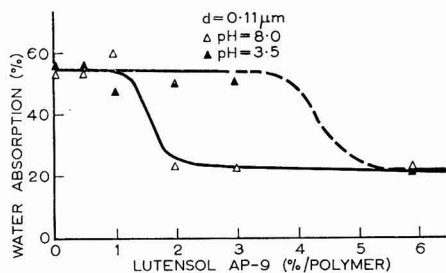


Fig. 4. Absorption of water after 10 days in relation to the amount of post-added Lutensol AP-9

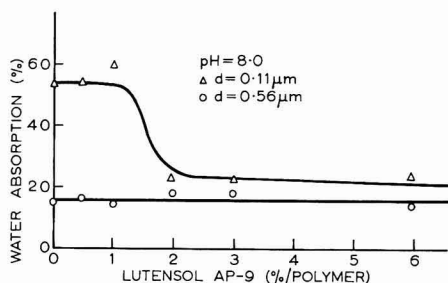


Fig. 5. Absorption of water after 10 days in relation to the amount of post-added Lutensol AP-9

It is suggested that the process of particle coalescence during film formation, especially the packing of particles in the film depends largely on the stability of the particles. The interfacial surface tension of a fine-particle latex is higher

than in the case of a coarse-particle latex. Consequently, the surfaces of fine particles are covered less by emulsifier and the particles have a tendency to premature flocculation during drying of the latex. Immobilised particles cannot form a regular "crystalline" structure; this results in higher water absorption of the films. This behaviour does not change even after 30 days' ageing. All results with the films aged for three or 30 days before immersion were practically identical.

Conclusions

Ref. 6

In agreement with the conclusions from previous work⁶, the experimental results indicate that addition of secondary emulsifiers to latices increases their stability and decreases the readiness with which their films will absorb water. Thus, an emulsifier will affect water absorption less by its hydrophilic character than by its positive effect on the close packing of particles in the film. It is suggested that the higher water absorption of films from latices with fine particles is caused by the lower stability of these particles.

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Preconstruction primers*

By C. A. Grey, L. A. Hill and F. Marson

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Summary

In the past, steel fabricators and ship-builders erected structures and built ships with unpainted steel components, so that extensive rusting of the steel occurred during the building period. In recent years, there has been an increasing use of "preconstruction" or "prefabrication" primers. The function of these materials is to prevent rusting during the fabrication period, so that the final structure is completed virtually free from rust. The large costs involved in rust removal and surface preparation are, therefore,

appreciably reduced and, in addition, an increased effective life of the structure is ensured.

The requirements for preconstruction primers are detailed; experience of their use is outlined; and the assessment of a number of commercially available materials is described. Problems arising from the use of preconstruction primers are considered.

Keywords

Types and classes of coatings and allied products

etching primer
inorganic coating
primer

Types and classes of structures or surfaces to be coated

steel

Raw materials:

binders (resins, etc)

alkyd resin
coal tar epoxy resin
epoxy resin
vinyl resin

prime pigments and dyes

aluminium pigment
iron oxide pigment
zinc dust

chemically active pigments

zinc chromate

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

corrosion resistance
humidity resistance
weather resistance

Les primaires de "préconstruction"

Résumé

Dans le passé les fabricants de charpentes en acier, et les constructeurs de navires utilisaient les éléments en acier nu pour construire des structures et des navires, de sorte que l'acier se rouillait sévèrement lors de la période de construction. Au cours des années récentes il y avait une consommation croissante de primaires de préconstruction ou de préfabrication. Le fonction de telles peintures est d'empêcher la formation de rouille pendant la période de fabrication afin d'assurer que la structure ultime est largement exempte de rouille. Ainsi les frais importants entraînés par l'enlèvement de la rouille et par la préparation des surfaces sont sensible-

ment réduits, et d'ailleurs un prolongement de la vie utile de la structure qui en résulte.

On mentionne en détail les caractéristiques essentielles des primaires de préconstruction, et l'on donne une esquisse des expériences mises en évidence au cours de leur emploi. On décrit les résultats de l'appréciation d'une gamme de ces produits qui sont disponibles sur le marché. On considère les problèmes soulevés par l'utilisation des primaires de préconstruction.

Vorkonstruktions-Grundierfarben

Zusammenfassung

Früher benutzten Konstrukteure und Schiffsbaumeister beim Errichten von Stahlkonstruktionen oder Bau von Schiffen unangestrichene Stahlbauteile, so dass weitgehend ein Rosten des Stahles während der Bauzeit zu verzeichnen war. In den letzten Jahren sind immer mehr "Vorkonstruktions-" oder "Vorfertigungs-" Grundierfarben zur Anwendung gekommen. Die Funktion dieser Materialien besteht darin, ein Rosten während der Bauzeit zu verhindern, so dass die endgültige Konstruktion praktisch rostfrei ausgeführt wird. Die erheblichen Kosten, die bei der Rostentfernung

und Oberflächenvorbehandlung entstehen, werden daher stark reduziert; ausserdem kann somit eine verlängerte Lebensdauer der Konstruktion gesichert werden.

Die Anforderungen an shopprimen werden im Einzelnen erläutert; ein Überblick über Erfahrungen in ihrer Anwendung wird gegeben; die Beschreibung einer Anzahl von im Handel erhältlichen Materialien wird vorgelegt. Eventuell bei der Anwendung von shopprimen entstehende Probleme werden erläutert.

Introduction

Corrosion is a major determining factor in the life of most steel structures, particularly of ships. Corrosion control is possible by means of cathodic protection, surface coatings, or both; one aspect of control, by "preconstruction" or "pre-

fabrication" primers, is discussed in this paper.

The work described was carried out at the request of the Australian Navy Department. In the absence of published information regarding Australian practical experience, a survey was required which would include a laboratory assess-

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ment of commercially available primers and a review of experience overseas.

Historical background

Structural steel and steel plate are formed by hot rolling processes, which leave a layer of iron oxides, called "mill-scale", on the surface; steel usually arrives at the fabricator's factory substantially in this condition. In the past, steel was exposed to outdoor weather to loosen the scale; the loose scale and rust were then removed by wire-brushing. Thus the surface which was painted was usually a mixture of residual intact scale, rust and rust-contaminated steel. Fortunately, red lead in oil was widely used as a priming paint so that, even under these primitive conditions of surface preparation, a large number of steel structures were successfully painted.

The increasing speed of shipbuilding altered this situation. When steel plate was exposed to the weather for long periods, an appreciable part of its millscale could be removed subsequently by wire-brushing. With modern construction speeds, the steel spends little, if any, time being weathered; the millscale is weakened insufficiently to permit its removal by hand cleaning. The use of blast cleaning at the constructed or semi-constructed stage to remove millscale is very costly. The invention of machines to clean flat steel plate reduced the blast-cleaning costs, but required the use of a primer to prevent re-rusting of the cleaned steel surface prior to the main painting stage.

In addition, when ships began to be used to transport large quantities of liquids in internal tanks, paints of high chemical and water resistance were required. Such paints, particularly epoxy paints, require a high level of surface preparation, such as that given by abrasive blasting. This trend, therefore, encouraged the use of abrasive-blasting machines at shipyards and demonstrated further the advantages of abrasive-blast cleaning. Similarly, in the US Navy shipyards, the use of high performance vinyl anti-corrosion and anti-fouling paints led to the use of abrasive-blast cleaning, since these paints also required a high standard of surface preparation.

Thus the use of sophisticated high performance paints and the use of abrasive-blast cleaning had a mutually accelerating effect; high performance paints must be used over properly prepared steel and once the steel was properly prepared it was logical to coat it with the best paint available. It was also recognised that if freshly cleaned steel plate is to remain in a suitable condition for painting, it should be protected soon after cleaning. One obvious way to do this was to apply a primer, which would subsequently become part of the protective system and which would be largely unaffected by fabrication procedures such as welding, bending and cutting. Such primers have come to be known as "prefabrication" or "preconstruction" primers. They are applied as thin films, often less than 25 micrometres thick.

Performance requirements

Preconstruction primers should possess as many as possible of the characteristics shown in Table 1, but it is unlikely that any one paint would possess all of these characteristics to the highest possible degree.

Table 1
Requirements of a preconstruction primer

1. Should be sufficiently dry to handle in about three to five minutes.
2. Should be capable of application by automatic spray so that a constant thickness may be obtained.
3. Should be mechanically strong, to resist damage in case of rough handling.
4. Should be capable of protecting steel plate from corrosion for periods of up to 12 months.
5. Should be capable of being used at a minimum thickness, so that the quality of any welds are not affected. The amount of fumes given off during welding should be as small as possible.
6. Should not give off highly toxic vapours during welding.
7. Should be resistant to high temperatures, so that the area adjacent to welding is not affected.
8. Should be flexible and able to withstand bending and impact during fabrication.
9. Should be suitable for use as the permanent primer for the final paint system.
10. Should be capable of being overcoated with the paints commonly used on ships.
11. Should be resistant to salt water immersion and the effects of cathodic protection.
12. Should be stable during storage in the can.
13. Should be readily available at an acceptable price.

Types of preconstruction primer

Obviously, there are many types of coatings which could be considered for use as preconstruction primers. The definition could be stretched even to include mixtures of lanoline and rosin, sometimes containing corrosion-inhibitors, which find occasional use. It was found that materials available commercially in Australia could be grouped into the classes given in Table 2.

Table 2
Type of primers available for use as preconstruction primers

Type 1	<i>Zinc primers</i> Class A One-pack epoxy B Two-pack epoxy C Metallic alkali silicates D Metallic organic-modified silicate E Polyethers
Type 2	<i>Etch primers</i> Class A One-pack B Two-pack
Type 3	<i>Iron oxide/zinc chromate primers</i> Class A Alkyd and modified alkyd B Vinyl C Epoxy D Miscellaneous
Type 4	<i>Aluminium primers</i> Class A Epoxy B Miscellaneous
Type 5	Miscellaneous primers

Assessment of commercially available materials

A number of commercial primers of the types shown in Table 2 were obtained, so that their suitability for use as preconstruction primers could be assessed; this assessment was carried out with the emphasis on their use in the shipbuilding industry and all properties were assessed using laboratory tests.

The properties required by preconstruction primers can be considered under the following five sections.

Application and drying properties

The fluid properties of the paints were examined using standard test methods and most paints of the types detailed above were found to be in suitable condition for application and storage. The pot-life of some two-pack primers, however, was found to be of a short duration, and with these paints it would be necessary to use metered twin-supply spray equipment.

The drying times of each type of primer varied considerably, but in general all types, with the exception of the alkyd based zinc chromate primers, could be formulated to give a sufficiently hard, dry film in the required time.

Typical results obtained for some of the fluid properties and drying times of the primers are given in Table 3.

Resistance to weathering

The exterior durability and the corrosion resistance of the primers were assessed by exposing them to both natural weathering and to accelerated laboratory tests. Standard salt spray, humidity and weatherometer tests were used in the latter case whilst the natural weathering was performed at an exposure site in a marine environment.

Of the laboratory tests, the Atlas "Weather-Ometer" test produced chalking of the primers, and only isolated cases of rusting of the substrate occurred. It was, therefore, considered to be unsuitable for use in predicting the performance of preconstruction primers. More general rusting

Table 3
Typical fluid properties of some preconstruction primers

Type	Description	Weight per litre (kg)	Non-volatile content (per cent)	Viscosity (krebs units)	Pot life (hrs)	Surface dry time (mins)	Hard dry time (mins)
<i>Zinc-rich</i>							
1A	One-pack epoxy	2.0-2.5	70-75	110-135	NA	5- 8	15- 30
1B	Two-pack epoxy	2.7-3.0	85-90	85-110	6- 30	3- 8	15- 120
1C	Metallic alkali silicate	3.0-3.4	80-85	85- 90	4- 24	4- 10	7- 60
1D	Metallic organic silicate	2.5-3.0	80-85	75- 85	16- 30	3- 10	5- 40
1E	Polyethers	2.0-2.5	75-80	80- 85	NA	4- 10	10- 60
<i>Etch primers</i>							
2A	One-pack	0.85-0.95	23-27	45- 70	NA	2- 4	4- 10
2B	Two-pack	0.85-0.95	17-27	45- 60	<50	3- 15	3- 20
<i>Iron oxide/zinc chromate primers</i>							
3A	Alkyd	1.2-1.3	58-69	55- 70	NA	15-150	45-1000
3B	Vinyl	0.9-1.0	25-30	60- 65	NA	5- 15	10- 30
3C	Epoxy	1.3-1.5	65-70	70-100	16-24	5- 30	15- 500
3D	Miscellaneous	1.0-1.5	58-65	60- 70	NA	2-100	15-1000
<i>Aluminium primers</i>							
4A	Epoxy	1.0-1.1	35-40	50- 55	10-<50	2- 5	10- 20
4B	Miscellaneous	1.0-1.2	28-35	50- 60	NA	2- 5	10- 20
5	Miscellaneous	1.1-1.5	40-65	60-115	—	5- 40	15- 180

NA: not applicable

Table 4
Summary of durability results

Type	Description	Average time of protection from rust (months)	Primers giving 12 months' service	
			No. tested	No. passed
1A	Zinc rich—One-pack epoxy	14	3	2
1B	Zinc rich—Two-pack epoxy	16	6	5
1C	Zinc rich—Metallic alkali silicate	18	4	4
1D	Zinc rich—Metallic organic modified silicate	18	6	5
1E	Zinc rich—polyether	6	1	0
2A	Etch primer—one-pack	1	2	0
2B	Etch primer—two-pack	1	5	0
3A	Zinc chromate—alkyd	7	8	2
3B	Zinc chromate—vinyl	4	2	0
3C	Zinc chromate—epoxy	9	4	2
3D	Zinc chromate—miscellaneous	7	3	1
4A	Aluminium—epoxy	11	4	2
4B	Aluminium—miscellaneous	6	3	1
5	Miscellaneous	4	4	0

occurred in the humidity test, but again the severity was considered insufficient to allow prediction of the performance required of primers exposed in a marine atmosphere. Salt spray tests were in general agreement with the results obtained from natural weathering, and this test was found useful for eliminating some of the poorer quality primers.

The results of the durability tests which were performed are summarised in Table 4. This shows both the average time of protection of each type of primer and also the number of each type which were capable of protecting blast cleaned steel for a period of 12 months—a period of time which is often required by the ship-building industry.

The results indicate that all classes of the zinc rich primers give good protection to steel, even when applied at the low film thicknesses required for preconstruction primers. Nearly all of these primers remained in good condition for the 12 months of weathering. The etch primers gave very poor protection in a marine environment and these would only be used as preconstruction primers for coating steel plate which is to be stored under mild conditions, such as those found indoors. The zinc chromate primers were intermediate in their performance, with the epoxy based materials performing slightly better than the other types; however, only a few were capable of 12 months' protection. The aluminium primers, particularly the epoxy based products, were the next best to the zinc rich primers. Although only a few were tested, there was evidence that when correctly formulated, they could be used as preconstruction primers for a period of 12 months. It was thought that some suppliers would submit high grade primers under the miscellaneous group, but this did not happen.

Resistance to fabrication procedures

Ref. 1

The likely resistance of the primers to fabrication procedures was also assessed by laboratory tests. Standard scratch, impact, flexibility and adhesion tests were used for this

purpose, both before and after artificial weathering. The test methods used for these evaluations, and the requirements necessary for a paint to pass the tests, are given in Table 5.

*Table 5
Test details*

Test	Method	Requirement
Scratch	Australian Standard K41 Method 403.1	Paint film to withstand scratching under a load of 0.5kg
Impact	DEF 1 053 Method 17(a)	When applied to 18-gauge mild steel, the paint film should withstand an impact of 2.75kg m
Bend (flexibility)	ASTM Method D522	Paint film to withstand an elongation of 20 per cent
Adhesion (cross-hatch)	DIN 53 151	No area of the paint film to lose adhesion

A summary of the results of these tests is given in Table 6. This Table gives an indication of the number of primers passing each test before artificial weathering. (Similar results were obtained after artificial weathering, except that the zinc rich and some zinc chromate primers tended to become more brittle.)

The zinc primers, which have a very high pigment loading, were found to have a low scratch resistance and were relatively brittle. Since these primers also protect by an electrochemical process for a limited period, however, corrosion in small damaged areas should be minimised. The adhesion of all of the zinc rich types of primers to carefully blast cleaned surfaces was good and it was also found that the epoxy based, zinc rich primers could tolerate a slightly lower standard of surface preparation. Both the etch primers and the zinc chromate primers were flexible and adhered sufficiently well to the steel substrate, but only the zinc chromate primers resisted scratching to a sufficiently high degree. Of these,

*Table 6
Summary of mechanical tests on preconstruction primers before artificial weathering*

Type	Description	Percentage passing test			
		Resistance to scratch test	Impact test	Bend test	Adhesion test
<i>Zinc rich</i>					
1A	One-pack epoxy	0	100	50	100
1B	Two-pack epoxy	35	40	63	83
1C	Metallic alkali silicate	0	33	37	100
1D	Metallic organic silicate	35	50	50	85
1E	Polyethers	0	100	100	100
<i>Etch primers</i>					
2A	One-pack	50	100	100	100
2B	Two-pack	50	100	100	100
<i>Iron oxide zinc chromate primers</i>					
3A	Alkyd	100	100	64	100
3B	Vinyl	100	100	100	100
3C	Epoxy	100	100	100	100
3D	Miscellaneous	50	50	75	50
<i>Aluminium primers</i>					
4A	Epoxy	50	100	50	100
4B	Miscellaneous	50	100	0	100
5	Miscellaneous	100	100	100	100

the epoxy-zinc chromate primers had an extremely high scratch resistance. The aluminium primers had good flexibility, adhesion and scratch resistance.

As yet, no tests have been performed to evaluate the welding compatibility of the primers. Information reviewed in the literature¹ and heat resistance tests, however, indicate that the zinc rich primers, particularly inorganic based primers, perform best provided the zinc fumes which are formed can be tolerated. The aluminium primers are said to be the best alternative to these, whilst it is claimed that zinc chromate primers can cause sticking of the electrodes during welding.

Compatibility to overcoating

Overcoating tests were carried out by applying to the weathered primers, paint systems commonly used in the topside, boot-top and underwater areas of a ship.

Only isolated adhesion failures were observed when these systems were exposed. These appeared to indicate, however, that overcoating of the inorganic, zinc rich primers could cause problems particularly in underwater areas.

Resistance to cathodic protection

Some of the better primers from the last mentioned trial were overcoated with a coal tar epoxy paint and exposed to sea water immersion under cathodic protection conditions as a further test of overcoating compatibility. Results of this test are summarised in Table 7.

Table 7
Summary of results of cathodic protection test

Type	Description of primer	No. tested	No. satisfactory
1A	Zinc rich—one-pack epoxy	2	1
1B	Zinc rich—two-pack epoxy	5	5
1C	Zinc rich—inorganic silicate	2	1
1D	Zinc rich—organic modified silicate	3	2
3A	Zinc chromate—alkyd	3	0
3C	Zinc chromate—epoxy	2	1
3D	Zinc chromate—miscellaneous	1	0
4A	Aluminium—epoxy	1	1

The resistance of the primers to this test was highly dependent on the type of binder used in them. The alkyd based materials were very quickly degraded. This was, no doubt, due to attack by the highly alkaline conditions created at defective points in the coal tar top coat, which resulted in saponification of the alkyd resin. This type of primer should not be used in cathodically protected areas or alternatively a high-build, impermeable top coating system must be applied to protect the primer. The silicate based primers were also susceptible to attack under these conditions, but to a far lesser extent than the alkyd materials.

The epoxy based primers, which have high chemical resistance, performed satisfactorily during the test.

Specifications

Refs. 1, 2, 4

There are no generally well-defined conditions of use for preconstruction primers, nor national specifications for the primers themselves, although individual organisations use their own specifications. The British Navy has a specification¹ for preconstruction primers. This allows for both a brushing

type, having a drying time of 30 minutes, and a spraying type, having a drying time of five minutes, in any of three classes: those pigmented with either aluminium, zinc or zinc chromate. The application of these types of primer is covered by a Process Specification².

The US Navy use an approval scheme to obtain suitable preconstruction primers⁴.

The Standards Association of Australia is preparing a Draft Specification. This classifies the primers into two types, depending on the degree of protection they afford, as a thin coat (less than 25 microns thick) to structural steel exposed in an aggressive environment. Type 1 protects steel for periods of up to one year before overcoating; type 2 protects steel for periods up to six months. Each type is required to perform as well as a given control: a two-pack epoxy/phenolic zinc pigmented coating for Type 1, and a red-oxide chromate pigmented phenolic primer for Type 2. The draft specification includes requirements for re-coating after a period of weathering, evidence of suitability for welding, and accelerated corrosion tests. It is anticipated that the specification will be published in 1976.

Overseas experience

Refs. 3-10

Kingcome and Smith³ have described prefabrication primers for use on Royal Navy ships. They state that outstanding durability is obtained with zinc dust based primers. In recent years, the zinc content of such primers has been reduced from 92 per cent to 65-80 per cent zinc, calculated on the dry film weight, to reduce difficulties with welding and to give improved performance, after top-coating, on underwater areas. The high zinc contents of underwater paints tended to cause blistering. Zinc based paints also had the best drying characteristics, the best resistance to mechanical damage, the best protection in weld-burn areas and were suitable for use with cathodic protection. The major objections to the zinc dust types were said to be in overcoating of outer bottoms and toxicity problems in welding and burning in confined spaces. Aluminium two-pack epoxies do not suffer from these defects but give only six months' protection at a thickness of 125 μ m. Zinc chromate or etching types are said to be slightly inferior to the aluminium types and are sensitive to cathodic protection.

The consumption of zinc-dust paints in Japan has risen from 160 tonnes in 1966 to 610 in 1970; this is mostly due to increased use of zinc paints in shipyards³. Electron Paint Marking (EPM) is widely used in Japanese shipyards and a special zinc rich paint has been developed for use with this system, which is similar to xerography and which is used to mark steel plate for cutting. Zinc rich paints have also been modified for use with numerical control cutting, a special process for fast cutting of steel. Zinc rich paints have been shown to be far more effective than wash primers on hulls with impressed current cathodic protection and this has been the main factor in the rapid growth of the use of zinc rich paints. Zinc rich primers are also widely used on harbour structures, bridges and petroleum tanks. The ratio of organic to inorganic zinc rich paints in Japan was 3:2 in 1971, but the demand for inorganic zinc rich paint is said to be growing.

In the USA, inorganic zinc rich primers have found growing use as preconstruction primers⁵. The primer is normally applied at 15-18 μ m at which thickness there is said to be no interference with subsequent fabrication procedures, such

as welding, cutting etc. Burn-back from weld areas is claimed to be negligible. The thin film primer is subsequently coated with a full thickness (75 μ m) of inorganic zinc, or is directly overcoated with an organic primer and finish system. The US Navy have used aluminium-based paints as weld-through primers; these materials were based on vinyl-butylal, styrenated alkyd or epoxy resins. This type of primer proved unacceptable for underwater use, but satisfactory for topsides. An examination of zinc-dust materials is planned⁶.

Zinc-dust paints for steel⁷ were first used in major applications in Holland in about 1953; the paints were used as preconstruction primers in the ship-building industry, particularly in the building and repair of oil tankers. Problems with overcoating were encountered and are being overcome by use of more suitable topcoats, by reducing zinc content for underwater use and by improved methods of cleaning prior to topcoating. Problems of intercoat adhesion, spot repair and recoating, however, may be the reason for the slight decrease in the use of zinc-dust paints in the marine industry in Holland. In nearby Norway, one major ship-building company is of the opinion that a zinc silicate primer gives the best performance of all types of preconstruction primer⁸.

In 1962, Wilson and Zonsveld⁹, of the Shell Company, described the development of a zinc-rich epoxy preconstruction primer. A study of the literature arising since that time indicates that where a high standard of protection is required, as in the ship-building industry, the use of zinc dust primers, either organic epoxy or inorganic silicate, as preconstruction primers is to be preferred. Jeffs¹⁰, of ICI Paints Division, states that the excellence of zinc rich primers for protection of the very active surface of blast-cleaned steel until ready for painting is rarely argued.

Discussion

Refs. 10-14

The rapid growth of the process of abrasive-blasting followed by preconstruction priming shows that it has many advantages, particularly of speed, convenience and cost. The process has perhaps been developed to the highest efficiency in the Japanese shipyards. The primed steel does become contaminated, however, during exposure, and some further surface preparation is necessary before painting. Sometimes wire brushing of the whole surface is required, and the removal of oil and grease is essential. Damage caused by welding requires re-blasting and re-coating.

It is generally conceded that the effect of delay between abrasive-blasting and painting is detrimental. Work in England¹¹ has shown that even a period as short as seven days between abrasive-blasting and painting may result in the durability of the coating falling to such an extent that the length of time over which it affords protection is reduced from over 68 months to 27 months. The only alternatives to preconstruction priming, therefore, are (i) to apply the whole paint system after blast-cleaning or (ii) to delay blast-cleaning and painting until after fabrication. The former is impracticable because cutting and forming would be interfered with and because different top-coats are used on different parts. The latter process was in common use in the past, and it involves heavy costs in rust removal and surface preparation. For many modern steel structures, particularly ships, prefabrication priming is the most efficient, economic and practicable process.

If the practice of preconstruction priming is generally conceded to be advantageous, however, the choice of type of preconstruction primer is not so generally agreed. Fancutt, Hudson and Stenners¹² consider that the best materials developed so far in respect of performance are probably certain two-pack types of zinc-rich epoxide resin paint containing about 90 per cent of zinc in the dry film. The Japanese are possibly using less zinc to avoid under-water blistering.

Jeffs¹⁰ believes that zinc rich preconstruction primers are excellent. Jackson¹³, however, states that when eight ships were built in European yards and a zinc-rich primer and an overcoating system of less than the preferred 250 μ m thickness were employed, all eight suffered major failure, which involved both blistering and rusting. On the other hand, when six ships built in Japan were zinc primed the coating's performance was satisfactory. Hodgson¹⁴ considers that iron oxide/zinc chromate two-pack epoxy paints seems to give the most reliable results, but he admits there is a tendency for these to blister or strip in immersed areas.

The authors' view is that in selecting a preconstruction primer, the thickness of primer and of finishing coats, and the severity of exposure conditions should all be considered. For example, it is clear that many primers which would be satisfactory for above-water conditions could fail if used below the water-line. It is also clear from the authors' tests that there is a variation in performance between samples from various manufacturers of a given type of primer. This variation tended to be less for zinc-based materials.

For long-term protection of about one year, without topcoats and under severe marine conditions, zinc-based materials perform best. Inorganic zinc silicates appear to be inferior to epoxy zinc primers, however, in respect of resistance to cathodic protection and compatibility when overcoated. The tests described indicate that, in general, two-pack epoxy zinc rich primers perform best.

Conclusions

It is clear that a wide range of materials can be used as preconstruction primers. For protection for periods of about one year in marine environments, zinc-based paints are to be preferred, although care should be taken to clean the zinc-painted surface before top coating and compatible top coats should be selected. A sufficient thickness of top coat should be applied and the use of zinc-based materials containing 65-80 per cent of zinc only (in the dried film) may be beneficial to avoid blistering under conditions of full immersion in water.

Acknowledgments

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Next month's issue

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

Quality control of painting in the construction industry by *F. G. Dunkley*

The flow of epoxy based powder coating films in relation to reactivity, rheology and wetting by *S. Gabriel*

Fungus-resistant paints for the humid tropics by *E. Hoffman, R. K. Hill and J. R. Barned*

The relative protection afforded by red lead dispersed in linseed oil, tung oil, oiticica oil and a long oil alkyd varnish by *A. J. Appleby and J. E. O. Mayne (Short Communication)*

Subscriptions for 1976 and binding of 1975 volume

1976 Members' subscriptions

Members are reminded that 1976 Membership subscriptions to the Association are payable on 1 January 1976. Forms were despatched to all members in October or November, depending upon address.

The Commissioners of Inland Revenue have approved of the Association for the purpose of the Income and Corporation Taxes Act Section 192, so that a Member subject to United Kingdom income tax is entitled to a deduction from the amount of his emoluments assessable to income tax under Schedule E for the whole of the annual subscription to the Association, provided the subscription is defrayed out of the emoluments of his office or employment and that the interests covered by the objects of the Association are relevant to such office or employment.

1976 library subscriptions

The *Journal* subscription rate to non-Members, including libraries, for 1976 will be £20.00 (\$50) post free by surface

mail, home and abroad. Individual copies can be purchased for £2.00. Remittance should be sent with order to the Association's offices.

Binding of Journal

Members will be pleased to know that J. S. Wilson & Son, 14a Union Road, Cambridge CB2 1HE, will undertake the binding of back volumes of the Association's *Journal* sent in by individual Members at a cost of £4.05 (including postage and packing) per volume.

Members wishing to avail themselves of this facility should send the parts, securely wrapped, direct to J. S. Wilson & Son Ltd, enclosing a remittance of £4.05 (including postage and packing) per volume, and ensuring that notes bearing their names and addresses are enclosed with the parcels. It is particularly important that packets are sufficiently wrapped to negate the possibility of damage in the post.

Information Received

Croxton & Garry appointed UK distributor for PQ products

Croxton & Garry Ltd, Esher, Surrey, has been appointed by PQ International, Inc., a subsidiary of Philadelphia Quartz Co., Pennsylvania, USA, to distribute the following PQ products to industrial markets in the United Kingdom: "Q-Cel" microspheres, a low density, inorganic filler for plastics manufacturing; "Q-Loid" alumina dispersion, an anti-stat/anti-soil agent for treating textile products of wool, nylon or acrylic, including carpets, draperies; it is also an anti-slip agent for use on cartons and paper bags; "Britesorb" synthetic magnesium silicate; "Qoram" organic ammonium silicates, and "Quso" non-crystalline, microfine silicas.

Diamond Shamrock sets third-quarter and nine-month records

Diamond Shamrock Corporation has announced record sales and earnings for the third-quarter and nine months ending 30 September 1975.

For the nine-month period, net income was \$82.1 million, up 25 per cent on the \$65.7 million recorded in the same period during 1974. Earnings per share for the period were \$4.93, compared with \$4.00 last year. The nine-months' sales figure totalled \$849 million, up 21 per cent on \$702 million in the same period last year.

Goodlass Wall acquires Inmont protective coatings division

Goodlass Wall & Co. Ltd, a wholly owned subsidiary of Lead Industries Group, is acquiring for cash from Inmont Limited of Wolverhampton, the protective coatings division (formerly Griffiths Brothers & Co. (London) Ltd).

Inmont Ltd, a subsidiary of Inmont Corporation of America, has decided to rationalise its activities at Wolverhampton in order to concentrate on its expanding automotive paints and refinishing business.

Goodlass Wall will continue to operate and expand this protective coatings division using the Griffiths sales force, under the well-established brand names of "Armour-seal" and "Ferrodor".

Hüls/Maurer supply DOP technology to Iraq

Intermediate Materials for Plastic Industries Co. S.A. in Baghdad, Iraq, has signed a contract with Ing. A. Maurer S.A., Berne, Switzerland, for the engineering supply, erection supervision and start-up of a dioctyl phthalate plant by a process licensed from Chemische Werke Hüls AG.

Montedison strengthens its position in marine paints

Montedison has acquired Veneziani Zonca S.p.A., of Trieste, a company with a centuries old tradition of high quality products for the field of marine paints. With the acquisition of Veneziani Zonca, Montedison has significantly strengthened its position in marine paints, and expanded its own activities in the area of paints and varnishes, where it already operates as Duco (part of the Division of Industrial Products—DIPI).

Veneziani Zonca will now have the opportunity to use the research, technological and commercial facilities of the Montedison Group, whilst Montedison now becomes part of the Transocean Marine Paint Association.

New offices for Ault & Wiborg

Ault & Wiborg Paints Ltd has combined the sales, service, technical service and other departments of its London and Birmingham branches of the Automotive and Industrial Divisions and moved them to Swan Centre House, Coventry Road, Yardley, Birmingham B25 8BT. The Refinisher Division is also in the course of moving to the new Swan Centre and expects to be installed by the beginning of 1976.

New paint plant opened by Blundell-Permoglaze

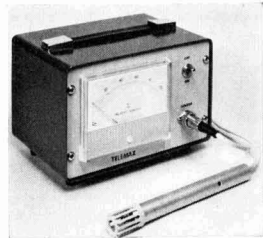
Blundell-Permoglaze Ltd has recently started production of water-based paint at its new plant built at the company's factory site in Hull. The production unit is the most modern of its type in Europe; it was built at a cost over £500 000 and is capable of producing over 11 million litres of water-based paint per year.

The demand for water-based paints has increased dramatically over the last few years, since the introduction of such products as vinyl emulsion and "semi-gloss" paint, and the company's investment in new manufacturing equipment is a sign of the confidence which Blundell-Permoglaze places in the continuing growth of demand for water-based paints.

New products

Dynasylan

In accordance with the expressed wishes of the rubber industry, Dynamit Nobel Chemicals has extended its range of "Dyna-



Telemechanics model RH/2, one of a range of new rapid-response instruments to monitor and control relative humidity from 0—100%

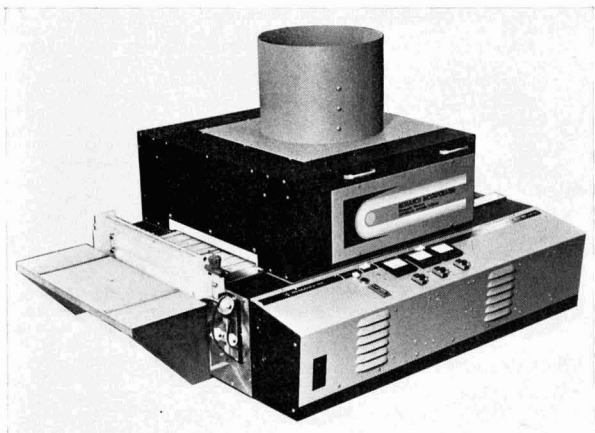
sylan" silanes by the addition of two new mercaptosilanes, namely mercaptopropyltrimethoxy silane and mercaptoethyltriethoxy silane. Neither of the two compound has the smell normally associated with mercaptanes and both can be added during rubber processing for the pretreatment of fillers or the production of special purpose compounds.

In addition, the range of aminosilanes has been extended by the introduction of "Dynasylan DAMO" (diaminosilane), and the range of alkylsilanes extended by the addition of "Dynasylan PTMO" (propyltrimethoxy silane).

Conveyor system for infrared curing

Research Incorporated of Minneapolis, USA, has introduced a new dry/cure system for coatings, which combines infrared lamps with forced hot air, to provide heating efficiencies of up to 85 per cent. This new modular system constitutes a major advance on existing electrically or gas-heated hot air ovens and on low intensity infrared systems.

Multiple heat zones are available using patented "Pyropanel" self-cleaning ceramic



The Research Incorporated Model 4682 system, which combines forced hot air with infrared lamps to dry and cure coating systems, is expected to be shown at this year's OCCA Exhibition—see New Products

reflectors with tungsten-quartz heating elements mounted above and below the conveyor belt and a hot air flow system built into the heaters themselves.

"Off-the-shelf" bench-top models are available with the option of up to four heating zones, with conveyor speeds up to approximately 0.3m s^{-1} and conveyor widths of approximately 12, 40 and 64 cm, and with process temperatures of up to 425°C easily attainable.

The UK representative of Research Incorporated is Wentworth Instruments Ltd; this company will be exhibiting at the 1976 OCCA Exhibition and intends to show the system on its stand. (See also photograph on page 29 and the "Conferences, symposia etc" section below.)

BASF product developments

BASF has announced the following product developments for the paint and printing ink industries:

Basoflex Yellow 098

This pigment dispersion for the printing ink industry has a wide field of potential applications in aqueous printing ink, and is particularly recommended for wall-paper printing inks. BASF has now improved the colour strength of its greenish "Basoflex Yellow 098", whilst retaining its good fastness and other properties.

Euthylen Brown 343 granules

BASF has supplemented its range of "Euthylen" colours with "Euthylen Brown 343" granules. This new product is an approximately 40 per cent dispersion of Iron Red in the usual "Euthylen" binder. The main applications are the colouring of polyethylene and polypropylene for film and sheet, containers, and injection moulding.

Sudan Orange 2R liquid

"Sudan Orange 2R liquid" is the latest addition to the BASF line of liquid dyes for the oil industry. Features of the new product are high colour strength, adequate stability at sub-zero temperatures, and infinite miscibility with oil derivatives. It is particularly suitable for colouring gasoline.

Thermoplast Yellow GS and Thermoplast Yellow R

Two new yellow grades have been added to the BASF line of "Thermoplast" soluble dyes for plastics. "Thermoplast Yellow GS" is slightly greenish and closely approaches the colour "Thermoplast Yellow G", whilst "Thermoplast Yellow R" is somewhat reddish. Both dyes feature very high colour strength, which is three to four times greater than that of "Thermoplast Yellow G".

New titanium dioxide grade from Laporte

A new grade of titanium dioxide for water-based high-gloss paint has been developed by Laporte Industries (Holdings) Ltd. Marketed as "Runa REGL", the new grade is intended to facilitate formulations with high opacity, ease of dispersion, in-can stability and high gloss. Further tests have confirmed abrasion qualities, necessary in ink formulation.

The largest market is for full and semi-gloss emulsion paints, where approximately 16 000 tonnes of pigment are used annually in the UK, but other important applications include aqueous industrial coatings, industrial stoving finishes, and printing inks. The high-gloss potential of "Runa REGL" has been established in paints based on a wide range of commercial polymers, including PVAc, olefins, acrylics and vinylidene chloride. In addition to the extensive UK market, Laporte is aiming for substantial export sales, especially in the major Common Market countries.

A technical brochure is available describing the physical properties of "Runa REGL" and suggested formulations of gloss and semi-gloss paints, stoving finishes and printing inks.



A patented airspray gun supply unit from Graco Ltd; the unit can be flush cleaned in approximately two minutes and is about one-quarter the weight of a conventional 20-litre pressure pot

Photo-activated adhesive

Under the trade name "Vitalit", a range of highly sophisticated ultraviolet-curing adhesives has recently been launched in the UK by Industrial Science Ltd, acting as distributor for the Swiss Chemical Company, Elsol (Zurich) Ltd.

Two types of adhesives (DAC and DSP) are available for bonding glass, porcelain, metals and polyacrylate, polystyrene or ABS plastics in any combination, where at least one adherent is transparent.

Literature

ICI chlorinated rubber paint guide

The Mond Division of ICI has recently published a free 24-page pocket book intended for the specifier of paint for industrial steelwork. Entitled "Data and systems for paints based on 'Alloprene' chlorinated rubber", the booklet covers surface preparation, environment, coverage capacity, estimation of paint required, and includes conversion tables for temperature, length and area, area and coverage capacity, volume and film thickness. Also included are case histories of eight different types of steel structures with details of the chlorinated rubber paint systems applied and their life.

NPL reports

Dr F. J. J. Clarke has kindly sent us copies of the National Physical Laboratory reports on the following studies, which he has conducted:

Goniophotometric and polarisation properties of the common white reflection standards

Problems of spectrofluorimetric standards for reflection and colorimetric use

Particle size distribution

The fourth section, the first for particle size distributions, of its "Atlas of light scattering curves" has recently been published by Science Spectrum, Inc. of Santa Barbara, California. This new section contains about 100 computer-generated differential light scattering patterns for aqueous suspensions of particles, ranging in average size from 200 to 1 200nm in 200nm increments.

Zinc diffusion coatings

Technicopy Ltd, in association with the Zinc Development Association, has published a translation from the Russian of "Galvanising, sherardising and other zinc diffusion coatings" by E. V. Proskurkin and N. S. Gorbunov.

Courses, symposia, etc.

Chemical Society—residential schools

The Chemical Society has announced residential schools for 1976 in the following subjects:

Fourier transform NMR spectroscopy

Advances in mass spectrometry

Stability and stabilisation of formulated products

The following courses will also be held during the year at the Urwick Management Centre, Slough, Berks:

R & D management studies for chemists 1976 (1-5 March, 11-15 October)

Management studies for production chemists 1976 (7-11 June)

Further information is available from Education Officer, The Chemical Society, Burlington House, London, W1V 0BN.

"Teach-in" on radiant heat

Wentworth Instruments Ltd, United Kingdom representatives for Research Incorporated, Minneapolis, USA, has announced that on Thursday 29 January 1976, it will be holding a "Teach-in" on the fundamentals of radiant heat and its uses in industry and research, at the United States Trade Centre, 4/5 Langham Place, London, WC1.

There will be speakers from the Electricity Council, specialists on radiant heat from the United States, films, slides and a demonstration of radiant heat equipment including the latest high density conveyor system for the dry/curing of coatings. Lunch will be provided. Admission will be free by invitation and interested parties are asked to make applications as soon as possible.

Bristol

Gloss paints

The Section found it necessary to hold an extraordinary general meeting at the Royal Hotel, Bristol, on Friday 31 October, before the commencement of the 209th ordinary meeting, due to the unfortunate resignation on health grounds of the Chairman, Mr G. R. Duckett.

The nomination of the Committee was Mr L. J. Brooke, who was duly presented with the Chairman's badge of office by Mr Duckett. This was the second occasion when Mr Brooke had become Chairman of the Section. Mr Fowles took over the office of Hon. Treasurer, the post vacated by Mr Brooke.

A paper entitled "Gloss paints, water-thinned or solvent-thinned?" was then presented by Mr D. G. Dowling, a member of the Section. The lecturer gave a historical background of the modern gloss paint, tracing the progress of oil-based systems, including non-drip alkyd types, to the present day water-based vinyl gloss. The advantages of this type of paint were outlined, including ease of application, low odour during application and non-yellowing.

On the other hand, at the present time, the traditional alkyd gloss paints still had some advantages, especially when highly-gloss films with maximum stain and mar resistance were required.

For use on external surfaces, the modern vinyl gloss possessed excellent durability and ease of application. The future trend was expected to be towards the greater use of water-thinned systems because of the possible shortage of vegetable oils, due to their increased demand for use as foodstuffs. It was possible that future technical advances in vinyl systems would overcome some of the present disadvantages.

The lecture, which was very well attended, finished with a most lively discussion period opened by Mr J. A. Wall. The vote of thanks was proposed by Mr J. R. Taylor and was well received by the members present.

J.R.T.

London

Ontario Branch

The testing of pigments in printing inks

The Branch held its first ever technical meeting on the evening of 22 October 1975 at the Skyline Hotel in Toronto, Ontario. Speaking to a group of 50 members and guests, Mr Walter Fibiger, of Canadian Hoechst Ltd, presented a lecture on the testing of pigments in printing inks.

Traditional methods of testing, the results of which were often highly influenced by individual operator technique, could be misleading to the ink manufacturer and unfair to the pigment supplier in a highly competitive market. Mr Fibiger demonstrated how a modest investment in more refined testing equipment could be allied with higher technical competence in the interpretation of test results. The reward would be greater economies of pigment use in ink making and application, and a deeper understanding of the many processes involved.

After a lively question period, a vote of thanks to the speaker was proposed by Mr B. Porteous, a member of the Branch Committee. Before closing the meeting, the Chairman, Mr P. Birrell, thanked members and guests for their great support of the Branch's first technical meeting which, judged by the numbers attending and the lively question period, had been a great success.

A.M.C.

Manchester

Powders and pigments in bulk

The first meeting of the Section's fiftieth year was held at the Manchester Literary and Philosophical Society on Friday 10 October, when some 50 members and guests heard Dr N. Harnby, of the School of Chemical Engineering, University of Bradford, give a paper entitled "Handling of powders and pigments in bulk".

Dr Harnby delivered a "professional" lecture on the basic principles of powder handling, discussing both free-flowing and non-free-flowing powders, the effect of the geometry of bulk hoppers on flow, and some of the principles involved in the mixing (and separation) of dry powders. The salient points were emphasised by the use of some clever models and apparent sleight of hand: why, for example, would a one-inch steel ball-bearing "float" to the surface of a beaker of sand when shaken, whereas a table tennis ball would not? During his lecture, the speaker demonstrated that most powder mixers were, in fact, efficient separators and, in any event, vibration in transport could easily separate powders according to their particle size.

During a lively question time, Dr Harnby pointed out that extremely small quantities of moisture could alter a powder's characteristics tremendously.

The vote of thanks by Mr G. Hurst was well received.

A. McW.

Midlands

Product costing

The first meeting of the current session was held at the Apollo Motel, Hagley Road, Birmingham, on Friday 26 September. The speaker, Mr B. Michie, FGA, ATII, of Carrs Paints Ltd, was introduced, his subject being "The elements of product costing".

The speaker opened by stating his intention of taking a broad view of the subject, rather than dealing with specific topics. Product costs were required, not only to arrive at a selling price, but also to assess the company's financial performance. Their use as a management tool was emphasised, and those aspects affecting the functions of the company as a whole were enumerated.

The areas of expense in retail/wholesale companies and in manufacturing companies were compared and contrasted. These costs should be related to the company as a whole and, taken together with sales forecasts, could be used for forward planning. By a comparison of actual performance against planned performance, decisions could be made rapidly and correctly.

The speaker next dealt with the main cost areas in manufacturing companies, breaking these down into various types of expenditure. The importance of the various cost areas varied from company to company.

The use of standard costs as a means of maintaining uniformity of approach within a company was discussed, standard costs being particularly important when, for example, a single product was being purchased from two or more suppliers. Another great advantage of the use of standard costs was the simplification of stock valuation.

With further reference to the use of forward planning, the speaker concluded by outlining some of the pitfalls awaiting those who did not correctly interpret the data available as a result of monitoring results against plans. Changes in certain factors (for example, volume and type of production, raw material prices, etc) could cause confusion when assessing

real production costs, and disastrously wrong decisions could result.

The speaker had kindly agreed to answer any questions, and dealt with these most capably. A vote of thanks was proposed by Mr R. Tennant.

F.W.C.

The coatings industry in a changing world

A meeting of the Section was held at the Apollo Motel, Birmingham, on Friday 17 October. Dr H. Wittcoff, of General Mills Inc. lectured on the coatings industry in a changing world.

The speaker's first objective was to examine the changing world, where changes of all kinds sometimes approached crisis levels, and his second objective was to examine the impact of these changes on the coatings industry. It was important to remember that change could signify opportunity, particularly in the vital areas of automation, pollution and population growth: each of these three areas was taken separately, and dealt with in more detail.

Automation had made possible a situation where the percentage of the working population engaged in manufacturing industry had decreased significantly, with a corresponding growth in service industries. Factory finishing implied less finishing in the field, with more business going to the producers of industrial finishes. In the USA, only 300 of the present 1300 paint manufacturers produced industrial paints, and much re-orientation was necessary. In the UK, the decorative market was contracting. Manu-

facturers had to think in terms of making surface finishes of all kinds and not only of paint. Problems with pollution had led to the current interests in water-based, high-solids and powder coatings. In the USA, there was a strong trend towards the hand-spraying of water-based coatings, particularly in the automotive industry. Exponential growth of world population was leading to exponential depletion of world resources. It was difficult to control population, and energy and raw material crises would continue. Smaller cars needed less paint, and the high cost of energy for heating ovens had already given a new lease of life to the market for certain two-pack systems. Exponential growth in R & D achievement, coupled with effective control of population, would be needed in order to overcome the more serious problems.

The final part of the lecture dealt with a number of the specific problems currently facing paint manufacturers, and possible ways of turning these difficulties to advantage. Trading and growth patterns favoured the large manufacturers, as did the more recent innovations, like electro-deposition, and ultraviolet and electron-beam curing. Water-dispersed coatings would show great growth rates, but solvent-based coatings (with little growth) would continue to form the bulk of industrial finishes.

In summarising, the lecturer indicated that all kinds of things were now happening which, though not all good, were in general both exciting and challenging. After a most interesting discussion, a vote of thanks was proposed by Mr R. Devenish.

F.W.C.

Review

Mixing: Principles and Applications

By Shinji Nagata

Kodansha Ltd, Tokyo

Pp. xviii + 458. Price £16.50

A simple title, but that is where the simplicity ends. This book is directed at the chemical engineer who wants to understand more about the basic principles of probably the most common operation in chemical processing. It sets out to study the mechanics of the motion of fluids in the only way possible—by applied mathematics. It is not a book for the plant man seeking a ready made solution to a problem. There are 10 main chapters.

Chapter 1 deals with the power consumption of mixing impellers and methods of measuring same. Empirical formulations are given for paddle agitators and other impellers in heterogeneous, highly viscous plastic and pseudoplastic liquids. Comparisons are made between the power consumption in cylindrical and square vessels.

Heat transfer in agitated vessels is covered in Chapter 2. So many factors influence the related coefficients and the author has elected to divide this subject into two main groups, namely the turbulent and laminar flow regions.

In Chapter 3 the flow patterns in agitated liquids are discussed, and the methods of measuring liquid velocity outlined by mention of some of the techniques employed.

Chapter 4 covers the mixing of homogeneous liquids through the basic concepts, mixing of high and low viscosity liquids and general blending. Continuous flow reactors are then covered, the author setting out to show how to predict the exact flow behaviour in a vessel.

Chapters 6, 7 and 8 deal with agitation in solid-liquid, liquid-liquid and gas-liquid systems. Emphasis is placed on the uniform suspension of solid particles in liquid (not easily attained) and reduction of diffusion resistance around solid particles. The liquid-liquid system concerns the process widely used in petroleum washing, organic synthesis and emulsion polymerisation.

The effect of agitation in heterogeneous systems is introduced in Chapter 9 with examples of such reactions as the nitration of benzene, the hydrogenation of methylstyrene and hydrogenation of fatty oils.

The final chapter on applications selects many operations previously discussed in the book and, by example, shows how this very complicated subject can be applied.

This book is very clearly printed and contains numerous diagrams, graphs and nomograms. Each chapter ends with its own notation and reference list. The book is adequately indexed.

This work is the result of Professor Nagata's studies in Japan, USA, Canada and Europe. Unfortunately, the author died whilst the book was in manuscript stage and, as the three contributors simply state in the preface, this book becomes the author's life work.

H. J. CLARKE



Eastbourne

OCCA CONFERENCE 1977



Grand Parade, Eastbourne, looking east from the Wish Tower

CALL FOR PAPERS

The next OCCA Conference will be held at the Grand Hotel, Eastbourne, England from 16 to 19 June 1977. The theme for the Conference will be:

The conservation of energy, materials and other resources in the surface coatings industry

The Hon. Research and Development Officer now invites offers of papers for presentation at this Conference. Anyone wishing to submit a paper for consideration should notify his intention as soon as possible to: The Director and Secretary, Oil and Colour Chemists' Association, Priory House, 967 Harrow Road, Wembley, Middlesex HA0 2SF, England (Telephone 01-908 1086; telex 922670).

OCCA-28 Exhibition

Alexandra Palace, London. 23-26 March 1976

The continuous dialogue
between suppliers
and manufacturers
in the surface coating industries



The Exhibition Committee has now allocated space to all organisations which have so far applied for space at the world's most important annual event in the surface coatings industries, which in recent years has attracted visitors from approximately 50 overseas countries. As well as exhibits from Australia, Austria, Belgium, Denmark, Germany, Hungary, Italy, Poland, Romania, Spain, Sweden and Switzerland, there has been a significant number of companies applying for space either direct from the USA or through their European associates. Some of these have not exhibited at previous OCCA Exhibitions, whilst others have not exhibited for several years. The Committee welcomes this transatlantic interest in the Exhibition.

The preliminary list of Exhibitors is as follows:

- Arcode
- Boulton, William, Ltd
- * Chemetron Chemicals International
- Chemolimpex Hungarian Tdg. Co. for Chemicals
- Ciech (Poland)
- † Cole Chemicals Ltd
- * Contraves Industrial Products Ltd
- * Desert Sunshine Exposure Tests
- † Diaf A/S
- Diffusion Systems Ltd
- † Dow Chemical Europe
- Durham Raw Materials Ltd
- † Elcometer Instruments Ltd
- Fuel & Metallurgical Journals Ltd
- Glen Creston
- Hercules Powder Co. Ltd
- * Hopton Mining Co. Ltd
- † D.H. Industries Ltd
- Jacobson Van Den Berg & Co. (UK) Ltd
- Laporte Industries Ltd
- * Manufacturers Eng. & Equip. Corp.
- Marchant Bros. Ltd
- Mastermix Engineering Co. Ltd
- † Metal Box Ltd
- † Millroom Accessories & Chemicals Ltd
- † Monsanto Europe S.A.
- Montedison
- National Westminster Bank Ltd
- Research Equipment (London) Ltd
- * Rio Beer

- * Scientific & Educational Aids (ABR) Ltd
- Sericol Group Ltd
- * Silberline Ltd
- † Smith, Herbert, & Co. (Grinding) Ltd
- Strazdins, A., Pty. Ltd
- Sun Chemical Corpn.
- Tioxide International Ltd
- Titanium Intermediate
- Torrance & Sons Ltd
- * UCB Chemical Division
- VEB Kombinat Nagema
- * Waterfall Group Travel
- † Wentworth Instruments Ltd
- Wheatland Journals Ltd
- Worsdall Chemical Co. Ltd

* Denotes companies who have not previously shown at an OCCA Exhibition.

† Denotes companies who were not at the 1975 Exhibition.

The Committee appreciates that there may be some companies who were unable to come to a decision about exhibiting during the autumn months and wishes it to be known that it will consider applications from such companies, provided these are received as **quickly as possible**. **Late applications will be featured in the February issue of the Journal and also the March issue, which will contain a special Preview of the Exhibition.**

Hours of opening and venue

The 1976 Exhibition will take place at Alexandra Palace, London, N22, the site of the successful Exhibitions held by the Association from 1965-1969, on the following dates and times:

Tuesday 23 March 9.30-17.30
Wednesday 24 March 9.30-17.30
Thursday 25 March 9.30-17.30
Friday 26 March 9.30-16.00

A map is printed on page 36 showing the approaches to Alexandra Palace, both by road and Underground. Adequate free car parking facilities are available, and Alexandra Palace is easily approached from the M1 motorway. Those travelling by Underground will find that the journey from central London on the Piccadilly Line takes approximately 18 minutes, and the Association will be running a free bus shuttle

service to and from Turnpike Lane Station on the Piccadilly Line and Alexandra Palace. A further map (opposite) shows the streets in the immediate neighbourhood of Alexandra Palace. Both of these maps will also be reproduced in the "Official Guide".

"Official Guide" and admission tickets

The "Official Guide" will contain details of each Exhibitor's stand and constitute a summary of those recent technical developments which will be shown. It is intended to prepare the "Official Guide" well in advance of the dates of the Exhibition so that copies can be circulated widely, thus allowing visitors an opportunity to plan their itineraries.

Members of the Association will automatically be sent an individual copy of the "Official Guide", together with a season admission ticket. **A small charge will once again be made to non-Members, however, and this has been fixed at £2.00 for a season admission ticket and copy of the "Official Guide"** (available either at the entrance to the Exhibition or in advance by sending payment to the Association's offices); in addition, copies of the "Official Guide" will be offered for sale at the Association's Information Centre, Stand 26, during the Exhibition opening hours.

Non-Members may reserve copies of the "Official Guide" and season admission tickets by completing the relevant form enclosed in this issue of the *Journal* and sending it with the necessary remittance to the Association's offices.

Information in six languages

Information leaflets in six languages are at present being issued to thousands of chemists and technicians on the Continent of Europe, and also to any visitors who completed cards at the previous Exhibition. Any reader wishing to have a copy of the leaflet, which contains an application form for season admission tickets and copies of the "Official Guide", should write immediately to the Association's offices.

Motif of the Exhibition

The motif for 1976, designed by Robert Hamblin, continues the theme of the last two exhibitions—in which attention was drawn to the heavy participation by exhibi-

tors and visitors from overseas—by showing the target for 1976 as London, where all the Association's annual Exhibitions have been held. The colours of the motif this year are those associated with an archery target and these colours will be carried throughout the publicity leading to the Exhibition. Two of them will be incorporated on the facias of the stands—the blue colour from North to South and the yellow colour from East to West. As in previous years, this will give the Exhibition both an entity in design and will afford pleasing differences in colour as visitors move from corridor to corridor.

Seating areas

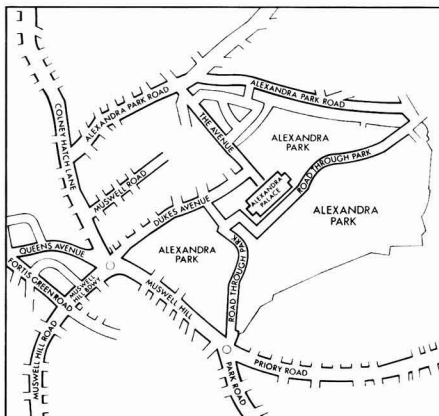
In recent years, visitors from 50 overseas countries have attended OCCA Exhibitions and, as well as arranging for interpreters to be available, the Association will once again provide attractive seating areas where visitors can relax between visits to stands. One seating area will be situated in front of the Information Centre, by the side of which the Interpreters' Stand will be placed, and the other seating area will be situated in front of the Technical Education and Travel Agency Stands. As before, floral displays will be arranged in the centre of each seating area.

Travel and accommodation

The Waterfall Travel Agency Ltd (Stand 28) will be prepared to advise on and to arrange hotel accommodation and travel facilities to the Exhibition. The company will also be able to make theatre ticket reservations for the evenings of the Exhibition. Advance bookings and enquiries should be addressed to Waterfall Group Travel, 61 Long Row, Horsforth, Leeds LS18 5AP. It is particularly requested that all enquiries be sent to this address, and not to the Association.

OCCA-28—THE TARGET FOR 1976! CAR PARKING FACILITIES

There are adequate free car parking facilities available at Alexandra Palace. Visitors travelling by road will be able to consult the simplified diagram showing the approach roads from Central London and the M1 motorway, which will be reproduced in the *Official Guide* to the Exhibition. In addition, a map will be printed in the *Official Guide* showing an enlargement of the Alexandra Palace area and this is reproduced below.



Further details on the Exhibition will be published in the Journal during the early months of 1976 and copies of the Official Guide and free season admission tickets will be sent to all members of the Association in February 1976.

Irish Section

Annual Dinner Dance

The annual Dinner Dance was held on Friday 21 November 1975 at the Clarence Hotel, Dublin.

The top table guests included Mr G. Clayton, Chairman of the Manchester Section, who deputised for the President, Mr. J. Tooke-Kirby, Chairman of the London Section, and Mr R. Moorhead, President of the Irish Paint Manufacturers' Federation, accompanied by their wives.

Those members of the Committee who arranged the function were gratified by the large attendance, which was a fitting reward for their efforts. Around one-hundred members and friends sat down to dinner and this number was probably in the higher bracket.

Dancing continued until 2.00 a.m., and Mr D. Sharpe's ideas for spot prizes were certainly original, but none the less amusing.

As always, this annual function was widely appreciated for the opportunities which it provided for meeting old and new friends.

Jordan Award

This award was instituted by the late Mrs M. R. Jordan in memory of her husband Dr L. A. Jordan, who was President of the Association 1947-49 and an Honorary Member, and who died in December 1964. The Committee invites applications for the fourth award of £100.

The rules of the Award are:

1. The Award will be made for the best contribution to the science or technology of surface coating by a Member of any nationality working in either the academic or industrial field who is under the age of 35 at the date of application.

2. The final date for submission of applications will on this occasion be 31 December 1976 and it is hoped to present the award at the Eastbourne Conference in the following June.

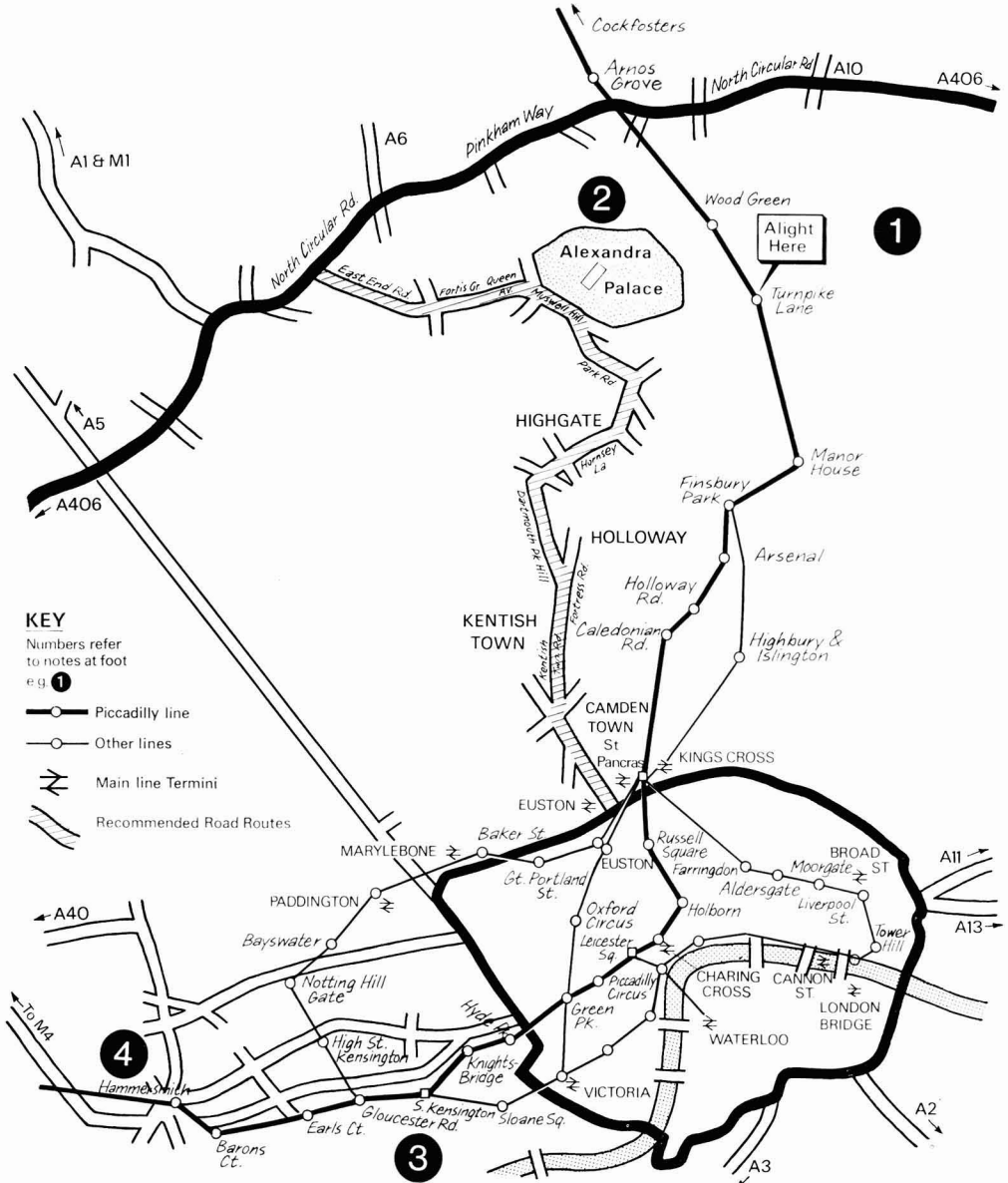
3. The selection of the recipient of the Award will be made by a Committee under the chairmanship of the Association's Hon. Research and Development Officer.

4. There will be two methods of application. First, by the submission of a paper describing original work by the candidate which is offered for publication in the *Journal* or has been so published during application. The alternative method will be by recommendation by a superior for work which for reasons of commercial secrecy cannot be published; in this case the candidate will be expected to submit a dissertation on a topic relating to his work and demonstrating his superior knowledge of the principles thereof. The Award is for individual merit and clear evidence of the candidate's own contribution will be required if a paper is offered under joint authorship.

5. Applications should be addressed to the Director & Secretary at the Association's offices.

OCCA-28

For the benefit of intending visitors to the Exhibition, a map is reproduced below of the area around Alexandra Palace showing the mainline stations in central London, the Piccadilly, Circle and Victoria Lines of the underground system and also the road links with the North Circular Road and motorways. See also the enlarged map of Alexandra Palace, reproduced on page 35.



KEY

Numbers refer to notes at foot e.g. 1

- Piccadilly line
- Other lines
- Main line Termini
- Recommended Road Routes

1. A free bus shuttle service will operate between Alexandra Palace and Turnpike Lane station on the Piccadilly Line (Underground), which is denoted by the thick coloured line. Destinations of trains may be marked as "Cockfosters" or "Arnos Grove" or "Wood Green".
2. Those travelling by road will find free car parking facilities at Alexandra Palace. See map on page 35.
3. Visitors arriving at West London Air Terminal may board the Piccadilly Line trains at Gloucester Road station.
4. At present the Piccadilly Line reaches westward as far as Hatton Cross Station and in 1977 will be extended by the addition of a further station in Heathrow Airport Terminal, so that visitors will then be able to travel direct from the airport terminal to Turnpike Lane station. In the meantime, a bus service operates between the air terminal and Hounslow West station on the Piccadilly Line.
5. The map also shows the position of the main line stations in relation to the Piccadilly Line.

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

- BERHANE, ABRAHAM, Mega Paints Manufacturing Co, PO Box 5599, Addis Ababa. (*General Overseas*)
- BOOTH, ANTHONY, BSc, 92 Bramhall Lane, Davenport, Stockport, Cheshire SK2 6JG. (*Manchester*)
- COBBETT, DAVID GEORGE, BSc, Sigma Paints (Thailand) Ltd, 703 Bangkok Insurance Building, 302 Silom Road, Bangkok, Thailand. (*General Overseas*)
- DIXON, EUGENE ETHERINGTON, BSc, 38 Thirkleby Crescent, Grimsby, South Humberside. (*Hull*)
- EICHHORN, C. JOHN R., MSc, NL Industries Inc, 5 Cavendish Court, 11/15 Wigmore Street, London W1. (*London*)
- FOWLER, CAROL ANN, LRIC, Crown Decorative Products Ltd, Hollins Road, Darwen, Lancs. (*Manchester*)
- HALL, BART, 180 Grand Avenue South, Apt. 1108, Cambridge (G), Ontario, Canada. (*London Section—Ontario Branch*)
- HART, REIN 'L, Synres (UK) Ltd, Six Acre House, Town Square, Sale, Cheshire. (*Manchester*)
- KAM, ROBERT, 11a Euston Road, Hughesdale, Victoria 3166, Australia. (*General Overseas*)
- KELLY, WILLIAM, 85 Hartleywood Drive, Agincourt, Canada. (*London Section—Ontario Branch*)
- LEFAVE, J. G., 69 Chant Crescent, Unionville, Ontario L3R 1Y7, Canada. (*London Section—Ontario Branch*)
- LESTER, ANDREW W., BSc, Lester Inks & Chemicals Ltd, 55 Glencameron Road, Thornhill, Ontario, Canada. (*London Section—Ontario Branch*)
- MURRAY, CARL ALLAN, 4 Hearthstone Court Bramalea, Ontario, Canada. (*London Section—Ontario Branch*)
- PATEL, KANTI CHHOTABHAI, 1 Wards Road, Ilford, Essex. (*London*)
- PRESCOTT, DENNIS JAMES, 7 Akatea Road, Span Farm, Glen Eden, New Zealand. (*Auckland*)
- RAMANANANDHAN, WYRAMUTTO NADARAJA, 14 Charlemont Road, Colombo 6, Sri Lanka. (*General Overseas*)
- RECKLESS, FRANK NORMAN, BSc, ARIC, 3 Edgebrook Crescent, City of Brampton, Ontario L6T 1Y6, Canada. (*London Section—Ontario Branch*)
- SKOTNICKI, BOGDAN, MSc, 24 Indian Trail, Toronto, Ontario M6R 1Z7, Canada. (*London Section—Ontario Branch*)
- SREEVANICH, RUANGNAM, BSc, Sigma Paints (Thailand) Ltd, Bangchan Industrial Estate, 36 Mooti 14, Minburi, Bangkok, Thailand. (*General Overseas*)
- STRUTHERS, JOHN ALEXANDER, BSc, Alexander G. Paterson Ltd, 180 Hope Street, Glasgow G2 2UE. (*Scottish*)
- VELAZQUEZ, HUGO, BSc, Inmont Canada Ltd, 303 Campbell Avenue, Toronto, Ontario M6P 3V8, Canada. (*London Section—Ontario Branch*)
- WARWICK, MALCOLM ERIC, BSc, ARIC, 41 Marlow Road, Southall, Middlesex UB2 4NS. (*London*)
- YATE, MICHAEL JOSEPH, Mossley Road, 11 Stafford Lane, Hednesford, Staffs. (*Midlands*)

Associate Members

- PERRY, ALEX B., ICI Ltd, 4 Blythwood Square, Glasgow. (*Scottish*)
- RIDWAN, WIHARDJA, J1 Kapt P Tendeang 31, Bandung, Indonesia. (*General Overseas*)
- SINGLETON, PAUL ALAN, Canadian Hoechst Ltd, 100 Tempo Avenue, Willowdale, Ontario, Canada. (*London Section—Ontario Branch*)
- SLEGTENHORST, JACQUES, Unilever-Emery NV, PO Box 2, Gouda, Holland. (*General Overseas*)

Registered Students

- BROWN, VALRIE YOLAND, Romford YMCA, Rush Green Road, Romford RM7 0PH, Essex. (*London*)
- DINGWALL, JOHN FRASER, McArthur & Jackson Ltd, 51 Hobden Street, Glasgow G21 4AT. (*Scottish*)
- MORLEY, MICHAEL JOHN, 11a Belmont Road, Twickenham, Middlesex TW2 5DA. (*London*)

Association Dinner Dance 1976

Early in the New Year members attached to the United Kingdom, Irish and General Overseas Sections will be sent the application form for the Association's Biennial Dinner and Dance to be held on Friday 14 May 1976 at the Savoy Hotel, London WC2R 0EU.

The Reception will take place at 7.00 pm for Dinner at 7.30 pm and on this occasion there will be two short speeches only—a Welcome by the President and a Reply on behalf of the guests—so that dancing, to the Jerome Orchestra, can commence as soon as possible and continue until 1.00 am.

The price of single tickets is £10.00 plus 80p VAT each and applications should be made by Members as soon as possible after receipt of the form. Tables will be arranged to accommodate 12 or 10 persons each, although it may be possible to arrange a few tables for eight persons. Non-members wishing to receive forms should contact the Association's offices at the address on the contents page of this issue.

Preliminary notice of Annual General Meeting

It is intended that the Association's Annual General Meeting will be held at approximately 3.00 pm on Friday 25 June 1976 at the Crown Hotel, Harrogate, immediately after the termination of the West Riding Section's two-day symposium on "Exports"; a notice allowing for the nomination of the three Elective Members of Council will be sent to Members attached to the United Kingdom, Irish and General Overseas Sections early in the New Year and completed forms must be returned to the Association's offices not later than 1 May 1976. It is not necessary for those who wish to attend only the Annual General Meeting to register for the symposium. The Agenda, Voting Paper and Annual Report will be circulated to Members in the usual way approximately six weeks before the date of the Annual General Meeting.

News of Members

Dr W. Carr, an Ordinary Member attached to the Manchester Section and a Fellow in the Professional Grade, has been seconded to the Department of Colour Chemistry at the University of Leeds. Dr Carr, at present Technical Manager of the Physical Laboratories of CIBA-GEIGY (UK) Ltd's Pigments Division has been an honorary visiting lecturer to the Department of Colour Chemistry for ten years and in his new capacity he will spend several days a week in the Department. He will become more involved in lecturing and the supervision of research work and the title of CIBA-GEIGY Senior Research Fellow has been conferred upon him. By supporting Dr Carr at Leeds, the Pigment Division hopes to strengthen its links with the University.



Dr William Carr



Mr Helge Meyer

Mr H. Meyer, an Ordinary Member attached to the General Overseas Section and a past Vice-President of the Association, has joined NIFAB Scandinavian Paint Consultants Ltd with responsibility for commissions within the paint industry and the educational field. NIFAB operates from both Stockholm and Copenhagen as a consultant firm in the surface coatings field, and works intimately with the Scandinavian Paint and Printing Ink Research Institute.

Mr R. J. King, an Associate in the Professional Grade and at present both Vice-Chairman of the Midlands Section and its representative on Council, has been appointed Deputy General Manager of Blundell Permoglaze Ltd.

Forthcoming Events

Details are given of meetings in the United Kingdom up to the end of the month following publication.

January

Monday 5 January

Hull Section: "High solids, water reducible aminoplast cross-linkers for modern coating systems" by M. M. Donnez, Monsanto Europe, to be held at the George Hotel, Land of Green Ginger, Hull at 6.30 p.m.

Thursday 8 January

Newcastle Section: "Biodeterioration of paints" by Mr C. N. Finlay, Nuodex Ltd, to be held at the Royal Turks Head Hotel, Newcastle upon Tyne at 6.30 p.m.

Friday 9 January

Manchester Section: "Masonry coatings" by Mr P. Whiteley, Building Research Establishment, to be held at Manchester Literary and Philosophical Society, George Street, Manchester at 6.30 p.m.

Scottish Section: Annual Dinner Dance.

Tuesday 13 January

West Riding Section: "Water based adhesives" by Dr K. Sellars of Harlow Chemical Company Limited, to be held at the Griffin Hotel, Boar Lane, Leeds at 7.30 p.m.

Thursday 15 January

Scottish Section: "Gloss emulsions and high performance decorative acrylic emulsions" by Mr G. Keith and Mr D. H. Kerrison, Rohm & Haas Ltd, to be held at Beacons Hotel, 7 Park Terrace, Glasgow at 6.00 p.m.

Friday 16 January

Irish Section: Ladies' Night, Fashion film—cheese and wine tasting, to be held at the Clarence Hotel, Dublin at 8.00 p.m.

Midlands Section and Trent Valley Branch: "Corrosion: the supplier's problems" by Mr A. E. Claxton of Inmnot, and "The user's problems" by Mr F. Timmins of British Rail, to be held at Birmingham Chamber of Commerce and Industry, Harborne Road, Edgbaston B15 at 6.30 for 7.00 p.m. Dinner lecture.

Monday 19 January

London Section: "Applications for cellulose ethers in paint manufacture" by Dr V. Knittel of Kalle, Wiesbaden, W. Germany, at East Ham College of Technology, High Street, London E6, at 7.00 p.m.

Wednesday 28 January

Manchester Section—Student Group: "The formulation and manufacture of emulsions for the paint industry" by Mr K. R. Geddes, Crown Decorative Products Ltd, to be held at Manchester Literary and Philosophical Society at 4.30 p.m.

Thursday 29 January

Thames Valley Section: "Packaging testing for hazardous goods" by Mr C. Swinbank, Packaging Co-ordinator ICI Ltd, to be held at Beaconsfield Crest Hotel (White Hart), Aylesbury End, Beaconsfield, Bucks, at 6.30 p.m. for 7.00 p.m.

Friday 30 January

Bristol Section: "Modern techniques of wood preservation and protection" by Mr R. E. Hambling of Cuprinol Ltd, to be held at Royal Hotel, Bristol at 7.15 p.m.

February

Monday 2 February

Hull Section: "Water thinned gloss paints" by Dr K. Sellars, Harlow Chemical Co Ltd, to be held at the George Hotel, Land of Green Ginger, Hull at 6.30 p.m.

Thursday 5 February

Newcastle Section: "Planning" by Mr J. A. Willey of Berger, Jenson & Nicholson Ltd, to be held at the Royal Turks Head Hotel, Newcastle upon Tyne at 6.30 p.m.

Friday 6 February

Manchester Section: "Smoke emission from polymer and paint films" by Mr K. A. Safe, Technical Service Manager, Paint and Building Industries, Vinyl Products Ltd, to be held at the Woodcourt Hotel, Brooklands Road, Sale, at 6.30 p.m.

Thames Valley Section: Buffet Dance at the Great Fosters Hotel, Egham.

Tuesday 10 February

Scottish Section—Student Group: "Organic pigments" by lecturer from ICI, to be held at the CIBA-GEIGY site, Hawkhead Road, Paisley.

West Riding Section: "The role of pigment preparations in the surface coating industry" by Mr M. Cotton of Sandoz Products Ltd, to be held at the Griffin Hotel, Boar Lane, Leeds at 7.30 p.m.

Wednesday 11 February

Manchester Section—Student Group: "Acrylic emulsions in decorative and industrial coatings" by Mr J. H. Sparrow, Rohm & Haas (UK) Ltd, to be held at the Manchester Literary and Philosophical Society at 4.30 p.m.

Thursday 12 February

Scottish Section and Eastern Branch: "Advances in water-based coatings for the printing and packaging industries" by Mr G. H. Hutchinson, Croda Inks, to be held at 7.30 p.m. in the Carlton Hotel, Edinburgh.

Midlands Section—Trent Valley Branch: "Non-toxic replacement for mercury in fungicides." *Speaker to be announced.* To be held at the Crest Hotel, Pastures Hill, Littleover, Derby.

Monday 16 February

Hull Section: "The use of microvoids as pigments" by a speaker from Toxide International. *Venue to be announced.*

Wednesday 18 February

London Section: "Health and safety". One-day symposium at the Thames Polytechnic, Woolwich, commencing at 9.30 a.m.

Thursday 19 February

Midlands Section: "Titanium pigment developments." *Details to be announced.*

Friday 20 February

Irish Section: "High solids material" by Mr D. Faulkner, Rohm & Haas (UK) Ltd, to be held at the Clarence Hotel, Dublin at 8.00 p.m.

Friday 27 February

Bristol Section: "Photopolymer printing plates" by Mr D. J. Hodgkins, manager of the Graphic Arts Division of BASF (UK) Limited, to be held at the Royal Hotel, Bristol, commencing at 7.15 p.m.

Association Conference 1977



CALL FOR PAPERS—SEE PAGE 33

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Many young technologists and scientists who visited the earlier Exhibitions have now risen to high positions within their organisations and the advantage to exhibitors of keeping in constant contact with their counterparts in the manufacturing industries needs hardly be stressed.

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For full details, see page 34.

CLASSIFIED ADVERTISEMENTS

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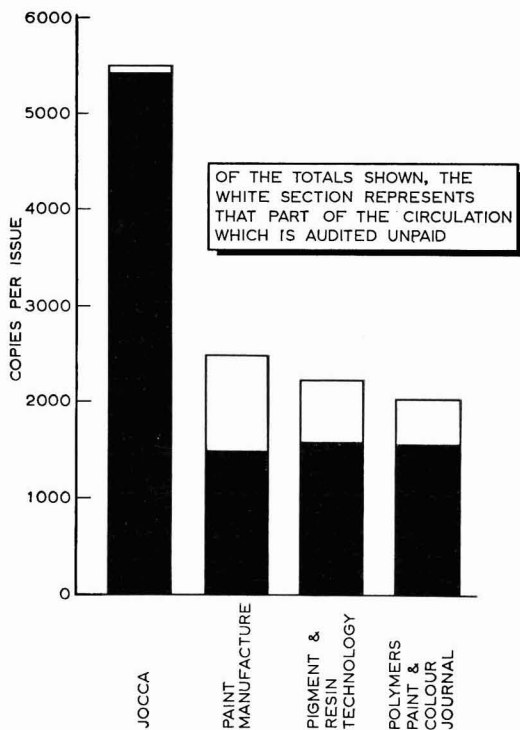
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For full details of advertising in this, and other Association publications, contact **C. A. Taylor**, Assistant Editor

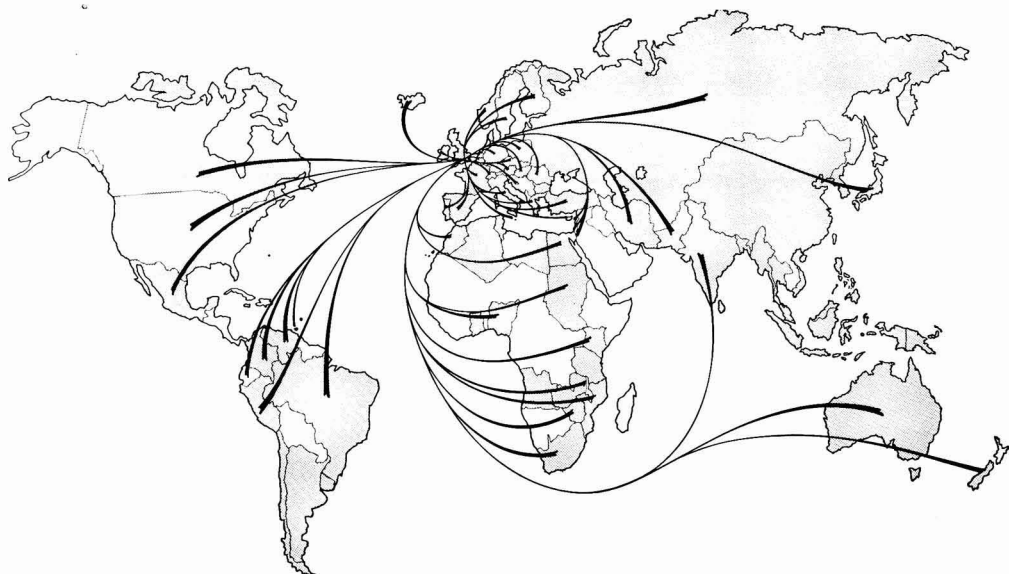
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OIL & COLOUR



CHEMISTS'

ASSOCIATION



TECHNICAL EXHIBITION

ALEXANDRA PALACE
23-26 MARCH 1976

The motif for 1976, designed by Robert Hamblin, continues the theme of the last two Exhibitions—in which attention was drawn to the heavy participation by exhibitors and visitors from overseas—by showing the target for 1976 as London, where all the previous Association annual Exhibitions have been held

FOR TRAVEL ARRANGEMENTS TO ALEXANDRA PALACE SEE PAGES 35 AND 36

TRAVEL ARRANGEMENTS

Since the Association's last Exhibition at Alexandra Palace, travel arrangements have been improved by the addition of the Victoria Line to the Underground system, which now links Victoria Station to the Piccadilly Line at Finsbury Park. The building of the extension of the Piccadilly Line from Hounslow to the Airport terminal at Heathrow is now well advanced and when this is completed in due course it will give a direct link with Turnpike Lane Station on the Piccadilly Line. In the meantime, a bus service operates from Heathrow Airport to Hounslow West Station. Those travelling by the Piccadilly Line should alight at Turnpike Lane Station and the Association will be running a bus shuttle service from this station to and from Alexandra Palace. The journey from central London to Turnpike Lane takes approximately 18 minutes

Reproductions are available of the two-colour map shown on page 36. Members of the Association may obtain copies by sending a stamped self-addressed envelope, marked "Alexandra Palace map" in the top left-hand corner, to the Association's offices at the address on the Contents page of this issue.